GALILEAN ELECTRODYNAMICS

Experience, Reason, and Simplicity Above Authority
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CONTENTS

EDITORIAL POLICY

Galilean Electrodynamics aims to publish high-quality scientific papers that discuss challenges to accepted orthodoxy in physics, especially in the realm of relativity theory, both special and general. In particular, the journal seeks papers arguing that Einstein's theories are unnecessarily complicated, have been confirmed only in a narrow sector of physics, lead to logical contradictions, and are unable to derive results that must be postulated, though they are derivable by classical methods.

The journal also publishes papers in areas of potential application for better relativistic underpinnings, from quantum mechanics to cosmology. We are interested, for example, in challenges to the accepted Copenhagen interpretation for the predictions of quantum mechanics, and to the accepted Big-Bang theory for the origin of the Universe.

On occasion, the journal will publish papers on other less relativity-related topics. But all papers are expected to be in the realms of physics, engineering or mathematics. Non-mathematical, philosophical papers will generally not be accepted unless they are fairly short or have something new and outstandingly interesting to say.

The journal seeks to publish any and all new and rational physical theories consistent with experimental fact. Where there is more than one new theory that meets the criteria of consistency with experiment, faultless logic and greater simplicity than orthodoxy offers, none will be favored over the others, except where Ockham's razor yields an overwhelming verdict.

Though the main purpose of the journal is to publish papers contesting orthodoxy in physics, it will also publish papers responding in defense of orthodoxy. We invite such responses because our ultimate purpose here is to find the truth. We ask only that such responses offer something more substantive than simple citation of doctrine.

The journal most values papers that cite experimental evidence, develop rational analyses, and achieve clear and simple presentation. Papers reporting experimental results are preferred over purely theoretical papers of equally high standard. No paper seen to contradict experiment will be accepted. But papers challenging the current interpretation for observed facts will be taken very seriously.

Short papers are preferred over long papers of comparable quality. Shortness often correlates with clarity; papers easily understandable to keen college seniors and graduate students are given emphatic preference over esoteric analyses accessible to only a limited number of specialists. For many reasons, short papers may pass review and be published much faster than long ones.

The journal also publishes correspondence, news notes, and book reviews challenging physics orthodoxy. Readers are encouraged to submit interesting and vivid items in any of these categories.

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Many thanks go to Slobodan Nedic **for proofreading this issue of Galilean Electrodynamics.**

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From the Editor's File of Important Letters:

Why is the Electron a Stable Particle?

If the electron had constituent parts, then presumably the parts would separate from each other because of internal Coulomb repulsion. So it seems that the electron cannot have constituent parts.

But the electron could nevertheless have some topological structure. In [1], Wesley and Bergman posited that the shape of the electron would be a ring. Carroll pursued this idea in terms of Schrödinger's equation [2]. The present note continues this line of thought.

In its simplest form, *i.e.* with no atomic potential well, Schrödinger's equation goes:

$$\nabla^2\psi = \frac{1}{v^2}\partial^2\psi / dt^2 \quad , \tag{1}$$

where v is a constant of dimension length/time. Following [2], let us define the wave function as a product: $\psi = \psi_0 T$, where ψ_0 is a function of three spatial variables, and T is a function of time. Use of this ψ in (1) provides:

$$\frac{1}{\psi_0}\nabla^2\psi_0 = \frac{1}{v^2 T}\partial^2 T / \partial t^2 \quad . \tag{2}$$

Since the spatial configuration of the spinning ring does not change with time, the left side of Eq. (3) is constant – call it $-\alpha^2$. We have

$$-\alpha^2 = \frac{1}{v^2 T}\partial^2 T / \partial t^2 \quad . \tag{3}$$

We can multiply both sides by v^2, and since v^2 is also constant, we create another constant $-\alpha^2 v^2 = -K^2$:

$$-K^2 = \frac{1}{T}\partial^2 T / \partial t^2 \tag{4}$$

A solution for T is $$T = \exp(iKt) \quad , \tag{5}$$

wherein K is identifiable as the angular frequency ω for the circulation.

Thus the idea of a spinning ring electron is consistent with Schrödinger's equation. So the answer to the question "Why is the electron stable?" could be that it has perpetual circular energy flow.

References

[1] D.L. Bergman and J.P. Wesley, "Spinning Charged Ring Model of Electron Yielding Anomalous Magnetic Moment", Galilean Electrodynamics **1** (5) 63-67 (1990).

[2] R.L. Carroll, "The Toroidal Electron", Galilean Electrodynamics **2** (5) 94-97 (1991).

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Editor's Note: In addition, the spinning-ring electron has nothing that observably changes in time, and hence no deterioration due to energy loss by radiation. It was, and it remains, a pretty good idea. *CKW*

Exploring Wave-Based Electromagnetism

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This paper gives some examples and scenarios where electromagnetic phenomena encountered in everyday life are interpreted in terms of a Wave Based Approach to Eectrodynamics i(WBE) Introduced in [1] The present paper gives some examples and scenarios where electromagnetic phenomena that we encounter in everyday life are interpreted by using the tools and the notation of WBE. The examples serve to explain and illustrate electromagnetic phenomena that are well known, although their ultimate origin may involve some mysteries hidden to us. There are three of them: **1)** Waves and propagation phenomena; 2) Electricity, gravity and some other physical phenomena; **3)** Magnetic, dielectric and ether phenomena.

1. Introduction

The basic assumptions of the WBE are as follows: **1)** An electron has a spherical wave structure to accomplish electromagnetic interactions; **2)** There exists an ether wherein those interactions take place and propagate within the space [2, 3].

The basic question about waves and propagation is how electromagnetic radiation is created in the world where matter is also based on waves - instead of discrete point particles. Before going into issues of electromagnetism and interactions of electrons, I will give a brief introduction of the atomic model that has been in my mind while developing the electromagnetic scenarios as presented in this study. I have also referred to a modern ether concept that has been under study recently.

Let us begin the exploration with electromagnetic radio and optical waves as generated by the nature – in fact, all electromagnetic waves are originally created by the nature, although mankind has its own interests to emulate the mechanisms involved. The first phenomenon considered herein is upper-atmospheric lightning, as thunderstorm and lightning itself seems to hide some mysteries of the Nature. Anyway, I made my best effort to find a wave-based mechanism behind those ghostly effects in the upper atmosphere (mesosphere).

The next step is to study typical man-made telecommunication scenarios at different radio frequencies, including also optical waves and the mystery of the photon. The emphasis is in clarifying the role of 'quantum waves' while interacting with electrons that may be free or bound by atoms /molecules. I have used also experimental evidences to support my conclusions whenever possible. My brief conclusion is that "Faraday induction" accompanied by a propagation delay due to electrons (in atoms /molecules) is the major mechanism behind the radio transmissions used in wireless communication systems.

The mechanism of energy exchange related to emission and absorption of a photon, as well as a process to produce photons in a coherent way in a laser, is illustrated in the view of Wave Based Electromagnetism.

To study electricity, gravity, and other phenomena, we begin with electrical conductivity, which is always an issue while considering electronic /electrical systems. I discuss briefly normal conductive state with a moderate resistivity and, as an extreme case, a transition to superconductive state within a metal lattice. Other phenomena of interest are inductance and capacitance in electrical circuits. The Electric / Gravity force ratio (F_e / F_g) connects the origin of gravity to that of electricity; I also refer (again) to my experimental studies on F_e / F_g -ratio in the troposphere. In addition to transversely modulated electromagnetic waves, the existence of longitudinal scalar waves is discussed. The Zeeman effect and the Aharonov-Bohm effect are explained by using the concepts of Wave Based Electromagnetism (WBE).

To study Magnetic, dielectric and ether phenomena, I discuss the role of magnetic fields in electromagnetism, and I propose a new wave-based way to interpret magnetism related phenomena in transformers, electric motors and generators. As the propagation speed of light and radio waves in air is determined by the refractive index n of the atmospheric gases, the mechanisms behind that 'index' are discussed in the scenarios presented. Once again, I take an opportunity to use the F_e / F_g ratios for atmospheric gases of Hydrogen, Nitrogen and Oxygen in modeling the index n in air.

2. Waves and Propagation Phenomena

A good conceptual model of an atom must provide a balance between the following factors:

a) Electric repulsion of electrons involved;
b) Electric attraction between electrons and protons of the nucleus; this effect may be compensated by spin interactions between electrons and nuclear particles [4];
c) Interaction with all material of the universe in accordance with Mach's Principle, as well as reception and emission of electromagnetic waves (photons, radio waves); this interaction is facilitated by the inward /outward waves ("matter waves" or "quantum waves") of the electrons involved [2] ;

The modern concept of 'ether' appears very relevant to the wave nature of matter. Numerous ether formulations have been ongoing since the times of Faraday and Maxwell (called 'luminiferous ether' at that time). This author's wish is that the current ether research will lead to a fruitful synthesis to satisfy both mathematical and physical aspects of ether. My conclusion is that ether, although unseen by us, is the source of fundamental particles and, hence, all other matter in the universe, and by supporting traveling waves it provides a medium for all interactions, including gravity, inertia and electromagnetism [3]. The ether is not just a hypothetical concept.

Since 1976, near-space experiments with atomic clocks [5] show that in space there exists a medium that alters slightly the frequency of the clocks, depending on the local gravitational potential, as expected by Albert Einstein in his General Relativity Theory (GRT). Furthermore, those experiments tell us that the propagation speed of electromagnetic waves (including light) along electronic (and optical) circuits of the clocks depends on the medium surrounding the circuits. I call that medium 'ether', and allow that its density will vary locally, as shown by the experiments. This leads to a conclusion that this medium is also able to support wave motions, such as quantum waves, and electromagnetic waves. As the ether is supposed to be a fundamental medium in Physics, it needs and deserves the further discussion in this paper.

Although it is not the purpose of this paper to present explicit calculations for atomic energy states, it is assumed that the atomic model illustrated in Fig. 1 is able to provide a diversity of energy states to emit /absorb electromagnetic radiation (photons) ranging from infrared through x-rays, as discussed in other studies elsewhere [2,3], [5,6], as well as observed experimentally during the last century. At this point of discussion, my conclusions are as follows:

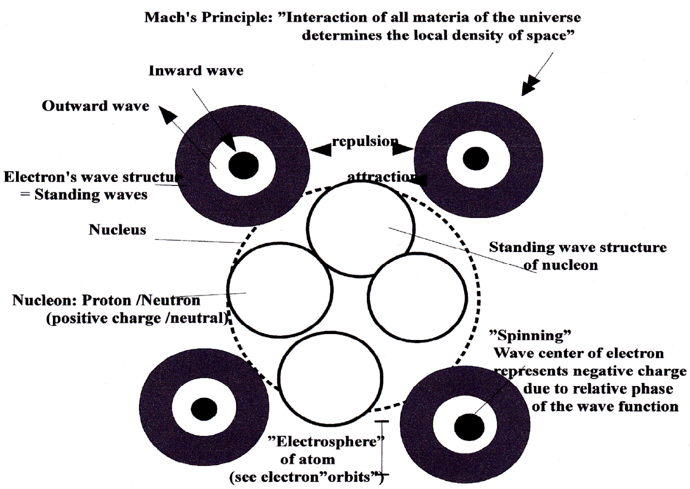

Figure 1. Model of atom used as a platform for electrons that are otherwise considered as major players in association with the electromagnetic effects discussed in the present study. For simplicity, neutrons are not shown.

When an electron moves (is accelerated) radially within electrophere it emits electromagnetic radiation at appropriate wavelengths. On the other hand, when an electron receives electromagnetic waves, *e.g.* transversally modulated quantum waves from other electrons, at one of those wavelengths, it will get into accelerated motion (forth and back), and hence it is storing (absorbing) a certain amount of energy. In addition to radial motion, the electron may encounter a slight deformation of its spherical wave structure and wave center while emitting or absorbing electromagnetic waves.

We may also state that an electron bound by an atom acts like a small radio transmitter /receiver at an extremely high frequency, of course.

3. Upper Atmospheric Lightning and Propagation of Long Radio Waves

This Section develops a proposed mechanism for these phenomena derived from WBE.

Upper atmospheric lightening, also called Transient Luminous Event (TLE), is a phenomenon observed from time to time in conjunction with thunderstorms and ordinary cloud to ground lightning discharges in the atmosphere. Although known since the 19th century, has been intensively investigated by the scientific community only quite lately - *i.e.* during the last twenty years. Among many research reports related to this topic I mention herein the doctoral thesis published by Nikolai G. Lehtinen at Stanford University [7]. Depending on the visual appearance (color, shape), and location of the TLE's in the upper atmosphere, we speak of 'Blue Jets', 'Red Sprites' and 'Elves', as in [7].

In spite of the intensive experimental research and many speculations related to the affecting factors and other conditions for each types of the TLE's, it seems that the common fundamental mechanism responsible for the TLE phenomena in the upper atmosphere is not known (?), or it is not explained in a consistent way in the reports.

The objective of this paper is to present a scenario that may help in understanding the electromagnetic mechanisms causing phenomena like upper-atmospheric lightning. This scenario is derived from Transfer Impedance (Z) concept of a coaxial conductor system (cable). On the other hand, Transfer Impedance effect can be interpreted as a case of Faraday induction and, hence, as a consequence of "wave based electromagnetism" described in my other papers belonging to this study.

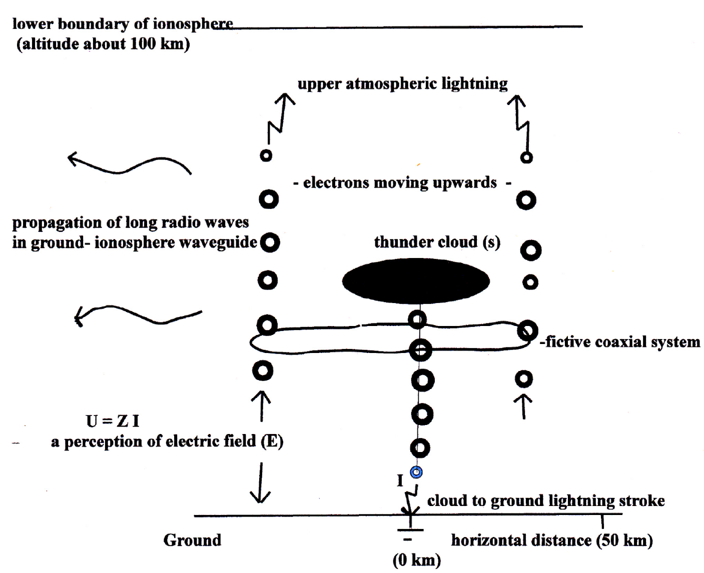

Figure 2. A "wave based electromagnetic" model for "upper atmospheric lightning" and long radio wave propagation phenomena between ground and ionosphere.

On Fig. 2, formula $U = ZI$ describes here the effect of an induced voltage (time- dependent electric field) accelerating electrons to move upwards in the (fictive) outer conductor of (vertical) coaxial-cable system. I is the time-variable current generated by a cloud to ground lightning stroke in the inner conductor of the (fictive) coaxial cable system of ionized gases in the atmosphere. The collisions of (upwards) accelerated electrons tends to excite atoms (N, O, ...) located in the upper layer of atmosphere (also) above the thunder generating clouds. This process may result in emission of visible light, *i.e.* occurrence of lightning effects we can perceive in the upper atmospheric layers tens of kilometers above the ground – if we are lucky. It shall be noted that the light phenomena will last typically a fraction of second. Anyway, a young Finnish amateur astronomer Timo Kantola succeeded in taking a digital photo of an upper-atmospheric lightning incident on 10 October 2009, during a thunderstorm over the Baltic Sea.

To ensure that the electromagnetic mechanism above works, it is assumed an existence of free electrons in the atmosphere concerned - this is more than likely in the typical condition of thunder-weather.

Besides visible light, the electrodynamic system of Fig. 2 is also able to generate long radio waves (VLF, ELF) at frequencies below 30kHz. Those lightning-induced radio waves are sometimes called also "atmospherics", and are considered as potential sources of 'interference' in many electronic devices, and even larger systems used for telecommunication purposes, *e.g.* in this induction scenario the thunder cloud serves as a primary source of transmitter current. Massive vertical electron flows of ionized gases provide an extremely high (up to 100km in this particular upper-atmospheric lightning case) antenna, and, hence, appropriate propagation modes for the ground -ionosphere waveguide may occur, as demonstrated in numerous experiments since the times of Marconi [8].

For the purpose of this study, it is reasonable distinguish between the following concepts related to electromagnetism:

Photon: a single exchange of a discrete amount of energy ($E = hf$) between two electrons belonging to two different atoms (or molecules). Thus, the emission or absorption of a photon is an incident occurring at a microscopic (subatomic) level of matter. A specific case of collective photon emission is a laser where a huge amount of photons is produced in a coherent process. Another specific case was shown in Fig. 2, where accelerated electrons may excite atoms in atmosphere, and, hence, cause emissions of photons. The mechanism by which a photon makes an energy transfer between two atoms has been considered and modeled by some authors [2],[6],[9],[10]. It is apparent that the process can take place smoothly without any discontinuity in wave structures of the electrons concerned.

Light: As our common understanding seems to be that photon is a quantum of light, we can consider that light is a flow of single photons, laser beam and lightning being examples. To detect the light we need a device that is sensitive to the wavelengths of the photons comprising the light (although we might not detect a single photon due to its infinitesimal amount of energy). Such a device may be our eye or an electronic instrument.

Radio waves / electromagnetic radiation: Fig. 3 demonstrate cases where accelerated electrons in a metallic conductor of primary circuit (transmitter) induce 'electro-kinetic field' in the surrounding medium (air), and this in turn will accelerate or excite (in atoms) 'secondary' electrons. In both cases the outcome of the process above is that a signal current is detected in the secondary circuit (receiver).

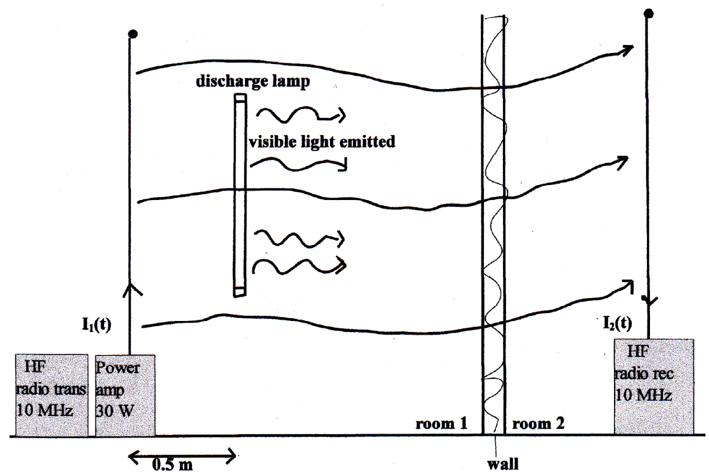

Figure 3. Demonstrating a radio transmission at 10MHz within a building.

If the electrons in the primary circuits (transmitters) are accelerated by a mechanism working in a periodic way, say, at a frequency of 100kHz, *e.g.*, the secondary circuit (receiver) will detect a current signal fluctuating at this same frequency of 100kHz. As a consequence, we may say that a radio wave, or electromagnetic radiation at a frequency of 100kHz is propagating between the transmitter and the receiver. It should be noted that in case of the lightning effect in the atmosphere, the transmitter of the radio waves is a discharge current of electrons through ionized gases of the atmosphere.

The polarization state of a transverse electromagnetic wave may sometimes be an issue. In the scenario of Fig. 2 it is obvious that the vertical motion of primary electrons is to cause a vertical polarization for induced electric field components. On the other hand, the circle as denoted by 'fictive coaxial system' may be interpreted to represent the orientation of magnetic field in horizontal plane.

Here I have mainly discussed so-called transverse electromagnetic waves. But longitudinal waves (Tesla waves, scalar waves) may also provide interesting features and potential applications [3], [11], [12]. Example 2 provides more information on scalar waves.

4. Radio Transmission at Different Frequencies

As a first approximation, it is assumed that a time-variable current $I_1(t)$ of transmitter antenna will (Faraday-) induce a current $I_2(t)$ in a secondary circuit (receiver antenna), as shown in Fig. 4a. Apparently, this is the only transmission mechanism in complete vacuum, *e.g.* for communicating to satellites in space. In this quite extreme case, modulated quantum waves of electrons solely, *i.e.* without any intermediate atoms as regenerators, should be responsible for the energy transfer between the transmitter and the receiver. This same happens also when we receive light from celestial objects, *e.g.* Sun /Moon light, and neglect any excitation /emission phenomena (absorption /scatter) by atoms, molecules, free electrons and other charged particles (ions) in earth's atmosphere. It may be interesting to study, how and in what degree those atomic /subatomic entities contribute to energy transfer in different radio transmission scenarios?

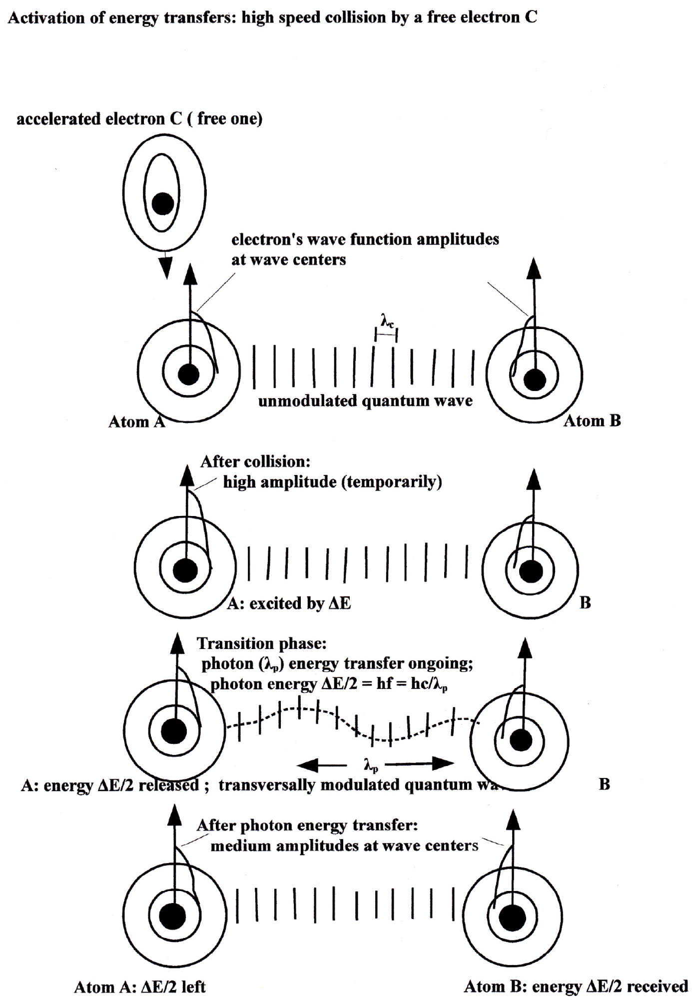

Figure 4a Photon in action – scenario.

Fig. 4b represents a real experimental case implemented when I was in army for my military service (1975): An ordinary discharge lamp was placed vertically close to the antenna of a HF (10MHz) radio transmitter. When the transmitter with 30W power amplifier was switched on the discharge lamp emitted visible white light at its full power! There is no doubt that radio transmitters (*i.e.* 'modulated quantum waves' from accelerated electrons) are able to excite electrons bound by atoms into higher energy states, and, thus cause consecutive emissions of photons which, in turn, can excite next atoms, *etc*.

The fact that atoms are able to absorb and emit photons at a wide spectrum of wavelengths, ranging from infrared, visible and ultraviolet light through x-rays, explains quite well why electromagnetic waves (including radio waves) can penetrate many kinds of material and obstacles (walls, buildings, *etc*.). Electronics designers who try to protect electronic circuits against electromagnetic interferences know this very well by experience; any small hole in the metallic shield surrounding the circuit concerned may be large enough for an electromagnetic radiation (photons) to propagate through! Regarding highly conductive metallic structures, any modulated quantum wave (electromagnetic wave) from an electron tends to induce currents of free (quasi-particle) electrons within the metallic lattice concerned, and, thus create fields to counteract against incidences of electromagnetic origin; that is a basic idea of protection against electromagnetic interferences, as mentioned above.

Another real experimental case is propagation of microwaves in turbulent troposphere. This example of propagation at high radio frequencies is part of my long lasting investigations, as mentioned in my earlier papers. Using my experimental result of measured delay variations and turbulence theories [13], [14], I derived an estimate for Electric Force /Gravity Force ratio F_e / F_g (1.2×10^{40}). The fact that this estimated figure is quite close to the figures reported also in other sources [15], including classic textbooks of physics and electromagnetism [16], indicates that electrons bound by atoms (N, O) of atmosphere play a crucial role while interacting (by excitations / emissions) with the microwaves of 7GHz propagating through the troposphere between parabolic transmitter and receiver antennas (diameter of 2m) separated by an approximate distance of 50km. Those successive interactions with atoms explain a slightly delayed propagation with reference to propagation in a hypothetical vacuum (where refractive index n = 1.000,000). The small delay time (of the order of 10^{-20} s per electron) is needed as the inward wave have to rotate (spin) the wave center of the electron to become the outward wave [2]. By using the notation of Ref. [3] we could say that this delay time is needed for reaction /diffusion processes of etheric components ('etherons') within the wave center of the electron. I will discuss this microwave propagation case in more details elsewhere in this study, this include the experimental arrangements with a lot of results and the propagation model I developed for turbulent troposphere.

At this point, it seems that due to an amazing capability of electrons /atoms (molecules) to be excited and cause emissions of photons over a wide range of wavelengths (from radio waves through x-rays) it may be more difficult to stop electromagnetic waves than to force those waves to propagate at the radio frequency determined by the primary source (radio transmitter) concerned.

However, our actual experience is that the efficiency of propagation from transmitter to receiver seems to depend on some known factors: transmitter power and frequency, location and directivity (gain) of transmitter and receiver antennas, weather conditions, existence of interfering sources ("electromagnetic pollution"). We know by experience that people can use their mobile phones (frequency bands typically within 1GHz – 2GHz) for an effective communication in various locations: outdoors, indoors, in vehicles, even underground (this may necessitate some proactive measures by telecom operators, too, *e.g.* using 'leaky cables' as antennas in metro tunnels to ensure adequate network coverage there).

Third experimental case is that made by Marconi more than 100 years ago: transmitting the first telegraph signal between England and USA over the Atlantic Ocean. The frequency of the radio carrier was only a few kHz (VLF) and a reflection of the radio waves from ionosphere is the mechanism that supposes to to explain the success of the experiment, in addition to obviously interference free (no excessive radio "noise") conditions of earth's atmosphere at that time (!). Furthermore, the extremely low symbol rate (about one symbol per second) of Morse signaling was to was to ensure "error free" data communication over a distance of thousands of kilometers.

As a summary, I conclude that although there is a diversity of electrons /atoms to provide successive energy transfers from the radio transmitter through the receiver, the actual "end to end" performance of the radio transmission link is restricted by factors such as existence of interfering sources and the capability of the transmitter -receiver pair to counteract against harmful interferencies. Multipath propagation effects may cause serious fades in radio reception. On the other hand, the existence of alternative propagation paths may be considered also as a means to accomplish a penetration of radio waves into otherwise inaccessible destinations, *e.g.* a mobile phone in an urban environment with many obstacles preventing a line-of-sight path between a base station and the mobile phone concerned.

5. Compton Scattering & Photoelectric Effect: Hypothetical Case of Microwave Antennas

This scenario is to demonstrate applications of Wave Based Electromagnetism.

Compton scattering is an effect where an incident photon is scattered by an electron bound (loosely) by atoms. As a consequence of inelastic collision part of the energy of the photon is transferred to the scattering electron (recoil effect) and the rest of the energy is taken by the scattered (emitted) photon which may have a slightly longer wavelength compared to that of the incident (exciting) photon. Arthur Holly Compton observed the effect in 1923 [16], and it has been traditionally associated with scattering of x-rays and gamma rays in materials.

By assuming the conservation of the energy and the momentum in the process, the following known formula is obtained for the wavelength shift of the photon scattered [17]:

$$\Delta\lambda = \lambda_2 - \lambda_1 = (h / m_e c)(1 - \cos\theta) \quad ,$$

where λ_1 = wavelength of the incident photon, λ_2 = wavelength of the scattered photon, the quantity $h / m_e c$ is kown as the Compton wavelength of the electron (2.43×10^{-12} m) and θ is scattering angle.

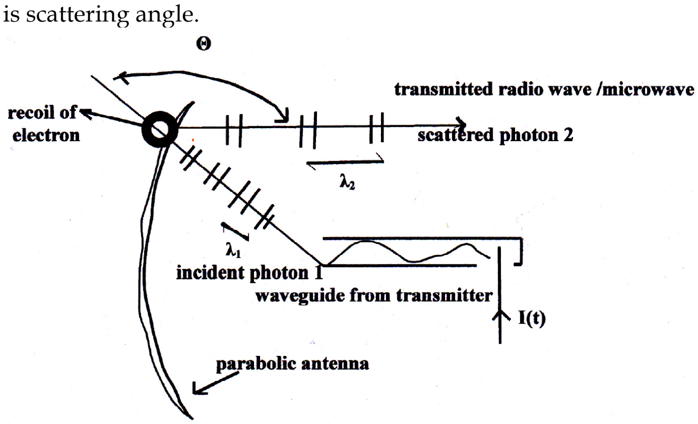

Figure 6. Compton scattering from parabolic antenna – scenario.

The formula above does not assume any definite values for the wavelengths λ_1 and λ_2; its their difference that matters, and it should be of the order of the Compton wavelength of the electron anyway. Hence, in principle, the (λ_1, λ_2) pair may have values within a range of electromagnetic spectrum, *i.e.* not restricted tightly to x-rays only. Using the notion of Wave Based Electromagnetism, photons may be interpreted as 'modulated quantum waves' between electrons bound by atoms. Keeping this in mind, I have presented a scenario of Fig. 6. It should be noted that scattering effects similar to those from the parabolic antenna are expected also within the waveguide, as they are both conductive metallic structures. Electric current $I(t)$ of primary electrons, as produced by the transmitter, fluctuates at a microwave frequency in GHz range and it accelerates the electrons to excite 'free' electrons in the metallic lattice of the waveguide, where the energy is transferred by the appropriate propagation modes. The last step is to emit photon 1 towards the parabolic antenna.

As a summary, Compton scattering above (Fig. 4b) can be explained by Doppler shift of wavelength while the electron in recoil motion is emitting photons. In principle, this consideration is valid for all electromagnetic radiation launched by the waveguide towards the parabolic antenna; *i.e.*, including both visible (and other) photons, as well as the microwaves concerned. Hence, Compton scattering is one way to describe the behavior of electromagnetic waves reflecting from conductive surfaces.

6. Discussion

By assuming that the wavelength of the incident photon 1 is somewhere within UV- and visible (or radio wave) spectrum, the Compton shift itself does not cause any significant reduction in the energy of the emitted photon 2. However, due to practical reasons parabolic radio antennas encounter a gain loss of about 3dB compared to the calculated one (may be typically of the order of 40dBi).

This loss of efficiency of a parabolic antenna sounds interesting as it is quite similar to the figures I have observed for catadioptric lenses ('reflex mirrors' with silver coating) used in astronomy and photography; in this optical case the reference value is the light intensity as transmitted through a refractive type of lens having equal focal length and numerical aperture. By assuming reciprocal propagation of the electromagnetic radiation (microwaves, light) in parabolic antennas and catadioptric lenses, respectively, we come to a conclusion that those two formally different devices seems to be identical while transferring photons /radio waves in a role of a transmitter or receiver. In case of the parabolic antenna the flow of radiation is modulated by a microwave radio signal , thus carrying some digital data to be transmitted. On the other hand, the photons focused by the catadioptric lens comprise the analog image of an object under study.

A remark on the Photoelectric Effect

As is known, the photoelectric effect is a phenomenon in which electrons are emitted from matter (metal, semiconductor) while illuminated by light, especially visible or UV. Those free electrons may cause "photocurrents" that are detectable by electronic circuits, like those ones used in photonic applications (fiber optics, *e.g.*). On the other hand, we can not fully exclude the possibility that receivers designed for the reception of radio waves may, in some circumstances, exhibit also its response to intensive bursts of photons reaching some ”photosensitive” areas (if any) of the receiver.

Referring to Fig. 4b, such a sensitive area could be the waveguide to coaxial adapter that connects the transmitter /receiver to the antenna system: Lets imagine that a burst of photons is reflected from the parabolic antenna to the waveguide where high energy photons may cause some emission of (photo)electrons that are coupled to the coaxial cable and further to the radio receiver. There is some empirical evidence supporting the hypothesis above: It is known that a high intensity UV-light can cause sparks (= electric current) between electrodes of powered electric circuits. In the opposite case a radio transmission may generate photons, as demonstrated in Fig. 3.

7. Different Wave Propagation Scenarios

The Sections above have demonstrated, by using some single examples ranging from long waves through microwaves (and not forgetting optical waves), how radio waves are generated and what are the likely mechanisms supporting the propagation in earth's atmosphere and beyond. To illustrate the typical propagation scenarios as related to telecommunication applications, Fig. 5 gives some additional details in a scenario where two hypothetical propagation paths between the transmitter and receiver are shown:

Path 1 is a case where time-variable transmitter current $I_1(t)$ (Faraday) induces a corresponding electric current $I_2(t)$ in the receiver antenna. No intermediate electrons /atoms are assumed in this ‘repeater-less’ case where modulated quantum waves emitted by the accelerated primary electrons carry the radio frequency signal with wavelength λ_C, the Compton wavelength of the electron (2.43×10^{-12} m), and, thus the wavelength of the unmodulated quantum wave. It shall be noted that Path 1 is possible only in vacuum (no scattering entities are present), and is most relevant in space communication applications.

Path 2 is a case where electrons /atoms in atmosphere ”scatter” modulated quantum waves; *i.e.* successive scattering entities interact with the quantum waves and accomplish a step by step energy transfers between transmitter and receiver electrons. Depending on the occurrence of electronic state transition between two successive atoms, we may state that a photon with wavelength λ_p, or a radio wave (λ_r) is transferred between those two atoms. As some extra time is needed for an interaction event within the atom concerned, its clear that this process tends to cause an additional propagation delay while transmitting radio waves in atmosphere, or in any other (non-vacuum) dielectric medium where refractive index n is larger than unity.

Although the co-existence of Path 1 and Path 2 between a transmitter -receiver pair is a quite hypothetical case, the scenario above shows that multi-path propagation in atmosphere, or within buildings *e.g.*, tends to distort the wave front propagating there, and, hence, to make the error free reception of the transmitted information difficult; in an extreme case the receiver will see just some radio noise. As radio waves of short wavelength are most prone to suffer from distorted wave fronts, it explains why it is difficult to achieve long effective propagation distances for microwaves, millimeter waves and optical links in atmosphere. The attenuation of the transmitted power with distance may not be the biggest problem, but the dispersion effect encountered by the information-carrying signal while it propagates through an inhomogeneous medium.

Regarding the metallic (hollow) waveguide in Fig. 4, each ‘virtual’ reflection point in the conducting wall can be considered as an instant where a secondary current of free electrons of the metallic lattice is generated as a result of Faraday induction. The last step in the chain of secondary currents is the antenna current $I(t)$. As the waveguide is normally filled by a gaseous dielectric medium (air), also scattering effects similar to that of scenario b) may be expected, as predicted in the Compton scattering scenario of Sect. 4. Hence, the initial radiation emitted by the antenna (parabolic one, *e.g.*) may comprise two types of ‘modulated quantum waves’: First, those modulated by the ‘radio wave’ with λ_r, and secondly, those transferring ‘photons’ (λ_p) in a train as synchronized by the ‘radio wave’. Whatever will be the case, the receiver at a far end will perceive the ‘radio signal’ transmitted, with some ‘noise’ of course.

Fiber-optics should be a different scenario. However, impurities and non-linear optical effects within the fiber set the ultimate limit for the longest repeaterless transmission distance. Hence, the performance of optical fiber links is typically dispersion limited, too - instead of being attenuation-limited, as might be expected for single mode fibers at least.

7.1 Forward / Backward Scattering

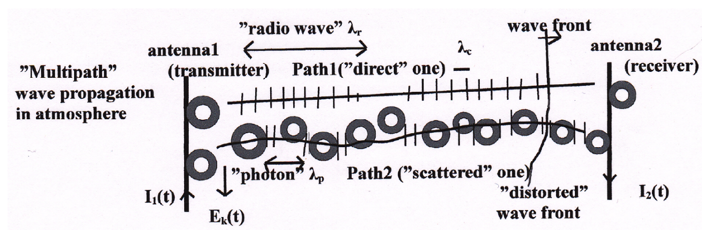

Figure 5. Wave propagation scenarios.

Path 2 on Fig. 5, assume that $\lambda_p = \lambda_r$. This is the case where ‘modulated quantum waves’ pass transparently the intermediate atoms between the transmitter and receiver. On the other hand, due to the fact that quantum waves have to rotate (spin) electron's high-density wave center, an additional propagation delay is caused by each interaction event with electrons anyway. By ignoring those interactions (and delays) with intermediate atoms we find that the radio wave propagation process itself is similar to that of Path 1 (direct), and, hence, it can be considered a delayed version of Faraday induction.

Figs. 6 and 7 show a case where $\lambda_p < \lambda_r$. In this scenario it is assumed that the radio transmitter generates some photons with a wavelength shorter than that of the radio wave concerned, *e.g.* IR-, UV- or visible light; the experiment presented in Fig. 3 shows that this really may happen even with a moderate transmitter power. In Fig. 6, a modulated quantum wave (photons) is transmitted ‘forward’ during the first half of a radio cycle (rc1). In the course of the second half of the radio cycle (rc2) the direction of the transmitter current is reversed (-I) and (downwards) accelerated electrons generate new photons. However, due to the reversed antenna current, the "energy density" of electrons in the antenna is decreased, and this situation is to force some new photons to travel backwards, *i.e.* to the transmitter antenna .

Although the scenario above is still hypothetical, it gives us a possibility to explain backward scattering of electromagnetic waves in the atmosphere and other dielectric media. The backward scattering may be regarded as unwanted (parasitic) effect in telecom systems. On the other hand, in case of radar systems it is highly wanted and useful feature (!).

It is also possible that some of the photons generated during the second half of the radio cycle (rc2) will travel forwards, and, furthermore, to the receiver antenna. The receiver perceives such kind of radio signals as harmonics, or spurious signals that tend to degrade the performance of the reception (refer to photoelectric effect !?). Generally speaking, it seems that both atmosphere and optic fibers exhibit some non-linear behavior as transmission media for electromagnetic waves (!).

Anyway, the scenario $\lambda_p = \lambda_r$ is still considered as a mainstream case, at least in telecom applications. Keeping this in mind, a real atmosphere comprises electrons bound by atoms /molecules and, depending on weather conditions, *e.g.* some concentration of free electrons (and ions respectively) that tends to induce a partial backscatter of the propagating radio waves, analogous to a reflection of electromagnetic waves from a partially conductive material. Adding this backscatter of the radio waves (λ_r) to generation of the photons (λ_p) discussed above we can conclude that nature has a diversity of radiative mechanisms to achieve a maximal energy dispersal in least time. The principle of least action is referred herein [18].

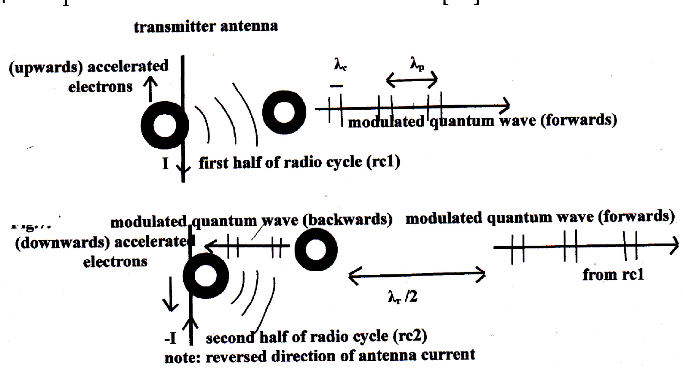

Figure 6. Forward/backward scattering scenarios.

7.2 Illustrations of Photon Action

The photon is the carrier of information in optical communications. In addition, photon emission is apparently involved also in wireless radio communications, as demonstrated in Sections 2 and 3. The concept of photon has remained more or less mysterious during the last century, and several attempts have been made in order to reveal the mechanism of energy exchange related to emission and absorption of a photon [2], [9], [10], [6]. Based on conclusions of other authors and my own experience and understanding, I have illustrated four cases in Fig. 7. The photon action between two electrons bound by atoms A and B, respectively. In this scenario I have assumed that the initial source of energy to be transferred is a free electron C that has been accelerated by a primary source (a lightning discharge or a radio transmitter, *e.g.*).

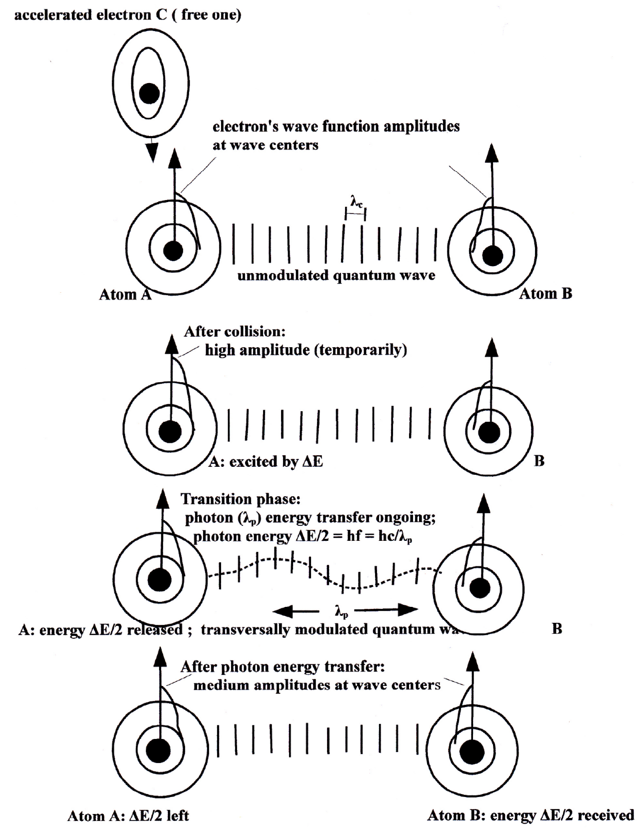

Figure 7. Photon in action scenario. Activation of energy transfers by high speed collision with a free electron C.

During the collision event, energy ΔE is transferred from the electron C to the electron A that jumps into a higher energy state for a while. In this excited state the amplitude of the wave function in the wave center A is temporarily increased. The difference of ΔE between the energies of electron A and B activates an energy transfer process where an occasionally modulated quantum wave packet transports an energy of $\Delta E / 2$ from electron A to electron B that will have an increased amplitude in its wave center accordingly. We may state that a photon with a wavelength of λ_p has been emitted by A and absorbed by B, respectively (conservation of energy is assumed). In this case the propagation speed of the photon is assumed to be $c = 3 \times 10^8$ m/s, *i.e.* the speed of light in the "ether of vacuum" concerned. Furthermore, for the wavelength of the photon we obtain $\lambda_p = 2hc / \Delta E$. It shall be noted that vertical, horizontal, or both polarization modes may be supported in Fig. 7; "circular" polarization is a specific case of photon transfer.

7.3 Sinusoidal Electromagnetic Waves

The scenario in Fig. 8 illustrates EM waves, *i.e.* electric (E) and magnetic (H) components, as generated by a radio transmitter. On the other hand, it can be applied also for cases of electrons bound by an atom while photons are emitted, respectively.

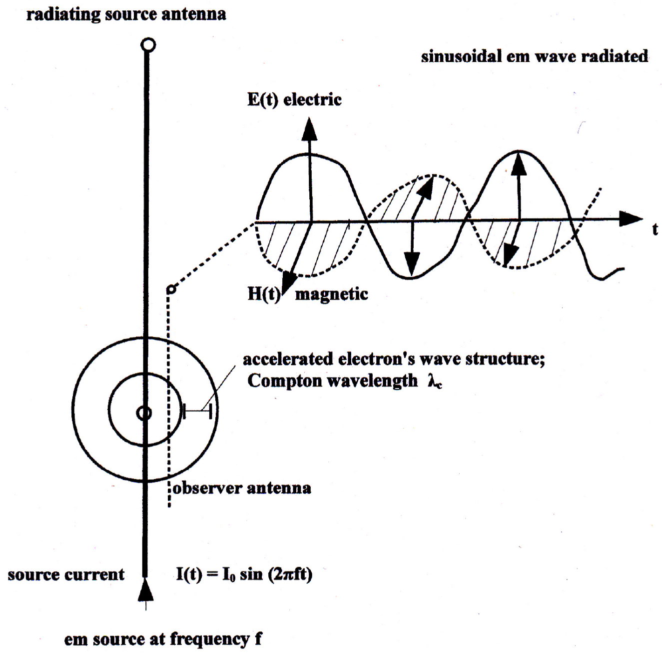

Figure 8. An electromagnetic (em) wave generated by an accelerated electron.

Electric component $\mathbf{E}(t)$ is a quantity measurable by an observer antenna. Hence, Faraday induction is the mechanism that will establish electric/electromagnetic interaction between the source and an observer. On the other hand, magnetic component $\mathbf{H}(t)$ may be interpreted as a measure of accumulated phase of electron's wave function in a unit time that is not directly measurable by electronic means [9].

7.3 Laser in Action

Light Amplification by Stimulated Emission of Radiation (LASER) is a process to produce photons in a coherent way. Let us imagine the arrangement shown in Fig. 9, where a semiconducting medium is closed within an optical cavity (Fabry-Perot). Pump current (I) is to accelerate some free electrons existing in the semiconducting structure. Collisions by free electrons excite electrons /atoms of the semiconductor to a higher energy state. For simplicity reasons, only five atoms and one electron per atom are shown in this scenario.

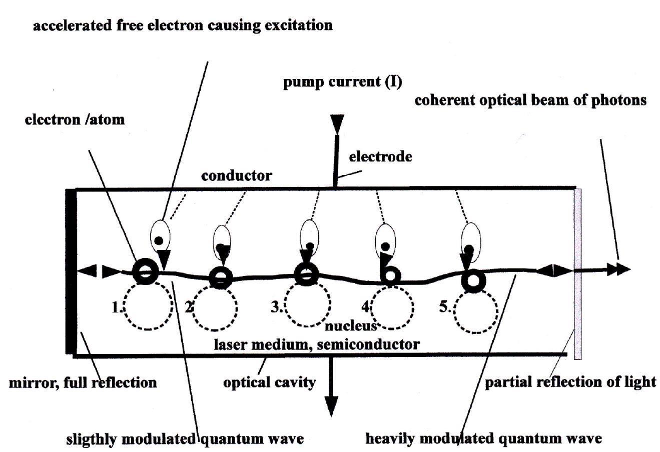

Figure 9. The scenario of semiconductor laser in action.

In the initial phase, the pump current (I) is switched on. Now I imagine that a free (accelerated) electron will collide with electron /atom 1 causing an excitation and, as a consequence, sligthly (transversally) modulated quantum wave of electron propagating towards excited electron /atom 2 that will add its own contribution to the (transversally) modulated quantum wave. The process will continue atom by atom. Finally, a heavily modulated front of quantum waves is obtained at the output of the optical cavity. Due to appropriate mechanical dimensioning and internal reflections at the ends of the cavity, the maximum amplification is achieved at a certain optical frequency. As a result, we will have a laser device producing more or less (phase)coherent stream of photons in visible or near infrared region of optical spectrum.

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Longitudinal Waves in Electromagnetism - Toward a Consistent Theory

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Starting from general expectations that the generation, propagation and reception of longitudinal electromagnetic waves in vacuum could provide basis for wireless energy transmission and efficient wireless communication, this paper contributes to overcoming limitations and constraints of the classical Maxwell's equations framework. That is achieved by confronting the criticism of at least one currently available theoretical scalar waves formulations with a few of the important work results related to scrutinizing of the very foundations of Maxwell's equations. Also indicated is the ability of the formulation of such phenomena in their present form. By overcoming the traditional constraints and long-held views/convictions regarding non- availability of longitudinal, that is scalar mechanism generated and propagated in the vacuum, theoretical framework can be created for synergetic approach between wireless energy and information transmission in line with Tesla's more than a century old views, convictions and conducted experiments. Keywords: Longitudinal Electromagnetic Waves, Advanced Electromagnetism, Future Wireless Communications

1. Introduction

The currently exploited mechanism for electromagnetic propagation via transverse fields involves radiation of antenna elements in all directions, so that on the average only a millionth part of the radiated energy acts at the intended destinations, including the ('massive') MIMO systems. The alternative mechanism, which is the coexistent longitudinal electromagnetic propagation, is commonly understood as having been 'thrown-out' from the official electrodynamics, formulated by simplifications introduced by Heaviside, Gibbs, and Hertz based on the already well-established Ampere's and Faraday's laws, resulting in absence of divergence of magnetic induction ($\mathbf{B}$) and the temporal variability of the electric induction ($\mathbf{D}$). Tesla's very early insistence on the existence of, and the importance of, an equally important longitudinal mechanism have been attempted, notably by Prof. Konstantin Meyl [1], in particular the most recent re-formulation after discovery of magnetic monopoles in the Helmholtz Institute, as well as extensions of electromagnetics equations by Gennady Nikolaev [2] (introduction of the longitudinal magnetic field as result of non-zero divergence of the magnetic vector potential, $\mathbf{A}$), and in particular by Vladimir Atsukovsky [3] (involvement of the time-variable electro/magnetic induction), The latter one provides very compelling representations of the realm of electromagnetics as dynamics of the particular viscous and compressive gaseous fluid, which allows for formation and disintegration of toroidal vortex structures [4,5], implicitly supporting the gyroscopic particles as the basic elements of the Ether substance.

As demonstrated by Tesla's Magnifying Transmitter (TMT) configuration, which has been replicated many times, especially within the last two to three decades, the energy transmitted by mediation of so-called Scalar Waves is thought to be circulating in the system until being absorbed by the matched receiver. Although Tesla had talked about propagation of such waves in the Ether, what he essentially attained was officially understood as longitudinal, progressive standing waves through Earth and/or ionizied media. But, based on the isights gained from the aethero-dynamical mechanism of magnetic induction [3], Tesla had actuallyly achieved extraction of energy from the Aether substrate, thus confirming his adamant non-acceptance of the 2-nd law of thermodynamics (https://www.dropbox.com/sh/e3zhyzaiedxu6dv/AABOzzgwiGFr452F_dqfnTrXa?dl=0). In this regard, the now largely actualized 'linear magnetism' (magnetic field vector co-liner with the direction of energy propagation) appears to be the crucial phenomenon relevant to both supra-luminal transmission speed and energy efficiency in free air or vacuum, as appears to be the case in biological systems

Although Tesla's primary usage of the waves was conceived to be for both energy supply and communications purposes, the energy transmission has been and remained his main goal, with the synergetic inclusion of the (land, see and air) vehicles' controlling functionality. While the wireless energy transmission itself can be considered as a much more advantageous (in terms of energy losses – in Tesla's one-wire system the energy actually flows around a very thin conductor), its significance in the domain of wireless cellular and sensors network, as well as in health applications, becomes welcome, or even indispensable.

Sect. 2 overviews some relevant work results of other authors on scrutinizing the very foundations Maxwell's equations, and their extension, or amendment, while the following Sect. 3, in its first part contributes to overcoming limitations and constraints of the framework of classical Maxwell's equations. In particular, it goes about conciliating the formally justifiable critics of the currently only proponent of theoretical and practical aspects of the so-called scalar waves technology. In the second part of Sect. 3, the existence of the longitudinal waves is demonstrated with the Maxwell's equations themselves, through application of the traditional formalism of using (electric) scalar and vector (magnetic) potentials. A hint of relatedness of these two aspects has been also provided. In the context of historical developments regarding the synergetic approach to wireless energy transmission and communications, certain practical longitudinal waves related transceiver options based on alternative dipole configurations are briefly overviewed in Sect. 4.

2. Overview of Relevant Works in Post-Maxwellian Electromagnetism

Ever since their introductions by Maxwell in the second half of the nineteen century of the set of linear differential equations and subsequent reformulations by Heaviside and Gibbs to essentially involve the vector analysis notations instead of the less-used quaternion algebra, despite occasional difficulties in their application to diverse practical problems, they have retained their original form (Table I - without underlined terms, and with equal sign instead of arrow).

A direct critic of these equations is hardly to be found in the open literature. The only two rather comprehensive treatises are [2] and [3], based on extensive sets of experiments and complementary regarding respective emphasis on electric and magnetic aspects of the electromagnetic field. While both authors rely on etheric nature of electricity and magnetism, the first one has developed a consistent and very compelling model of Ether as a gaseous substance with viscosity and compressibility features, In the following is provided an overview of the main findings.

2.1 Works Related to Atsukovsky's Treatise [3]

In his very long career as an electrical engineer and academician, based on insights into Ether substrate as a gaseous substance exhibiting both compressibility and viscosity – the features that either one or both were missing from all previous conceptualizations and postulations, Atsukovsky [9] developed a very consistent and compelling theory of Etherodynamics, comprising all structures and phenomena from the atomic to galactic levels. Based on this, Atsukovsky came up with differential form of electromagnetic field equations taking an extended and largely improved form (Table I, with underlined terms added):

Table 1. Amended Maxwell's Equations in Differential Form.

1.	$\nabla\times\mathbf{E}_{\varphi} \Leftarrow \underline{\boldsymbol{\delta}_{\mathrm{m}}} = -\mu\mu_0\dfrac{\partial}{\partial t}(\mathbf{H}_{\Psi}+\underline{\mathbf{H}_{\Sigma}})\quad;$
2.	$\nabla\times\mathbf{H}_{\Psi} \Leftarrow \boldsymbol{\delta}_{\mathrm{e}} = \left(\sigma+\varepsilon\varepsilon_0\dfrac{\partial}{\partial t}\right)\left(\mathbf{E}_{\varphi}+\underline{\mathbf{E}_{\Sigma}}\right)\quad;$
3.	$\nabla\cdot\mathbf{D}+\underline{\dfrac{\partial}{c\partial t}D}=\rho\ \ *\ ;\quad \nabla\cdot\boldsymbol{\delta}_{\mathrm{e}}+\dfrac{\partial}{c\partial t}\delta_{\mathrm{e}}=0\ \ *$
4.	$\nabla\cdot(\nabla B)+\dfrac{\partial}{\partial t}(\nabla B/c)=0\quad.\quad *$

Here $\mathbf{D}$ is the vector of electric induction, $\boldsymbol{\delta}_{\mathrm{e}}$ is the vector of electric current density in a medium, $\mathbf{B}$ is the vector of magnetic induction. The footnote that goes along the equations marked by * is that division of vectors $\mathbf{D}$, $\boldsymbol{\delta}_{\mathrm{e}}$, and ∇B by vector $\mathbf{c}$ means that those vectors are collinear; that is, they have exactly the same direction. As usual, $\mathbf{E}$ and $\mathbf{H}$ are, respectively, the electric and magnetic fields; $\mathbf{D}=\varepsilon\mathbf{E}$ and $\mathbf{B}=\mu\mathbf{H}$ are, respectively, electric and magnetic inductions, and ε is electric permittivity and μ is magnetic permeability of the medium, δ_{e} is the electric current density (in place of the usual $\mathbf{j}=\sigma\mathbf{E}$), and δ_{m} is the magnetic current density counterpart, and σ is the electrical conductivity of the medium; ρ is the density of electric charge in the medium. The vectors (letters in Bold) and scalars (other than constants) are generally functions of position within a selected coordinate system and of the time.

The first feature of the extended, *i.e.* largely improved, set of differential Maxwell's equations are two forms of asymmetry introduced – regarding the cause-effect (the first two equations do not apply in both directions) and presence of generally different electric and magnetic field strength vectors, both in the first two equations. (The additional terms within the brackets denoted by index 'Σ' stand for the fields components external to the considered elementary volumes of the medium, and more close elaboration and justification of that can be inferred from [3].) These asymmetries might be the features that were inherently present in Maxwell's second and third formulations of electromagnetism based on quaternion algebra, due primarily to the non-commutativity of the multiplication operation.

The second extension featured in the amended Maxwell's equations, of prime importance in this paper, are the non-zero divergences of both electric and magnetic fields (the third and fourth equations) in absence of the free-charges, arrived at exactly based of the dynamical features and the Ether regarding its compressibility. Implicitly, the related electric and (the gradient of) magnetic inductions are 'intimately' related to velocity of propagation through to the quite unusual division of the two vectors. Rather than looking at this operation as conventional scalar multiplication, in that the velocity vector is 'inverted', this should be treated through the so-called the real division algebra, where quaternions represent the basis. The extended integral equations then follow:

Table 2. Amended Maxwell's Equations in Integral Form.

1.	$e=\oint_{\ell}\mathbf{E}(t-\underline{r/c})\cdot d\ell \Leftarrow -d\Phi_{\mathrm{m}}(t)/dt$
2.	$e_{\mathrm{m}}=\oint_{\ell}\mathbf{H}(t-\underline{r/c})\cdot d\ell \Leftarrow I=dq(t)/dt$
3.	$\Phi_{\mathrm{e}}=\oint_{\mathbf{S}}\mathbf{D}(t-\underline{r/c})\cdot d\mathbf{S} \Leftarrow q(t)$
4.	$\Phi_{\mathrm{m}}=\oint_{\mathbf{S}}\mathbf{B}\cdot d\mathbf{S}=0$

Here Φ_{e} and Φ_{m} are electric and magnetic fluxes; I is electric current in conductor; q is charge moving in direction of electric current (directed movement gives to the latter two the vector form).

Based on conceiving Ether as a gaseous fluid of elementary particles, named "a'mer(s)" (in tribute to Demokrit), in deference to all previous models, including those of Maxwell, Helmholtz, Lord Kelvin, *etc.*, with the exception of only Tait and Tesla, in [3], and in [9] in a more general context of a universe on all scales (essentially tied in itself in a kind of 'recycling' process), Atsukovsky [3] has established a basic, essentially dynamically stable toroidally shaped structures, which further organize into higher level configurations through the very basic mechanism of velocity/temperature/pressure gradients, the very same mechanisms by which at certain stages the structures get gradually disintegrated. Regarding the very basic proton and electron configurations, it goes about the flows of the Ether fluid elements forming the torus-like geometry, that is a toroidal vortex structure, in that its velocity in the ring direction lies in the nature of electricity (plus sign, in one direction; minus sign in the other), while the velocity of the very same "fluid' elements over 'meridians' of the same torus represent the (mono-polar?!) magnetic charges.

This has strong support in some of the formulations of generally non-linear fluid dynamics equations, where the fluid element represents a tiny elongated gyroscopic (with rotation along its axis) 'prisms' (featuring the precession effects, which might account for both the viscosity and compressibility features), [4], and (in light of discussion above) a kind of an omnipresent sponge with a huge 'spaghetti', which represent a latent capability for creation of any of imaginable vector (magnetic) potentials, and/or monopole-like 'charges', whether of (di-)electric or magnetic types. In that sense, the effective electric and magnetic charges can arise under influence of remote (and intermediately materialized) ones, due to process of intermediately propagated induction, so that the conventional constraints regarding their absence in vacuum ($\nabla \cdot \mathbf{D} = 0$ and/or $\nabla \cdot \mathbf{B} = 0$) become unnecessary limiting and thus should largely become obsolete. (Here apparently lies essential difference between electromagnetic and light phenomena, in that light is continually propagating dynamic highly-stable toroidal vortex - photon structure, with the only common feature with EMs being jut the speed of the transverse propagation [3].)

2.2 Related to Nikolaev's Opus [2]

While Nikolaev has pointed to deficiencies of Maxwell's equations mostly in similar aspects, as did Atsukovsky (referred to only as an example of the people who came from the academia circles, and still have scrutinized the classical electromagnetics/electrodynamics foundations), he addressed them primarily from the viewpoint of applicability of the magnetic vector potential $\mathbf{A}$. On one side, he pursues and exploits the physicality of the (vacuum) displacement current (rate of change of the electrical induction field $\mathbf{D}$) when it comes to overcoming the inconsistencies of the Maxwell's equations regarding the problems of non-locality, and on the other, he overcomes the lack of correspondence of the measurement results in case of open-current loops (for example, linear dipole antenna) with calculations when only one component of magnetic field ($\mathbf{H} = \nabla \times \mathbf{A}$) is evaluated (with known distribution of displacement current), while as usually assuming that $\nabla \cdot \mathbf{A} = 0$. Namely, in such situation, the solution produced does not satisfy the outgoing Maxwell's equations. The full correspondence is attained only with the non-zero magnetic vector potential.

Nikolaev revisited the problem that had led Atsukovsky to augment the right-hand side of the first of Maxwell's differential equations, He noted the presence of an electric field around a transformer, while the time variation of the magnetic field does not take place ($\partial \mathbf{H} / \partial t = 0$); that is:

$$\nabla \times \mathbf{E} = -c^{-1} \partial \mathbf{H}(\mathbf{r}) / \partial t = 0 \quad , \quad \nabla \cdot \mathbf{E}(\mathbf{r}) = 0 \quad . \tag{1,2}$$

so that the induced electric field should be zero.

The main result that Nikolaev came up with, and which may have some relevance in the subsequent considerations in this paper, is related to the necessity to generally account for two forms of the magnetic field – the conventional, 'normal' to direction of a current ($\mathbf{H}_{\perp} = \nabla \times \mathbf{A}$) and the new one, with direction parallel to current flow ($H_{||} = -\nabla \cdot \mathbf{A}$). Nikolaev named the latter component *the second*, or *scalar, magnetic field*. It could be related to the recently introduced 'linear magnetism' related to electromagnetic activities of biological structures, and even 'elements transmutations'.

The physical reality of this field component has been demonstrated in experiments with interactions of conductors situated co-linearly (along the same line) with each other, as well as with a permanent cylindrical (and torus) form magnet cut in half along its length and re-assembled in the same form after one of its halves is rotated by 180° (without any resistance – the magnetic forces perform this re-configuration by themselves, which according to S. Marinov provided basis for 'perpetual mobility') around the 'axis' perpendicular to the cylinder axis. Moreover, while in accordance with the Lenz-s law the current induced in a part of a conductor (with sliding contacts on its ends) being moved perpendicular to a vector magnetic field ($\mathbf{H}_{\perp} = \nabla \times \mathbf{A}$) flows a direction such that resistance to its movement arises, in the case of scalar magnetic field, surprisingly, the longitudinal movement of the same conductor segment within the scalar magnetic field will actually be aided in that movement !?! This can then be termed the anti-Lenz effect. (It has been noted in the Preface of [2] that the first one who observed the longitudinal movement of a segment of conductor on sliding contacts was Carl Hering, with effects described in Transactions of American Institute of Electrical Engineers, **42**, 311, 1923, which was reprinted in the S. Marinov's journal Deutsche Physik, **1** (3), 41, 1992. Hering has a patent on a transformer based on mutual compensation of the involved magnetic fields.)

Considering this, and the well-known detectability of the magnetic-field effects, even in cases where the magnetic field intensity does not exist (its intensity zero – the famous Aharonov-Bohm prediction in 1956 and related experiments), some recent engineering practices [8], and, finally, non- uniqueness of a magnetic vector potential regarding its curling measure representing the same ('normal') magnetic field ($\mathbf{A}' = \mathbf{A} + \nabla\psi$ and $\mathbf{H} = \nabla \times \mathbf{A}' = \nabla \times \mathbf{A}$, at least for time-independent scalar potential Ψ), actually suggest that it must be representing an aspect of the real (dynamical) structuring of the very Ether substrate. (One of the possible so-called guage-transformations, the Ludwig Lorenz's one, is $\nabla \cdot \mathbf{A} = -\partial\phi / \partial t$, and depending on the particular form, various field options arise.)

3. Overcoming Barriers to Longitudinal Phenomena in Electromagnetism

Ever since Maxwell's formulation of (firstly entirely algebraic, and later in the form of quaternions algebra, bearing much wider group asymmetry than tensors, and let alone vectors, which remain in the wide use as of today) equations that describe the electromagnetic phenomena, there have been no explicit constraints on the form of the related waves. Actually, the starting point was purely mechanical analysis and formulation of transmission of momentum through a medium, so that only its nature and features were to determine if generally both transverse and longitudinal, or just one of them, would be manifest.[1] Unfortunately, due to the available set of experimentally confirmed and heuristically derived laws on one side, and the postulated (ideal) features of the involved Ether medium (homogeneity, incompressibility and non-viscosity) on the other, the course of historical development was such that a rather paradoxical situation arose: only the transverse waves have 'survived', in spite of the ideal medium that actually should not allow them!?!

On those grounds, and based on his own experimental (in his Colorado laboratory) evidencing of the longitudinally traveling EM-waves, Tesla claimed that if Hertz had produced reception of whatever oscillations originated at a dislocated transmitter, that might actually must have been happening through the longitudinal, and not trough the transverse mechanism, since Tesla was opting for the Ether's compressibility (ability to 'shuttle' in direction of propagation) but apparently did not admit (certainly wrongly, since not having been aware of its viscosity) the possibility of appearance and/or propagation of transverse effect. (He, though, still kept distinguishing between his, Tesla's waves and the Hertz-ian waves?!)

Whatever the situation might have been, the above exposed and briefly replicated treatise of V.A. Atsukovsky undoubtedly provides foundations for both electromagnetic perturbations and their subsequent propagation through vacuum, that is through Ether, and not allowing for the presence of only longitudinal waves in material media. This in turn can reaffirm some earlier findings, as Heaviside's odd and nearly incredible giant curled EM energy flow component actually accompanying every far more feeble Poynting energy flow in every EM system or circuit (it definitely would be interesting to see if it may bear any relationship with the Second magnetic field of Kolya Sibirsky), and going beyond what Helmholtz and Lord Kelvin had, towards reaffirming of the Des Cartesian vortex physics. Not withstanding the historical aspects and the missed opportunities, including Heaviside's "giant curled EM energy flow", the stances of mainstream science are scrutinized bellow.

3.1 Traditional Wave-Equation Framework

In the context of the Laplace's homogenous (classical) wave equation

$$c^2 \Delta W = \partial^2 W / \partial t^2 \quad , \tag{3}$$

its general solution has the form

$$W(\mathbf{r},t) = W(t \pm r / v) \quad , \tag{4}$$

where v represents the speed of propagation, including the linear combination thereof. As a matter of fact, (3) had actually been derived by pre-supposing that very same 'oscillatory-waving' process.

By using the vector algebra, the identity for the Nabla (or Laplace's ∇^2) operator on the left-hand side of (3) it can be written as

$$c^2 \left[\nabla(\nabla \cdot \mathbf{W}) - \nabla \times (\nabla \times \mathbf{W}) \right] = \partial^2 \mathbf{W} / \partial t^2 \quad . \tag{5}$$

This was essentially exploited and varied in the early stage of work of Prof. Meyl [1] towards formulation of the electromagnetic equations which would encompass both transversal and longitudinal waves propagation mechanism in vacuum, that is in a medium without free charges. In doing so, essentially the first and the second Maxwell's equations are taken ($\nabla \times \mathbf{E} = -\partial \mathbf{B} / \partial t$; $\nabla \times \mathbf{H} = \partial \mathbf{D} / \partial t$; with $\mathbf{j} = \mathbf{0}$ in the latter one), by applying the rotor operation on both, along the connection between electric induction and electric field strength ($\mathbf{B} = \mu \mathbf{H}$), and between the magnetic induction and the magnetic field strength ($\mathbf{D} = \varepsilon \mathbf{E}$) to arrive at the same form for the both electromagnetic field components in form

$$c^2 \left[\nabla(\nabla \cdot \mathbf{E}) - \nabla \times (\nabla \times \mathbf{E}) \right] = \partial^2 \mathbf{E} / \partial t^2 \quad , \tag{6}$$

$$c^2 \left[\nabla(\nabla \cdot \mathbf{H}) - \nabla \times (\nabla \times \mathbf{H}) \right] = \partial^2 \mathbf{H} / \partial t^2 \quad , \tag{7}$$

in Variant I,

Another form, Variant II, has been derived from the so-called Faraday law and its 'dual' form, respectively: $\mathbf{E} = \mathbf{v} \times \mathbf{B}$ and $\mathbf{H} = -\mathbf{v} \times \mathbf{D}$:

$$v^2 \left[\nabla(\nabla \cdot \mathbf{E}) \right] - c^2 \nabla \times (\nabla \times \mathbf{E}) = \partial^2 \mathbf{E} / \partial t^2 \quad , \tag{8}$$

$$v^2 \left[\nabla(\nabla \cdot \mathbf{H}) \right] - c^2 \nabla \times (\nabla \times \mathbf{H}) = \partial^2 \mathbf{H} / \partial t^2 \quad . \tag{9}$$

The general understanding is that the second term in left-hand part is supposed to contribute to transverse propagating waves, and the first term to the longitudinally propagating one. The Variant II even predicts different velocities of the two. By strictly sticking to the unconditional validity of the Maxwell's third & fourth equations, Prof. Bruhn [6] provided indications of untenability for the related interpretations, and incorrectness of certain derivations, ranging from the inability of these systems of equation to be 'satisfied' by the conventional plane-wave solution consisting from an out-going and an in-going wave (as though this is the only possible wave-solution that meets such an requirement), certain formal inadequacies of applying differentiation rules leading to predefined inter-dependence of position and time, as well as the paradoxical (?!) orthogonality of both field vectors with direction of propagation, while one of them should actually be collinear with it, if to propagate longitudinally (related to Variant II), and finally the obvious disappearance of the longitudinal component by the mere non- existence of either electric or magnetic inductions, as

$$\nabla \cdot \mathbf{D} = 0 \quad ; \quad \nabla \cdot \mathbf{B} = 0 \quad .$$

Besides intrinsic limitation of the classical wave equation in its construction and the form of its solution, it involves an additional constraint – direct (implicit) relationship between the two components of the vector fields, $\mathbf{E}$ and $\mathbf{H}$. Moreover, these

[1] The LWave is the traveling (and/or stationary) longitudinal counterpart to the traveling (in modern terminology – transverse) electromagnetic (TEM) wave. Using the terminology from Maxwell's original treatises, it can be written as a longitudinal wave in the electromagnetic momentum where the electromagnetic momentum is curl-free (or nearly so). Langmuir's electrostatic plasma wave is one concrete example of a LWave. A brief account of the related historical development is to be found at http://maxwellfluidcompression.blogspot.rs/

forms are produced in retrofit, assuming $\nabla \cdot \mathbf{D} = 0$ and $\nabla \cdot \mathbf{B} = 0$ under which apply the equations

$$\Delta \mathbf{E} = \nabla(\nabla \cdot \mathbf{E}) - \nabla \times (\nabla \times \mathbf{E}) \quad ,$$

and
$$\Delta \mathbf{H} = \nabla(\nabla \cdot \mathbf{H}) - \nabla \times (\nabla \times \mathbf{H}) \quad .$$

This very well illustrates insurmountable difficulties and inappropriateness of attempting to overcome the rigidity of a certain theoretical framework, while still holding it 'sacred'.

However, Atsukovsky's critical analysis and amendment of most of the fundamental flaws of Faraday, Maxwell, Heaviside and Gibbs offer basis for overcoming many constraints in the current electromagnetics formulation. First, it is the inherent asymmetry in the first two equations, whereby the two fields are generally different, so that in place of equality between the left- and the right-hand side the 'unilateral' cause-effect relationship applies, (expressions 1 and 2 In Table I). Although a systematic approach might lead to a more accurate and compelling formulation, presently even in the considered case of just going out from the classical wave equations, Atsukovsky's analysis and experimental work (at least in the realm of electric induction, *i.e.* electric field) expressed by (Item 3 in Table I) may fully justify (6) and (7), Indeed, in case of the explicitly absent electric charge(s), $\rho = 0$, by taking the gradient part of (6) one gets

$$\nabla(\nabla \cdot \mathbf{D}) = -c^{-1} \partial(\nabla D) / \partial t \quad , \tag{10}$$

while, due to $\nabla\nabla \cdot = \nabla \cdot \nabla + \nabla \times \nabla \times$ for the related part follows:

$$\nabla(\nabla \cdot \mathbf{D}) = -c^{-1} \partial(\nabla \mathbf{D}) / \partial t + \nabla \times (\nabla \times \mathbf{D}) \quad . \tag{11}$$

Moreover, because of presence of scalar divisions of inductions and their propagation velocity vectors, by having, say u, in place of c in the above equations, notwithstanding inherent obsoleteness and irrelevance of the classically- relativistic transformations between two inertial systems used for arriving at (8) and (9), different velocities of longitudinal and transversal waves propagation could be somewhat supported. Again, the asymmetry underlying the (consistent) derivation of these two equations comes from the fact that, considering in terms of the implied Lorentzian force(s), in the two equations $\mathbf{E} = \mathbf{v} \times \mathbf{B}$ and $\mathbf{H} = -\mathbf{v} \times \mathbf{D}$ velocities pertain to different aspects of particle charges – electric in the first, and the magnetic in the second one, (The intricacies related to the differentiation rules and the critical reference to in [6] might rather have been addressed to the historical development of electromagnetics, wherein the Hertz's formulation of electrodynamics with using full instead of partial time-derivatives have made the Maxwell's equation invariant to the classical Galilean transformations, based on which the Lorentz transformations, L-force and STR become obsolete [10].)

3.2 Scalar and Vector Potentials Formalism

Although the traditional Maxwell's equations expressed through the classical wave equation do not allow for the scalar, that is the longitudinal, waves in media without charges, and/or *in vacuo*, it does not mean that in line with the commonly agreed upon decrease of the number of possible solutions with increase of the number of constraints a rather specific, and/or peculiar solutions would result. Indeed, that has turned out to be exactly the case with purely longitudinal waves based on the so-called force-free magnetic field, that is the magnetic vector potential which curl is collinear with itself. Such a configuration and the related current distribution has been derived [11], and is outlined here as an example of the varieties of electromagnetic field in overcoming the claims about the traditional Maxwell's equations regarding the unavailability of the scalar, that is longitudinal electromagnetic waves therein.

Besides the four Maxwell's equations, with $\mathbf{j} = 0$, *i.e.* $\boldsymbol{\delta}_e = 0$ in the area considered, but of form to induce a suitable $\mathbf{A}$,

$$\nabla \times \mathbf{E} = -d\mathbf{B} / dt \, , \; \nabla \times \mathbf{B} = c^{-2} d\mathbf{E} / dt \, , \; \nabla \cdot \mathbf{E} = 0 \, , \; \nabla \cdot \mathbf{B} = 0 \, . \tag{12}$$

added are two equations which for magnetic vector potential:

$$\nabla \times \mathbf{A} = \lambda \mathbf{A} \quad \text{and} \quad \nabla \cdot \mathbf{A} = 0 \quad , \tag{13}$$

In line with the force-free magnetic field discovered back in 1952 [12], the magnetic vector potential parallel to it has the form

$$\mathbf{A} = \nabla \times (\phi \mathbf{u}) + \lambda^{-1} \nabla \times [\nabla \times \phi(\mathbf{u})] \quad , \tag{14}$$

with $\mathbf{u}$ an unit-vector, and the potential $\phi(r)$ represents a solution of the scalar differential (Helmholtz's) equation

$$\nabla^2 \phi + \lambda^2 \phi = 0 \quad , \tag{15}$$

where λ is a constant.

The magnetic and electric fields ($\mathbf{E}$, $\mathbf{B}$) defined as $\mathbf{B} = \lambda A \cos(\omega t)$ and $\mathbf{E} = \omega \mathbf{A} \sin(\omega t)$, with $\omega = \lambda c$, do indeed satisfy conventional Maxwell equations. The thus constructed electric and magnetic fields are genuinely Maxwellian self- sustained, 'non-Hertzian' longitudinal (and 'scalar' at least to the extent of being derived from the scalar potential function) 'oscillation' *in vacuo*. The current density which, in accordance with the conventional techniques, generates such a field then is $\mathbf{j}(\mathbf{r}, t) = \mathbf{J}(\mathbf{r}_b)\cos(\omega t)$, where $\mathbf{J}(\mathbf{r}_b)$ represents current concentrated at position $\mathbf{r} = \mathbf{r}_b$ from the central axis of a torus form, on which surface the $\mathbf{E}$ and $\mathbf{B}$ fields' line of forces are situated, intertwining one 'inside' the other, with a limiting curve which is itself a line of force.

It turns out that this particular solution of the traditional Maxwell's equations (along the corresponding field generation current densities) provides a structure which falls very close to the very Ether-substrate elements, that is its potentiality[3] in creating such dynamically more-or-less stabile structures, based on conceptualization of which, and some additional features, the very 'colossal construction' of Maxwell can and has to be amended, along the lines of Atsukovsky's results and insights, The missing features, or aspects, apparently are the compressibility and viscosity, as per [3], so that with reduced ideal features these elementary structures become capable of mediating propagation of electromagnetic disturbances of generalized form, including both the transversal and longitudinal mechanisms.

4. Implications for Wireless Transceivers

The first experimental proof of validity Maxwell's equations performed by Hertz by the end of 19th century actually was the first arrangement that has been fully detached from the surface of Earth. However, since the transmitter and receiver were in near proximity of each other, it might have happened that besides the targeted transverse waves present were also the longitudinal, *i.e.* the scalar ones.

Interestingly, so far only vertically oriented dipole elements on both the transmission and reception ends have beenexploited in practice. However, if taking collinearly situated dipoles at the transmitter and receiver sites, the situation can be opposite, especially in line with the "second (scalar) magnetic field" of Kolya Sibirski, which more and more has been receiving recognition in domain of electromagnetism of biological systems and differentiation between para- and dia-magnetism mechanisms.

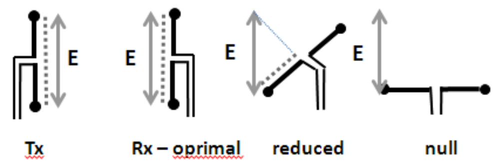

Figure 1, Comparison of conventional dipole transceiver antennas positionings.

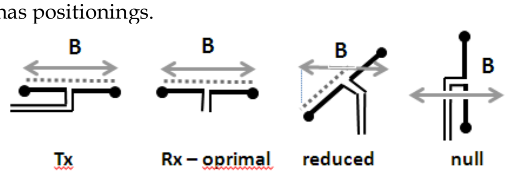

Figure 2. Comparison of an alternative dipole transceiver antennas positioning.

Indirect support for this could be the longitudinal electric field demonstrated in [3] for the semi-conducting mediums, as is see-water. In the context of the vector magnetic potential formalism, can be referred to work in [15], regarding the so-called 'force-free' magnetic field (with $1/r$ drop in intensity, while in detecting Hertzian, *i.e.* transverse radio waves there is $1/r^2$ drop in intensity), and the corresponding transceiver designs/patents [13, 14], including those known as Rodin- coils and Möbius strip/coil, whereby the Tesla's transceiver system with the Tx-secondary and Rx-primary planar-winded coils comes to think of as radiating and radiation absorbing elements, in particular if deformed into half-dome structures.

5. Conclusion

The main part of this paper has provided a wide and compelling body of evidence on the feasibility of longitudinal electromagnetism within the classical Maxwellian formulation, as well as in the context of its extensions. The ethero-dynamical support for such extensions indicate that the magnetic vector potential, usually considered as quantity useful only for analytical calculations, actually has a physical meaning as the measure of movement of the etheric substrate. The existence of longitudinal, *i.e.* scalar, electromagnetic waves has been indirectly supported by some results of others. Some alternative dipole measurements have been proposed in order to support, and in a way surpass, Tesla's old ideas and assertions regarding energy efficient communications.

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A 'No-Moving-Parts' Heterodyne Atom

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The heterodyne model of matter [1,2] is used here to describe an atom with no moving-parts. Here, the atom's electron is not represented as a classical 'orbiting' point particle, but rather as a fixed, spherical standing wave that fills the entire atom. An associated wave equation, based on scalar potentials, is developed. So this wave and its wave equation are derived from considerations different from, and perhaps less mysterious than, those applied in traditional Quantum Mechanics. The correspondence between the heterodyne model predictions and observable reality is evaluated. **Key Words:** heterodyne model, "no-moving-parts" atom, atomic wave equation.

1. Introduction

While the formalism underpinning wave mechanics has been remarkably successful, a question surrounds the arbitrary way in which the original wave equations are derived. In general, developing the equations begins by choosing a suitable Hamiltonian or dispersion relation and replacing terms in the relation with 'operators'. Each operator, including expressions of the central field (if an atom is considered), is then multiplied by a wave function, Ψ. The wave equation is assembled from these new amalgamations. Such multiplication might be understood with particular differential operators, where Ψ is preserved intact after the differentiation is performed on it, but explaining the product of the wave function with the central field operator is more challenging. To date, a first-principles derivation of the quantum wave equation has not been rigorously formulated, and no firm argument has been proffered to clarify why any of these exceptional steps are necessary. Ultimately, however, the quantum wave equations are justified simply by their results.

In two articles published in this journal [1, 2], we represented a single particle by a pair of spherical, counter-traveling, light-speed waves, what we referred to as the 'heterodyne model'. The wave combination was associated with the general solution to a spherical wave equation in which independence of θ and φ was assumed. Applying a similar approach to the atom may go some way toward addressing the issues above, particularly the inclusion of the 'central field $\times\Psi$' term. The aim of this paper is twofold: (a) to introduce the concept of a heterodyne atom with 'no moving parts' and (b) to consider the feasibility of developing a wave equation for such an atom.

2. The Planetary Atom

In 1911 Rutherford [3] introduced his 'solar model' of the atom. With subsequent advances, such as the inclusion of Bohr's quantum rules [4], the planetary theme continued; that is, until the Copenhagen interpretation challenged its simplicity and blurred the picture.

From the Copenhagen perspective, an electron within the atom inhabits a subterranean domain beyond our physical reach and understanding, which precludes us from knowledge of the electron's specific behavior. Furthermore, determining a particular electronic characteristic not only depends on the method used, but the chance of observing such a characteristic is subject to the outcome of an undetectable 'probability wave'. We will not discuss these unorthodox and controversial ideas here, although we mention that, since they are neither provable nor disprovable, they correspond more to points of *faith* than fact.

Given the lack of behavioral specifics about an atom's electron, such terms as 'orbit' or 'revolve' are excluded from the Copenhagen lexicon. On the other hand, there is an unspoken understanding that a ground state electron, despite its elusiveness, is itinerant and undergoes continuous, albeit random, *repositioning* about the nucleus. No physicist or chemist would insist that the electron is motionless, fixed at a stationary point, since there are distinct position-dependent probabilities associated with locating it. Thus, we are left with two inextricable modes of thinking, an official denial of orbiting particles, but acceptance that some sort of orbital activity occurs. Use of the phrase 'electron orbital' has become an agreeable compromise, a subtle acquiescence that both views have some relevance.

While the Copenhagen interpretation is intuitively comforting, anomalies of the planetary paradigm are also well known. Some of these are mentioned below. But what is most notable is that elimination of the orbital model has never been attempted, and its removal might allow a fresh conceptual approach. Bohr [5] pointed out that an orbiting electron radiates, resulting in rapid energy loss and orbit collapse. With the invention of 'allowable orbits' and then, later, the application of probabilistic *orbitals*, coupled with 'indeterminacy', the problem was circumvented. In the process, Copenhagen's interpretation challenges were tolerated. But the orbital paradigm itself was not contested.

While discovery of electron configurations was a major advance on Rutherford's simple elliptical model, important philosophical questions remained. What central or other force and what operational mechanism cause the electron to satisfy these more complex orbitals? Copenhagen's response was that the prediction is enough in itself. If the mathematics determines probable locales that match reality then the issue need not be considered: it is academic. However, the present authors find this view dismissive of the fundamental and crucial question of 'effect-without-cause'. A longstanding and universal principle of physics is rendered invalid by the assertion that 'we neither know nor can find out'. In the absence of an alternative approach, the Copenhagen interpretation was generally accepted, despite significant consternation from some. Today, it concerns few scientists. Not only is there no experimental test to assess the veracity of the Copenhagen view, but there is no desire. Yet, the rationale seems incomplete and unsatisfying and, given the convolution of *orbital* trajectories, the planetary concept itself is questionable. In his book, *Quantum Reality* [5], Nick Herbert observes that, for the hydrogen atom in its third excited state, the electron configuration manifests as two identical donut-shaped clouds separated by an impenetrable chasm. Statistically, the electron spends half its time in the vicinity of each cloud, but cannot traverse the intervening space between them. With this untenable prospect, Herbert concludes that electron behaviour cannot be likened to that of a classical particle and so defers to the *cannot know* camp. Again, no-one raises the obvious possibility that the planetary concept itself is the cause of these dilemmas. Below we present a model of the atom that is non-planetary.

3. A 'No-Moving-Parts' Atom

We recall that the second goal of this paper is to develop the wave equation for a heterodyne atom, but we first consider how such an atom might be visualized. For simplicity we will consider a hydrogen-like atom and we will invoke the heterodyne model mentioned earlier, where a single particle (an electron) is not regarded as a featureless point or solid sphere, but as a diffuse, light-speed standing wave, Ψ. Logically, then, the electron would continue in this form as a spherically symmetric standing wave, Ψ, hovering about the hydrogen's nucleus. As such, its cloud-like form would pervade the entire atom. Density of the cloud, $|\Psi|^2$, would contribute 'substance' to the atom, which would diminish with radial distance but would also form concentrated shells that correlate directly with familiar electron *orbitals*. This preliminary picture of the electron retains the essential structure of the troublesome planetary model, yet offers an alternative that is both unexpected, but also quite natural.

We give $|\Psi|^2$ the generic title 'configuration density' to accommodate for the possibility of multiple interpretations, such as 'probability density' or the density in energy/mass should the light-speed nature of Ψ be linked to electromagnetism - or perhaps to cater for an entirely new quantity. The authors strongly favour interpreting Ψ as electromagnetic (EM), but we also recognise the difficulties in forming spherical waves from EM vectors. To some degree this can be dealt with if Ψ is a scalar quantity whose gradient leads directly or otherwise to such waves. Relating Ψ to electromagnetism would then allow $|\Psi|^2$ to be automatically associated with the heterodyne particle's energy density. Given the provisional nature of all this we will not attempt to interpret the specific meaning of the standing wave at this point. Rather, for flexibility we will assume Ψ corresponds to luminal-velocity waves of any type.

Although the electron, as a spherical standing wave, might rotate about the fixed centre of the atom, it bears no resemblance to an isolated point-particle in orbit and as such the heterodyne atom might be regarded as having 'no-moving-parts' (NMP). This signifies a major interpretational departure from the Copenhagen picture of a transitory electron, although at a fundamental level, given the structural likeness, the formalism should be very similar. The issue of effect-without-cause is automatically removed by the NMP model since central forces are not required to explain complex (or even simple) trajectories and clearly the problems of both an accelerating charge and Herbert's 'donut' dilemma no longer apply. While, in its own way, the Copenhagen approach also circumvents these problems, the NMP model is not burdened by Copenhagen's interpretational concerns. Ockham would certainly endorse the application of such a view. We now proceed, albeit heuristically, toward a NMP wave equation, satisfied by Ψ, where $|\Psi|^2$ describes the electron's distribution of *configuration density* within the atom.

4. Transformation Equations

Our previous articles showed how the spherical standing wave, representing a particle, transforms into a modulated spherical *wave packet* when observed to be moving at the relativistic speed, v. Explicitly, light-speed counter-traveling waves, from which the standing wave is formed, become Doppler shifted in the non-rest frame. In combination, these waves 'heterodyne' into spatial and temporal groups through which a rapid phase wave passes. The respective energy and momentum of the phase wave transform longitudinally as

$$W = W^o \Big/ \sqrt{1-\beta^2} \quad \text{and} \quad p = \beta W^o \Big/ c\sqrt{1-\beta^2} = \beta \Delta p \quad , (1, 2)$$

while their group wave counterparts transform as

$$\Delta W = \beta W^o \Big/ \sqrt{1-\beta^2} = \beta W \quad \text{and} \quad \Delta p = W^o \Big/ c\sqrt{1-\beta^2} \quad .(3, 4)$$

Here, c is the speed of light *in vacuo*, $\beta = v/c$ and W^o is the standing wave's rest energy. The phase wave expressions can be shown to match perfectly with those derived from particle collisions, providing convincing support for the heterodyne description. De Broglie's group and phase speeds for matter waves also match identically with the same quantities derived from the heterodyne model; namely,

$$v_g = \Delta W / \Delta p = v \quad \text{and} \quad v_p = W / p = c^2 / v \quad . \qquad (5, 6)$$

5. Dispersion Relations

We are now in a position to find a suitable dispersion relation from which to develop the atom's heterodyne wave equation. We seek a relativistic equation that reflects the spherical, light-speed nature of the waves. Since Schrödinger's equation is non-relativistic, it is not representative. We turn to the dispersion relation on which the Dirac and the Klein-Gordon equations are based, namely

$$W^2 - c^2 p^2 = W^{o2} . \qquad (7)$$

Dirac began with the usual process of replacing the terms in (7) with their *quantum operators*. But, of course, this required eliminating the radical $W = \pm\sqrt{c^2 p^2 + W^{o2}}$. He equated the quantity inside the square root to a perfect square and expressed the result in matrix form. This led to four first-order interdependent differential equations. The methodology was unconventional, but it was laudable and was happily inducted into the then fledgling quantum theory.

While, as a dispersion relation, equation (7) appears as a possible foundation for our wave equation it poses a philosophical difficulty. To demonstrate this we consider its implications for a typical stationary atom. We expand the first term of (7) using (1) and combine it with W^o to produce

$$\beta^2 W^2 - c^2 p^2 = 0 \,. \tag{8}$$

From this we can take either of two paths leading to one of two results. Firstly, substituting $\beta W = \Delta W$ and $p = \beta \Delta p$ into (8) we arrive at $\Delta W^2 - v^2 \Delta p^2 = 0$, a group wave expression where v is the group speed, v_g (see (5)). Alternatively, dividing (8) by β^2 yields $W^2 - (c^2 / v)^2 p^2 = 0$, a phase wave expression where c^2 / v is the phase speed, v_p [see (6)]. Although this is interesting in itself, in both these equations the translational speed, v, arises naturally when considering an orbital model of the atom. But, in contradistinction, the same association cannot be made in the current context of a heterodyne atom, since, as a no-moving-parts system, its electrons are by definition stationary; the quantities v, v_g and v_p have no physical meaning. Prima facie, this would suggest preclusion of equation (7) as an appropriate dispersion relation. However, in view of the light-speed nature of Ψ, we set $v = c$ so that $v_g = v_p = c$. Thus, the group and phase wave equations and, in fact, equation (8) all reduce to the same form

$$W^2 - c^2 p^2 = 0 \quad . \tag{9}$$

We therefore discard the Dirac and Klein-Gordon equations as prospective wave equations since (7), from which they derive, cannot be associated with a no-moving-parts atom. On the other hand, (9) is consistent with such a model and so we adopt it as the starting point from which an appropriate wave equation might be formulated.

6. Toward a NMP Wave Equation

Before proceeding, we point out as an aside that the Copenhagen view perceives the electron's 'stationary states' as consisting of standing 'probability waves'. Given that all standing waves are composed of identical counter-traveling wave pairs, how does Copenhagen interpret a counter-traveling probability wave pair?

As a precursor to the wave equation we wish to develop, we replace (9) with its *operator* equivalent,

$$\partial^2 \Psi / \partial t^2 - c^2 \nabla^2 \Psi = 0 \quad . \tag{10}$$

We now recall the discretion associated with developing a wave equation based on the planetary model, which involves (a) inserting into the equation a central field term and (b) multiplying the term by the function, Ψ. There is the temptation at this stage to employ these same arbitrary steps for the heterodyne approach. We avoid this by looking for naturally occurring light-speed wave equations, similar to (10), that also incorporate a central field term automatically. Such equations are already known to us. They are the inhomogeneous light-speed wave equations, where the central field term arises as the 'source/sink' of the waves. Specifically, they include the EM wave equations, as well as their scalar and vector potential counterparts. The EM wave equations might be reduced to Maxwell's equations in a way that is similar in function to Dirac's equations. Archibald (1955) [6] and Good (1957) [7] have shown that a process of this type is achievable. However, we reject general use of EM wave equations for reasons given in Section 3, namely the problematic nature of forming spherical waves from interdependent electric and magnetic vectors. (At the end of this paper we will briefly consider how longitudinal EM waves, despite their own issues, might resolve this problem.)

A vector potential representation may be useful, particularly when applied to a moving atom, but guided by the success of scalar approaches, we settle on the scalar potential equation,

$$\partial^2 \Psi / \partial t^2 - c^2 \nabla^2 \Psi = \rho / \varepsilon_0 \quad , \tag{11}$$

to represent the NMP wave equation. Here, the central field term, ρ / ε_0, includes the charge density, ρ, of the electron and the permittivity of free space, ε_0, while Ψ represents the scalar potential. With this procedure the need to subjectively insert a central field term is removed.

We now use an idea presented by Schrödinger in his fourth paper of 1924 [8]. There, the charge density took the role played by Ψ in our present paper. That is, ρ was incorporated as part of the wave function, Ψ. Since it represents the source/sink of the wave in (11) we, too, will merge the two entities. We assume that, apart from a possible difference in radial amplitude, the charge density and the scalar potential are at least proportional. We express this in the relation $\rho = K f(r) \Psi$, where $f(r)$ is a radial function of typical form r^{-m} ($m = 1, 2, 3...$) and K is a proportionality constant. Thus, knowing that K and $f(r)$ can be specified at a later time, the final wave equation describing the NMP atom becomes

$$\partial^2 \Psi / \partial t^2 - c^2 \nabla^2 \Psi = K f(r) \Psi \quad . \tag{12}$$

7. Time Independent Representation

With a hydrogen-like atom in mind, we consider the time independent form of (12), namely

$$(W^2 / \hbar^2) \Psi + c^2 \nabla^2 \Psi + K f(r) \Psi = 0 \quad ,$$

which rearranges to

$$\nabla^2 \Psi + c^{-2} \hbar^{-2} \left[W^2 + \hbar^2 K f(r) \right] \Psi = 0 \quad . \tag{13}$$

Here c and $\hbar$ have their usual meaning and W is the energy associated with Ψ. Assuming separation of variables, $\Psi(r, \theta, \varphi) = R(r) Y(\theta, \varphi)$, we obtain the familiar spherical harmonic equation,

$$\frac{1}{\sin\theta} \frac{\partial}{\partial\theta} \left[\sin\theta \partial Y(\theta, \varphi) / \partial\theta \right] + (\sin\theta)^{-2} \partial^2 Y(\theta, \varphi) / \partial\varphi^2 + l(l+1) Y(\theta, \varphi) = 0 \quad , \tag{14}$$

and the radial equation,

$$\frac{d}{dr}\left[r^2\frac{dR(r)}{dr}\right]+\left\{r^2\left[W^2/c^2\hbar^2+Kf(r)/c^2\right]-l(l+1)\right\}R(r)=0 \quad (15)$$

Solutions to (14) are well known and offer no new information.

We focus attention exclusively on (15). We attempt to alter (15) so as to match it with its counterpart equation for the orbital model. We make the substitution $W^2/c^2\hbar^2=-\frac{1}{4}\eta^2$ and suitable parametric changes, $R(r)=y(r)/r$ and $r=x/\eta$. We also choose $f(r)=1/r=\eta/x$ and $K=\kappa\eta^{1/2}$, so that $Kf(r)=\kappa\eta^{3/2}/x$ (the new constant, κ, is still to be specified). With all these steps (15) simplifies to

$$d^2y(x)/dx^2+\left[-\frac{1}{4}+\frac{\kappa}{c^2\eta^{1/2}x}-\frac{l(l+1)}{x^2}\right]y(x)=0 \quad (16)$$

We now compare this directly to its orbital equivalent, namely

$$d^2y_j^k(x)/dx^2+\left[-\frac{1}{4}+\frac{2j+k+1}{2x}-\frac{k^2-1}{4x^2}\right]y_j^k(x)=0 \quad . \quad (17)$$

Solutions to (17), the associated Laguerre functions, can be used to express solutions to (15) in the form $R_{n,l}(r)=Ay_n^l(r)$, where A is a normalization constant and j, k, l, are integers. Clearly, the modified radial equation (16) (describing the NMP electron) corresponds identically in form to (17) (the radial equation associated with the orbital model). Compatibility between the orbital model of the atom and the NMP model is obvious and so (15) arises as a worthy alternative to (17). This suggests that there is considerable merit in regarding the hydrogen atom as a no-moving-parts heterodyne particle, given that planetary problems are naturally removed along with the interpretational difficulties of Copenhagen.

As emphasis, we equate the final term of both (16) and (17) to obtain $k=2l+1$. Since j and l are integers, then $(2j+k+1)/2$ is also an integer, n. Comparing the third terms of (16) and (17) then leads to $\kappa/c^2\eta^{1/2}=n$, so that $\eta=\kappa^2/c^4n^2$. Since $|\eta|=|2W/c\hbar|$, then $|W|=|\hbar\kappa^2/2c^3n^2|$. Choosing κ such that $\hbar\kappa^2/2c^3$ is the ground state energy for hydrogen leads to an expression that can be matched identically to the Bohr relation $W=-13.6/n^2$ eV $=-2.18\times10^{-18}/n^2$ J, a very satisfying result.

Before concluding, we briefly consider an alternative to the scalar potential wave equation above. We will not elaborate in detail, but we believe it is noteworthy. We begin with Maxwell's equations in which the magnetic field, B, is zero. This reduces to two expressions, $\nabla\cdot\Psi=\rho/\varepsilon_0$ and $\partial\Psi/\partial t=-J/\varepsilon_0$, where $\Psi=\Psi(r,\theta,\varphi,t)$ is the electric field, ρ and ε_0 are as previously defined and J is the current density. A magnetic field of zero implies that, if Ψ undulates in space and time, then its propagation is longitudinal (*i.e.* radial). This is usually opposed on the grounds that EM waves, having no rest frame, cannot have zero momentum. Thus, their helicity (polarization alignment with momentum) cannot be zero and longitudinal propagation is rendered impossible. However, uniquely, the light-speed waves of a heterodyne particle (a *massive* particle for which there is always a rest frame) can be combined to form zero helicity and, thus, allow longitudinal propagation. Applying the same method as that used to develop (12), we let $\rho/\varepsilon_0=K_\rho f(r)\Psi$ and $J/\varepsilon_0=K_J f(r)\Psi$ and solve Maxwell's two equations. Clearly, a further means of describing an atom in terms of the NMP heterodyne model seems possible, highlighting the breadth of flexible options that seem available with such an approach. We hope to consider Maxwell equations for longitudinal electric waves ($B=0$) in a future publication.

8. Conclusion

In this paper we have suggested that difficulties with the solar model of the atom might be avoided by considering a no-moving-parts (NMP) heterodyne approach. We have then attempted to develop a wave equation to describe such an atom, recognising the luminal-speed character of heterodyne systems and aiming to include a central field term naturally. A number of equations were identified that meet these two conditions, namely the inhomogeneous electromagnetic (EM) wave equations and their associated scalar and vector potential equivalents. While not the only option, the scalar form was chosen to represent the NMP hydrogen-like atom. With that choice, the radial component of the scalar potential wave equation was then shown to be compatible with the same equation of the orbital atomic model. The approach was also used to derive an expression equivalent to Bohr's energy relationship. These do not signify direct proof, but they give considerable strength to the NMP heterodyne model generally, especially considering that the approach eliminates planetary anomalies without the interpretational issues of Copenhagen. Overall, the NMP model is presented as a completely new template on which to base the atom.

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