Longitudinal Waves in Electromagnetism

Towards Consistent Theoretical Framework for Tesla's Eergy and Information Transmission

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Summary— **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.**

Key Words: Longitudinal Electromagnetic Waves; Advanced Electromagnetism; Future Wireless Communications

I. 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 the 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 the longitudinal, progressive standing waves through Earth and/or ionizied media. However, based on the insights gained from the aethero-dynamical mechanism of magnetic induction [3] Tesla did effectively attain the 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 it 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 very welcome, maybe even indispensable.

In this paper, 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.

II. 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 just partially used quaternions 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.

A. Work 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, underlined terms added):

TABLE I. AMENDED MAXWELL'S EQUATIONS IN DIFFERENTIAL FORM

1.	$\nabla\times\boldsymbol{E}_{\varphi}\underline{\Leftarrow\boldsymbol{\delta}_M}=-\mu\mu_0\frac{\partial}{\partial t}\left(\boldsymbol{H}_{\psi}+\underline{\boldsymbol{H}_{\Sigma}}\right)$
2.	$\nabla\times\boldsymbol{H}_{\psi}\underline{\Leftarrow}\boldsymbol{\delta}_e=\left(\sigma+\varepsilon\varepsilon_0\frac{\partial}{\partial t}\right)\left(\boldsymbol{E}_{\varphi}+\underline{\boldsymbol{E}_{\Sigma}}\right)$
3.	$\nabla\cdot\boldsymbol{D}+\underline{\frac{\partial\boldsymbol{D}}{c\partial t}}=\rho;$ * $\nabla\cdot\boldsymbol{\delta}_e+\underline{\frac{\partial\boldsymbol{\delta}_e}{c\partial t}}=0;$ *
4.	$\nabla\cdot\underline{\nabla}\boldsymbol{B}+\underline{\frac{\partial}{\partial t}\left(\frac{\nabla\boldsymbol{B}}{\boldsymbol{c}}\right)}=0;$ *

Here **D** is the vector of electric induction, δ_e is the vector of electric current density in a medium, **B** is the vector of magnetic induction. The footnote that goes along the equations marked by * is that division of vectors **D** , δ_e **,** and ∇B by vector **c** means that those vectors are collinear; that is, they have exactly the same direction. As usual, **E** and **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 by the amended Maxwell's equations of the prime relevance to this paper's topic 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:

TABELA I. MAXWELL'S EQUATIONS IN INTEGRLAL FORM

1.	$e = \oint_l \mathbf{E}(t - \underline{r/c}) \cdot d\mathbf{l} \Leftarrow -d\mathbf{\Phi}_m(t)/dt$
2.	$e_M = \oint_l \boldsymbol{H}(t - \underline{r/c}) \cdot d\boldsymbol{l} \Leftarrow \boldsymbol{i}(t) = d\boldsymbol{q}(t)/dt$
3.	$\Phi_e = \oint_s \boldsymbol{D}(t - \underline{r/c}) \cdot d\boldsymbol{S} \Leftarrow q(t)$
4.	$\Phi_M = \oint_s \boldsymbol{B} \cdot d\boldsymbol{S} = 0$

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 exception of onlyr 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.

B. 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.

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'.

Considering 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 gauge-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.)

III. OVERCOMING BARIERS TO LONGITUDINAL PERTURBATION 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!?!

The above exposed and briefly replicated treatise of V.A. Atsukovsky undoubtedly provides foundations for both electromagnetic perturbations and their propagation through vacuum, that is through Aether, and not allowing for the presence of longitudinal waves in material media only. Notwithstanding historical aspects and missed opportunities, including Heaviside's "giant curled EM energy flow", the stances of the main-stream 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, Δ (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

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

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

in Variant I.

Za autora/autore iz samo jedne institucije: Za promjenu načina prikaza 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 $\mathbf{H} = -\mathbf{v} \times \mathbf{D}$:

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

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

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 3-rd and 4-rth 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), 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 $\nabla \cdot \mathbf{D} = 0$; $\nabla \cdot \mathbf{B} = 0$.

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

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

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,

[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/

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

$$\nabla(\nabla\cdot\mathbf{D}) = -\frac{1}{\mathbf{c}}\frac{\partial}{\partial t}(\nabla\mathbf{D}) \quad (10)$$

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

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

and similarly for **B**.

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 number of possible solutions with increase of number of constraints a rather specific, and/or peculiar solutions would result. Indeed, that had 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 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.* $\boldsymbol{\delta}_e = \mathbf{0}$ in the area considered, of a form to induce suitable $\mathbf{A}$,

$$\nabla\times\mathbf{E} = -d\mathbf{B}/dt\ ,\ \nabla\times\mathbf{B} = \frac{1}{c^2}d\mathbf{E}/dt\ ,\ \nabla\cdot\mathbf{E} = 0\ ,\ \nabla\cdot\mathbf{B} = 0 \quad (12)$$

added are two equations which for magnetic vector potential:

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

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

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

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

$$\nabla^2\phi + \lambda^2\phi = 0\ , \quad (15)$$

where λ is a constant.

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 potentiality3 in creating such dynamically more-or-less stabile structures, based o conceptualization of which, and some additional features, the very 'colossal construction' of Maxwell can and has to be amended, along 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.

IV. IMPLICATOONS FOR WIRELESS TRASCEVERS DESIGN

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 been exploited 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.

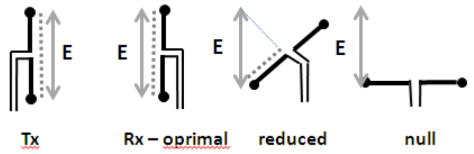

Figure 1, Comparison of conventional dipole transceiver antennas positioning.

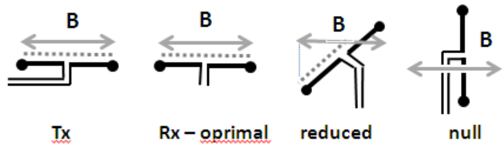

Figure 2. Comparison of an alternative dipole transceiver antennas positioning.

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, it 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 be thought of as radiating and radiation absorbing elements, in particular if deformed into half-dome structures. (The recent, most convincing, but largely 'suppressed' longitudinal electric waves demonstrating experiment is given in [16], thus the transceiver set-up in [1].)

V. Conclusion

The main part of this paper has provided a wide enough 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 aethero-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 configurations and 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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