Tesla Scalar Wave Geometry

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1 author:

Larry Reed

Tesla Longitudinal Scalar Wave Geometry

Abstract

The geometrical wave structure of Tesla scalar waves is illustrated including depiction of means of generation and detection. Proposals by various researchers have been previously advanced advocating that classical Maxwell/Heaviside equations should be generalized to admit the existence of non-Hertzian, longitudinal scalar waves by inclusion of additional scalar field to the existing **E**- and **B**-fields of classical electrodynamics used to describe Hertzian, transverse electromagnetic waves. Such proposals fail to consider the effects of retardation of magnetic vector potential **A** which become significant at high frequencies, large currents or at long distances. Inclusion of known retardation effects obviates the need for additional gradient-driven forces to account for longitudinal **E**-fields and associated electrokinetic effects. The maximum velocity of propagation of Tesla longitudinal scalar waves in vacuo corresponds to $(\pi/2)c = 1.57c_0$ in contrast to the Weber limit $c_W = \sqrt{2}c_0$ for transverse waves. Discussion includes illustration of Pythagorean resonant and Fibonacci damping ratios and scale-invariant plasmoid geometry apparent in the design of the Tesla Wardencliffe 'Magnifying' transmitter. Various types of longitudinal scalar wave interactions are described including potential applications.

Introduction

After over a century of obscuration, there has been a renewed interest in the ideas and inventions of Nikola Tesla including longitudinal (non-Hertzian) electromagnetic wave propagation and the wireless transmission of power as described in Tesla's patent disclosures[1,2,3]. The difference between transverse (Hertzian) and longitudinal (non-Hertzian) EM waves has remained speculative, in part, due to lack of a visualizable geometric model of Tesla waves. Longitudinal EM scalar fields have been speculated to have more than one form or interpretation. There are no known surviving public documents by Tesla depicting geometry or mathematical description of such waves. Typically, what is shown in the literature, is simply the electrostatic electric field pattern between spherical capacitors representing the monopoles of Tesla's transmitter and receiver with spiral-wound pancake coils. With application of a direct current, the monopole elements act as a capacitor. However, with application of an alternating current, as in any capacitor, there arises a Maxwell 'displacement' current. This current flow does not involve actual transport of electrons across the dielectric-filled gap, but arises as a result of outward, radial surface movement of electrons during the accumulation phase inducing an opposing electron flow in the adjacent electrode via magnetic field coupling. This magnetic coupling enables propagation of EM energy between electrodes. The general arrangement of the Tesla transmitter and receiver consists of a monopole spherical electrode of low capacity connected to one end of a one-arm spiral-wound pancake coil of low self-inductance resonantly coupled to an adjacent similarly wound coil connected to the signal generator or load. A single ground wire interconnects the transmitter and receiver. Tesla waves have been described as non-Hertzian, longitudinal scalar waves which are distinctly different from Hertzian, transverse electromagnetic waves. Refer to Fig. 1.

Scalar Wave geometry

Tesla waves are transmitted and received by monopole antenna elements unlike conventional Hertzian waves which are associated with dipole antennas. In essence, a monopole antenna represents one-half of a dipole antenna, hence, beyond the near-field region, there is no EM loop closure once the wave detaches from the antenna. The electric field lines of a Tesla wave remain attached to the antenna ball and oscillate transversely to the Poynting vector. This action is akin to waving a whip while straight-armed swinging through an arc of 180 degrees. Another distinguishing feature is the single-arm, spiral-wound coils connected to the monopole antennas. When energized with a sinusoidal alternating current, electrons alternatively accumulate on the surface of the spherical electrode or vacate said electrode. Under static conditions, electric field lines tend to radiate perpendicular to the conductive metallic surfaces of the electrodes while magnetic field lines are oriented parallel to conductive surfaces. The orthogonality of electric flux lines to the conductive surfaces results from the rapid neutralization of voltages within a conductor. At the completion of each current cycle, the direction of the **E**-field reverses inducing an alternating electrokinetic force $\mathbf{F_k}$ (= $q\mathbf{E}_k = -q\delta\mathbf{A}/\delta t$) on charge carriers opposing motion. The in-wound spiral coils impart a torsional field component to the electron flow which winds and unwinds with each cycle. The radiated field pattern at constant frequency is that of an Archimedean spiral which alters direction at the completion of each cycle. The distance between spiral arms corresponds to one wavelength. The oscillating torsional field component about the coil axis creates a torsional moment imparting an oscillation force on nearby test objects. See Fig. 2.

Scalar and vector potentials

Scalar fields as represented by the well-known Aharanov-Bohm effect are described in terms of electromagnetic 4-potential $\mathbf{A}^\mu$ (= ϕ/c, **A**) where ϕ is the scalar potential and $\mathbf{A}_x$, $\mathbf{A}_y$, $\mathbf{A}_z$ are the magnetic vector potentials. The potentials are more primitive than the associated electric **E** and magnetic fields **B** as the later can be derived from the former. The A-B effect demonstrating a phase shift in electron de Broglie waves in a EM field-free region of potential provides experimental proof of the physical existence of potentials. The electric field intensity **E** (= $-\nabla V - \delta\mathbf{A}/\delta t$) is a measure of the accumulation of charge and the time rate-of-change in magnetic vector potential. The potential electrodynamic momentum $\mathbf{p_{el}} = \hbar\mathbf{k} = q^+\mathbf{A}$ whereas the generalized canonical momentum $\mathbf{p} = \gamma m\mathbf{v} + q\mathbf{A}$. The magnetic induction field **B** (magnetic flux density) is the curl of the vector potential field (= $\nabla \times \mathbf{A}$). In SI MKS units, scalar potential ϕ (= V) is measured in volts (= m^2/sec·rad), vector potential **A** is measured in Wb/m (= T·m = m/rad), electric field strength **E** is measured in volts/m (= m/s·rad), magnetic flux density **B** is measured in Teslas (T = 1/rad). Scalar fields may be generated and detected by means of spiral, solenoidal, bifilar, caduceus, and Möbius-wound coils and vector-potential transformers. These devices, depending on how they are wound, tend to cancel **E**- and **B**-fields in the far-field with phase lag varying depending on reactance.

For a sinusoidal excitation time-varying **E**-field of a spherical antenna of radius r with potential $\phi_E = 1/r \sin(kr-\omega t)$ may be expressed as

$$\mathbf{E}_x = \sin(kx - \omega t); \mathbf{H}_x = \sin(kx - \omega t) ; k = \omega/c \qquad 1)$$

$$\mathbf{E} = (k/r\cos(kr - \omega t) - 1/r^2 * \sin(kr - \omega t) \cdot \hat{\mathbf{r}}$$

which alternates direction with each cycle. As shown by Jefimenko[4,5], the motion of time-variable currents results in an induced electrokinetic force $\mathbf{F}_k$ (= $q^+\mathbf{E} = -\delta\mathbf{A}/\delta t$) opposing motion. Retardation effects become significant at high frequencies, high currents and/or long distance. Due to the effects of inductive and capacitive reactance, there is an associated phase angle difference between voltage and current. As a result, in general, the derivative of the time-varying potential $\delta\phi/\delta t$ will not coincide with the direction of the change in vector potential $\delta\mathbf{A}/\delta t$. The electric **E**-field intensity is defined as $\mathbf{E} = -\nabla\phi - 1/c\, \delta\mathbf{A}/\delta t$. The integrals of retarded quantities are intrinsically linked with the principle of causality. The retardation symbol [ ] denotes that the function to be evaluated within the brackets is to be evaluated at an earlier time t' = t − r/c. The electric field intensity $\mathbf{E} = -\nabla\phi - \delta\mathbf{A}/\delta t$ where ϕ and **A** are retarded electromagnetic potentials. The electric field produced by a time-varying current is directed along the current direction and exists only as long as the current is changing. The sign of the electrokinetic field $\mathbf{E}_k$ is opposite to the sign of the inducing current. The electrokinetic force $\mathbf{F}_k$ (= $q^+\mathbf{E}_k$) acting on charge carriers opposes the change in current. The electric field includes two independent components: an electric component created by a time-varying voltage and a magnetic field component created by time-varying currents. Contrary to common belief, there is no direct causal link between the two as described by the Maxwell/Heaviside equations.

Tesla longitudinal scalar wave resonant transmitter and receiver

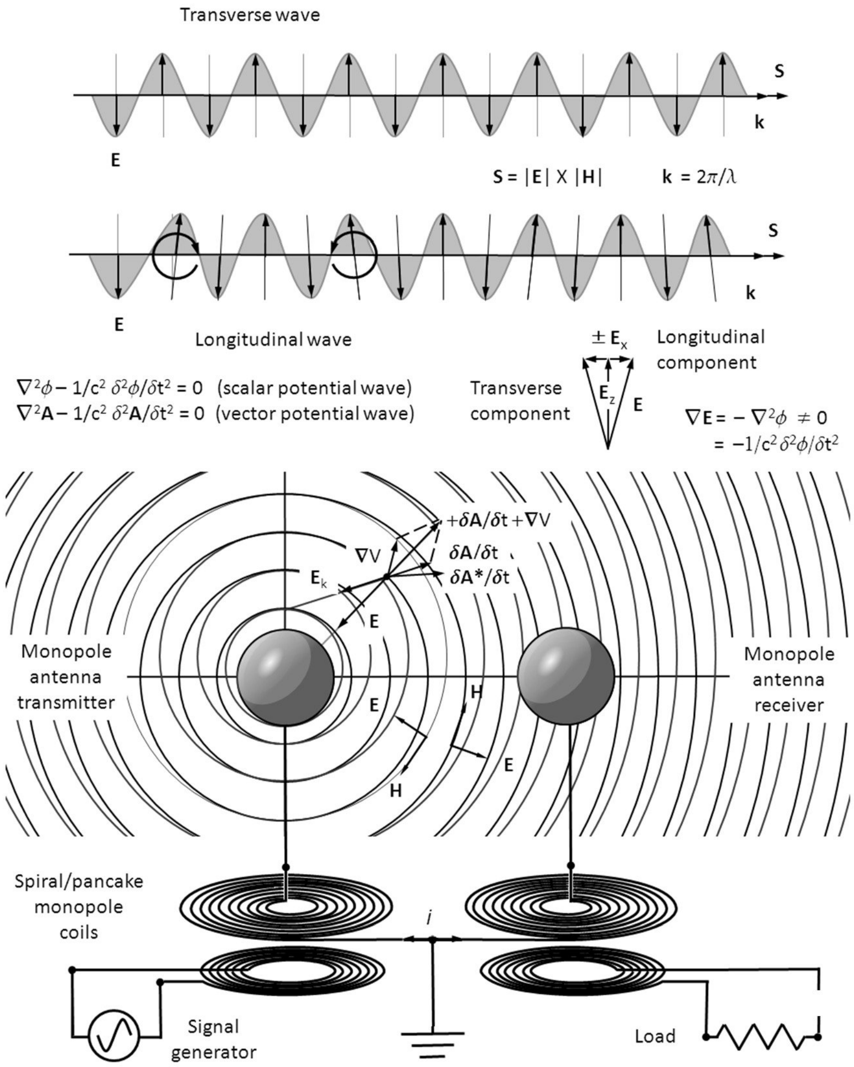


Fig. 1. General arrangement is shown of a coupled Tesla transmitter and receiver system for wireless transmission of energy and interconnected by a common grounded wire. Electromagnetic induction typically is associated with relatively slow current variations over relatively small regions and, as a result, effects of retardation are often ignored. Retardation becomes significant with rapid changes in potential over time or large changes in current with corresponding changes in magnetic field strength. Tesla circuits typically involve high voltage, high frequency changes and large changes in current with time. Hence, the effects on retardation become significant, particularly over long distances. Unlike Hertzian, transverse EM waves, Tesla non-Hertzian, longitudinal EM waves do not detach to form closed loops in the farfield region and the wave vector **k** oscillates about the mean direction of the Poynting vector **S**. As a result, there is a longitudinal **E**-field component in addition to a transverse **E**-field component that changes direction with each change in current direction.

Alternating Tesla wave torsion field

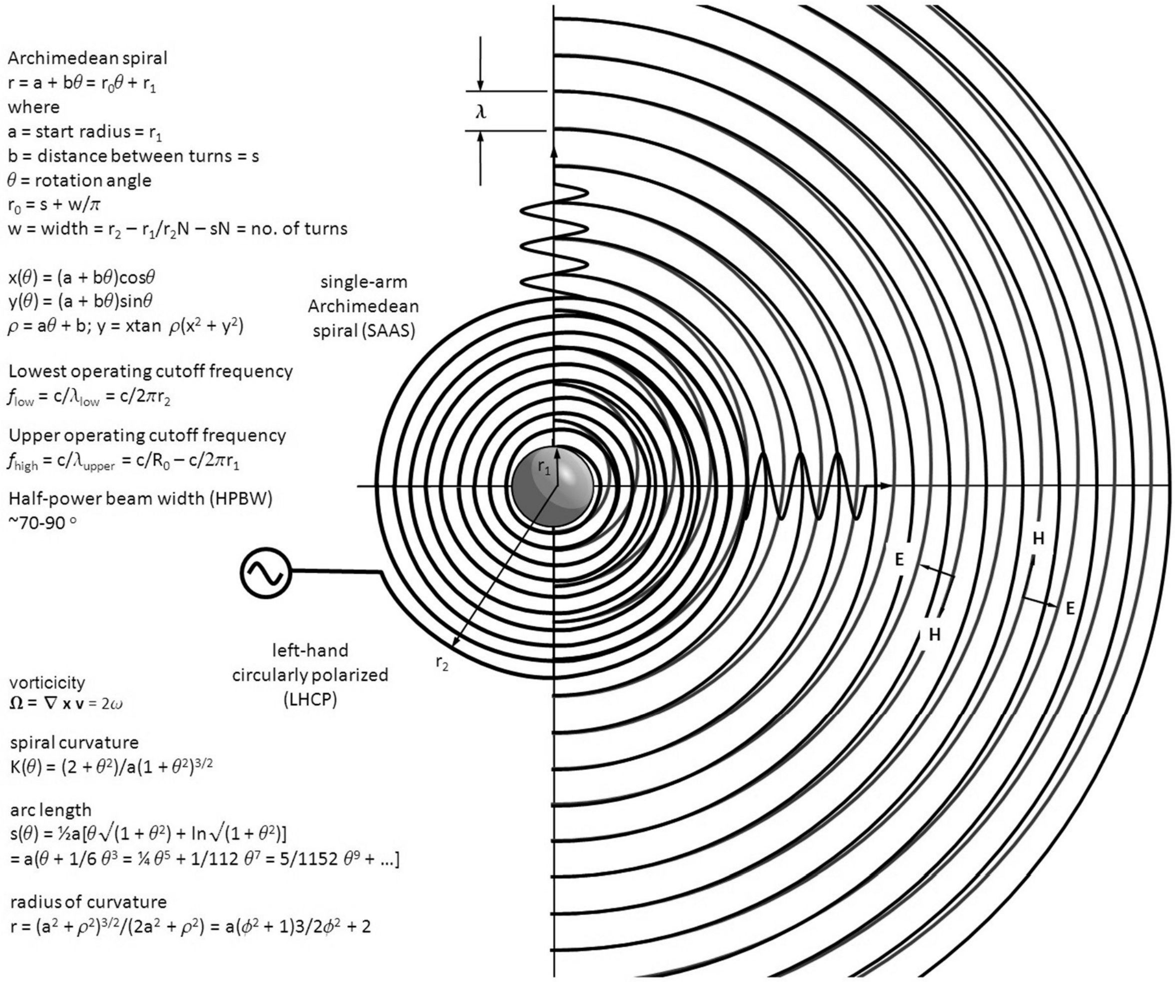


Fig. 2. Axial view of a Tesla longitudinal wave monopole transmitter. As shown, the radiated oscillating field includes a bi-directional, longitudinal **E**-field component in direction of the wave vector **k** (= $2\pi/\lambda$).

Scalar wave equations

In classical electromagnetism (CED), according to the Heaviside interpretation, the electric field **E** and the magnetic field **B** were viewed as observable, physical fields while the scalar potentials ϕ and magnetic vector potential **A** were taken as unphysical mathematical abstractions. The four Maxwell/Heaviside equations consist of coupled first-order differential equations relating electric **E** and magnetic **B** fields. Electric and magnetic fields may be expressed in terms of potentials

$$\mathbf{B} = \nabla \times \mathbf{A} = \text{rot}\, \mathbf{A} \qquad \text{magnetic flux density} \; [\text{T} = \text{Wb/m}^2 = 1/\text{rad}] \tag{3}$$

$$\mathbf{E} = -\nabla\phi - 1/c\; \delta\mathbf{A}/\delta t \qquad \text{electric field intensity} \; [\text{V/m} = \text{m/(s·rad)}] \tag{4}$$

where electromagnetic 4-potential $\mathbf{A}^{\mu} = (\phi/c, \mathbf{A})$ $\mu = 0, 1, 2, 3$

The Lorenz gauge condition simplifies electromagnetic equations and ensures Lorentz invariance. It relates the divergence of the vector potential ($\nabla \cdot \mathbf{A}$) to the time derivative of the scalar potential ($\delta\phi/dt$). Applying the Lorenz condition $\nabla \cdot \mathbf{A} + 1/c\ \delta\phi/\delta t = 0$, the Maxwell equations can be reduced to two inhomogeneous wave equations

$$\nabla^2\phi - 1/c^2\ \delta^2\phi/\delta t^2 = -4\pi\rho \qquad \text{scalar potential wave} \tag{5}$$

$$\nabla^2 A - 1/c^2\ \delta^2\mathbf{A}/\delta t^2 = -4\pi/c\ \mathbf{J} \qquad \text{vector potential wave} \tag{6}$$

where ϕ = scalar potential, $\mathbf{A}$ = magnetic vector potential ρ = charge density, $\mathbf{J}$ = current density

Longitudinal scalar waves have been described by Meyl[6,7] as potential vortical waves obeying a wave equation. Potential wave equations have the form

$$\nabla^2\phi - 1/c^2\ \delta^2\phi/\delta t^2 = 0 \qquad \text{scalar potential wave} \tag{7}$$

$$\nabla^2 A - 1/c^2\ \delta^2\mathbf{A}/\delta t^2 = 0 \qquad \text{vector potential wave} \tag{8}$$

Langmuir plasma waves have the form

$$\nabla^2\phi - 1/c^2\ \delta^2\phi/\delta t^2 - \rho/\epsilon = 0 \qquad \text{plasma wave} \tag{9}$$

where $\nabla \mathbf{E} = \text{div}\ \mathbf{E} = \rho/\epsilon$

Scalar longitudinal waves replace potential waves when the physical fields **E** and **B** are zero. Scalar waves and curl-free vector potential waves may be generated by toroidal, solenoidal, poloidal, Möbius, caduceus, and bifilar spiral wound coils. In the absence of **E** and **B** fields, no energy transfer to objects occurs and, hence, scalar waves can penetrate non-interacting matter. Such scalar waves can not be detected directly because they do not impart energy and momentum to matter. However, they can impart phase shifts to matter and may be detected through interference means as demonstrated by the Aharanov-Bohm effect. In the presence of highly, non-linear media, it is possible that $\mathbf{B} = \nabla \times \mathbf{A} \neq 0$. Electron de Broglie wave phase shifts in the absence of **E** and **B** fields, in accordance with the Aharonov-Bohm effect, exhibit a 1/r dependence as only information is transmitted rather than energy. Potential longitudinal waves (Tesla waves) can wirelessly transmit energy and power. Sources of Tesla radiation are charge carriers (plasma waves) and vortex generators.

Gauge transformations

Two common types of EM gauge transformations are Coulomb gauge $\nabla \cdot \mathbf{A} = 0$ and Lorenz gauge $\nabla \cdot \mathbf{A} = -\mu_0\epsilon_0\ \delta\phi/\delta t$ where **A** = magnetic vector potential and ϕ = scalar potential. In EM theory, such a gauge transformation is used to test the gauge invariance of EM fields. For static problems, the 3D Coulomb gauge expressed in terms of instantaneous values of fields and densities simplifies calculations of scalar potential, but erroneously assumes infinite velocity of propagation. The Coulomb gauge ($\mathbf{E} = -\delta\mathbf{A}/\delta t$, $\mathbf{B} = \nabla \times \mathbf{A}$) is often used where there are no sources are present, i.e. $\phi = 0$). This gauge is also useful in quantum electrodynamics where transverse radiation fields are given by vector potentials alone as the instantaneous Coulomb potential contributes only to the near fields. The 4D Lorenz gauge is independent of the coordinate system chosen and maintains Lorentz invariance such that the laws of physics are the same for all observers in uniform motion relative to each while the Coulomb gauge does not. In the Lorenz gauge, the divergence of **A** may be arbitrarily changed with addition of curl-free components (partial gauge fixing) without changing the Lagrangian of the underlying electromagnetic physics. See Figs. 3, 4 and 5.

Generalized classical electrodynamics equations

A generalized Classical Electrodynamics (CED) theory, advanced by van Vlaenderen[8], introduces an extra scalar expression **S** (= $-\epsilon_0\mu_0\ \delta\phi/\delta t - \nabla\cdot\mathbf{A}$) as a new observable, physical field to the electromagnetic **E-** and **B-**fields in the Maxwell/Heaviside equations. The inhomogeneous potential wave equations (IPWE) are reformulated to incorporate a generalized Gauss' law and a generalized Amperê law that include partial derivatives of **S**. The $\delta\phi/\delta t$ term becomes significant in high voltage, high frequency pulsed power systems, whereas the $\nabla\cdot\mathbf{A}$ term becomes significant for high currents such as charging/discharging of a capacitor. Setting **S** = 0 as a special case Lorenz condition recovers the Maxwell/Heaviside equations. With **E** = 0 and **B** = 0, $-\delta\mathbf{S}/\delta t = \rho/\epsilon_0$ and $\nabla\cdot\mathbf{S} = \mu_0\mathbf{J}$. Thus, it is argued that a dynamic scalar field **S** can be induced by a dynamic charge/current distribution with a generalized Poynting vector $\mathbf{P} = \mathbf{E} \times \mathbf{B} - \mathbf{E}S$ and a longitudinal force $\mathbf{F}_l = \mathbf{J}S$ that acts on current element **J**. The generalized theory proposes that longitudinal forces acting parallel to the current density **J** observed in some experiments can be explained by a scalar field and the existence of a time-varying, longitudinal **E**-field component.

Scalar waves (SW) and scalar longitudinal waves (SLW) according to an extended electrodynamics theory (EED) by Reed and Hively[9] based on the previous work by van Vlaenderen lack a magnetic field component and, hence, are unconstrained by the skin effect as dissipative eddy currents are avoided. The expanded form of electromagnetic theory includes an additional scalar field C in addition to the usual fields (**E**, **B**) and potentials (ϕ, **A**). Ampere's law nd Gauss law are recast as

$$\nabla \times \mathbf{B} \cdot 1/c^2\ \delta\mathbf{E}/\delta t \cdot \nabla C = \mu\boldsymbol{J} \qquad \text{Modified Ampere's Law} \qquad 10)$$

$$\nabla \cdot \mathbf{E} + \delta C/\delta t = \rho/\epsilon \qquad \text{Modified Gauss' Law} \qquad 11)$$

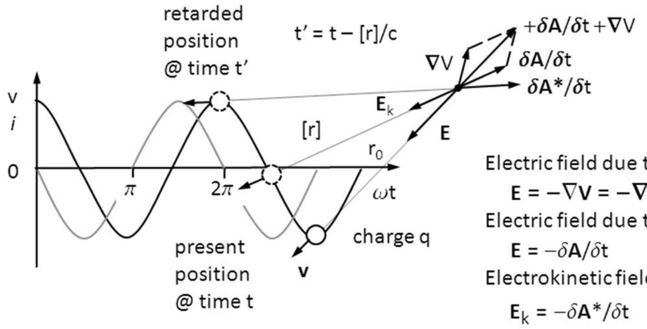
The EED model predicts a scalar wave (SW) that carries energy without momentum and a scalar longitudinal wave (SLW) that carries energy and momentum. Scalar waves in the modified scheme are described as gradient-driven waves obeying a wave equation

$$1/c^2\ \delta^2 C/\delta t^2 - \nabla^2 C = \mu(\delta\phi/\delta t + \nabla\cdot\boldsymbol{J}) \qquad 12)$$

where $\nabla\cdot\boldsymbol{J} = -\ \delta\rho/\delta t$

The above modifications to Maxwell's equations, so far, lack thorough experimental confirmation. The modified Maxwell's equations do not reflect the effects of retardation of magnetic vector potential **A*** (= $-\int \mathbf{E}_k\ dt$ + const) when current changes are very fast or when changes in current are remote from point of observation. Retardation effects are generally ignored when the size of the system is relatively small and the changes are relatively slow. In the case of high frequency Tesla coils, the effects of retardation of the electrokinetic force $\mathbf{F}_k = q^+\mathbf{E}_k$ (= $-\ q^+\delta\mathbf{A}^*/dt$) become significant. The electrokinetic field $\mathbf{E}_k$ opposes the motion of electrical current and provides the physical explanation for Lenz's Law ($V = -N\delta\phi/\delta t$)[4,5]. The time-varying electric field **E** lies opposite to the vector sum of the time derivative of the scalar potential $\delta\phi/\delta t$ and the retarded derivative of the magnetic vector potential $\delta\mathbf{A}^*/\delta t$. Inclusion of the effects of retardation, account for a time-varying longitudinal **E**-field and longitudinal force $\mathbf{F}_k$ acting on charge carriers. The gradient in the **E**-field is reflected in the vector sum of the $\delta\phi/\delta t$ and $\delta\mathbf{A}^*\delta t$ terms. The electrokinetic force $\mathbf{F}_k$ provides the predicted longitudinal force without the need for modification of Maxwell's equations with an additional scalar gradient force. The apparent lack of a magnetic **B**-field, said to explain the penetrating power of scalar waves, may be understood as the net result of rapid oscillation of the lateral **B**-field component averaging to zero over longer wavelength periods, ($\langle \mathbf{B} \rangle = 0$), **E-** and **H-** phase lag, and the greater celerity ($c \leq (\pi/2)c_0$).

Coulomb gauge vs. Lorenz gauge



Electric field due to accumulation of charge q:
$\mathbf{E} = -\nabla V = -\nabla\phi$
Electric field due to changing magnetic field:
$\mathbf{E} = -\delta\mathbf{A}/\delta t$
Electrokinetic field due to retarded magnetic field:
$\mathbf{E}_k = -\delta\mathbf{A}^*/\delta t$

Potentials **A**, ϕ satisfying Lorenz condition: $\nabla\cdot\mathbf{A} + \delta\phi/\delta t = 0$ are given by

$\mathbf{E} = -\delta\mathbf{A}/\delta t - \nabla\phi$ $\quad$ $\mathbf{B} = \nabla \times \mathbf{A}$

Coulomb gauge:	Gauge transformations:	Lorenz gauge:	Electrokinetic impulse
$\mathbf{E} = -\delta\mathbf{A}/\delta t$	$\mathbf{A}' = \mathbf{A} + \nabla\lambda$	$\mathbf{E} = -\nabla\phi - 1/c\, \delta\mathbf{A}/\delta t$	$\mathbf{E}_k = -\delta\mathbf{A}^*/\delta t$
$\mathbf{B} = \nabla \times \mathbf{A}$	$V' = V - \delta\lambda/\delta t$	$\mathbf{B} = \nabla \times \mathbf{A}$	$\mathbf{A}^* = -\int \mathbf{E}_k dt$ + const

Dynamic scalar field: $C = \nabla\cdot\mathbf{A} + 1/c^2\, \delta\phi/\delta t$; $S = -\epsilon_0\mu_0\, \delta\phi/\delta t - \nabla\cdot\mathbf{A} = \nabla\cdot\mathbf{A} - \nabla\cdot\mathbf{A}$ (Lorenz condition)

Change in canonical momentum: $dp/dt = d(m\mathbf{v} + q\mathbf{A})/dt = q\nabla(\mathbf{vA} - \phi)$
Gradient of interaction energy: $q\nabla(\mathbf{vA} - \phi)$

$\nabla\cdot\mathbf{A} = -\mu_0\epsilon_0\delta\phi/\delta t$	$\nabla\cdot\mathbf{B} = 0$	(Gauss' Law)	$\nabla\cdot\mathbf{E} = \rho/\epsilon$	(Coulomb's Law)
$\nabla \times \mathbf{A} = \mathbf{B} = \mathbf{E}/c$	$\nabla \times \mathbf{B} = \mu\mathbf{J} + 1/c^2\, \delta\mathbf{E}/\delta t$	(Ampere's Law)	$\nabla \times \mathbf{E} = -\delta\mathbf{B}/\delta t$	(Faraday's Law)

Extended electrodynamics theory with extra terms:

$\nabla\cdot\mathbf{A} = -\mu_0\epsilon_0\delta\phi/\delta t$	$\nabla\cdot\mathbf{B} = 0$	$\nabla\cdot\mathbf{E} = \rho/\epsilon - \delta C/\delta t$
$\nabla \times \mathbf{A} = \mathbf{B} = \mathbf{E}/c$	$\nabla \times \mathbf{B} = \mu\mathbf{J} + 1/c^2\, \delta\mathbf{E}/\delta t + \nabla C$	$\nabla \times \mathbf{E} = -\delta\mathbf{B}/\delta t$

Fig. 3. Comparison of Coulomb gauge $\nabla\cdot\mathbf{A} = 0$ and Lorenz gauge $\nabla\cdot\mathbf{A} = -\mu_0\epsilon_0\, \delta\phi/\delta t$ where **A** = magnetic vector potential and ϕ = scalar potential. A longitudinal scalar wave is created as a result of superposition of $\delta\phi/\delta t$ and $\nabla\cdot$ **A** terms which occur independently.

Jefimenko observes that, contrary to common belief, Faraday induction is not caused by changing magnetic fields, but by the electrokinetic fields produced by changing currents. Electrodynamic fields, like electrostatic fields and magnetostatic fields are force fields that are causally independent. The illusion that a change in electrokinetic fields and magnetic fields are causally linked presumably arises as a result that Hertzian dipole fields in the far-field are orthogonal and in-phase giving the appearance they are interacting with each other. However, in the reactive, near-field region of a dipole antenna, the electric and magnetic fields are not in-phase and the phase velocity is superluminal. The phase difference falls to zero in the far-field closed loop region. For scalar longitudinal waves, the **E**- and **H**-fields will, in general, not be in-phase due to reactance effects and, hence, expected to exhibit time-varying wave impedance. The wave impedance Z_0 (= |**E**|/|**H**|) of electric and magnetic fields of transverse EM waves in the near-field vary with frequency. Wave propagation in waveguides is described by Transverse Electric (TE), Transverse Magnetic (TM) or Transverse Electromagnetic (TEM) modes as determined by the longitudinal component. The wave vector **k** defining the direction of planes on constant phase is, in general, not in the same direction as the energy flow vector S and depends on the type of media. For isotropic media, plane waves have wave fronts that are in-phase whereas in anisotropic media, there is a phase shift in adjacent wave fronts such that **S** and **k** are no longer aligned. In the case of right-hand metamaterials (RHM) the wave vector **k** and Poynting vector

S are aligned in the direction of propagation as are the phase velocity $\mathbf{v}_p$ and group velocity $\mathbf{v}_g$. For left-hand metamaterial (LHM), the Poynting vector **S** and group velocity $\mathbf{v}_g$ are in the direction of propagation whereas the wave vector **k** and phase velocity $\mathbf{v}_p$ lie in the opposite direction.

Tesla Longitudinal Scalar Wave Torsion

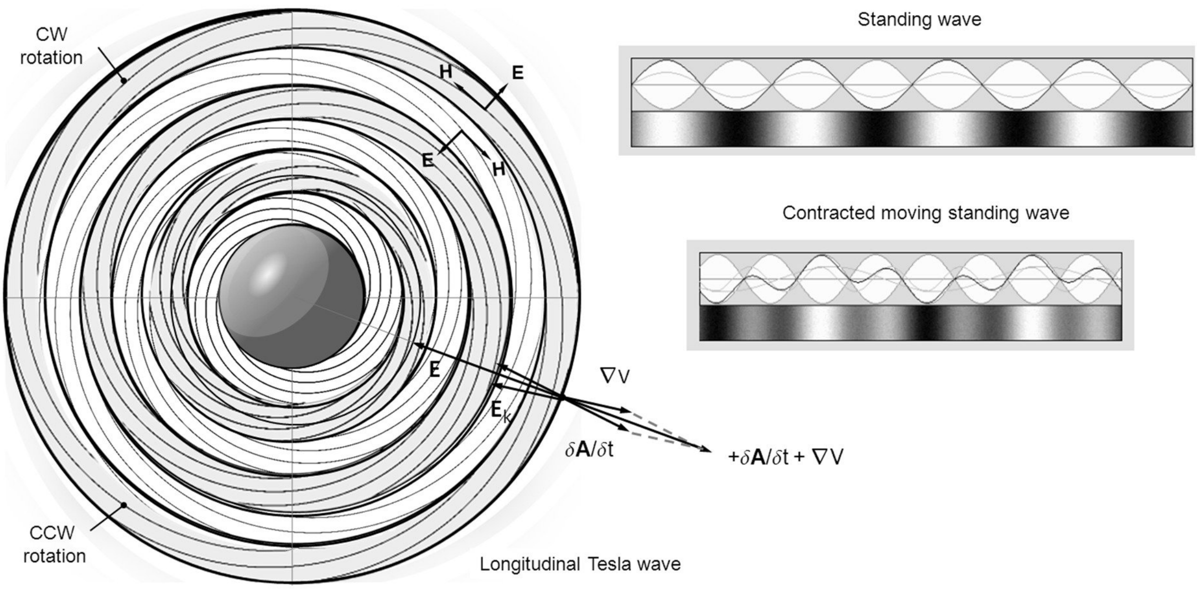


Fig. 4. Illustration of Tesla longitudinal scalar wave torsional oscillation about a monopole antenna. With each current cycle, there is a change in direction of twist. The electric field **E** equals the negative of vector sum of the electric field due to the accumulation of charge and electric field due to the changing magnetic field. Due to inductive and capacitive reactance, voltage and current are not in phase. The vector potential is in phase with the current. Retardation effects become significant at high voltages and high frequencies.

Velocity of scalar waves in vacuo

The physical vacuum represents a very stiff, high bulk modulus, polarizable media supporting propagation of transverse and longitudinal EM waves. In the zero point field (ZPF) representation, the vacuum is a Bose-Einstein condensate (BEC) superfluid filled with quantum oscillators with frequencies up to the Planck cut-off frequency with each oscillator having a zero-point energy equal to $\frac{1}{2}\hbar\omega$. Faraday electric and magnetic field lines in the physical vacuum are theorized at the Planck scale to consist of positive and negative Planck masses[18,19]. The presence of such masses with high curvature and torsion obstruct energy flow limiting the velocity of light to the relatively high, but finite value c_0 (= $1/\sqrt{(\epsilon_0\mu_0)} = c\cdot n = Z_0/\mu_0 = \mathbf{E}/\mathbf{B} = \sqrt{v_g v_p} = \Gamma\cdot c = c\sqrt{K_{PV}} = l_p/t_P \simeq 2.997924\text{E}8$ m/s) in vacuo and providing an explanation for measured vacuum radiation impedance Z_0 ($\simeq 376.77\ \Omega$). The opposing curvatures average out over distances >> Planck length thus accounting for the lack of curvature as measured over cosmological scales. **E**-field lines represent temporary synchronous alignment of oppositely-charged Planck masses while **B**-field lines represent vortical filaments of rotating coupled pairs of oppositely-charged Planck masses. As such, a zero curvature vacuum is limited to a maximum celerity c equal to the Weber constant c_W (= $\sqrt{2}c_0$) which is the tangential speed of a helical photon propagating at the velocity of light c_0 where **E**- and **H**-fields are in-phase. When **E**- and **H**-fields are in phase quadrature, the max. velocity = $(\pi/2)c$ = 1.57c in line with Tesla's results.

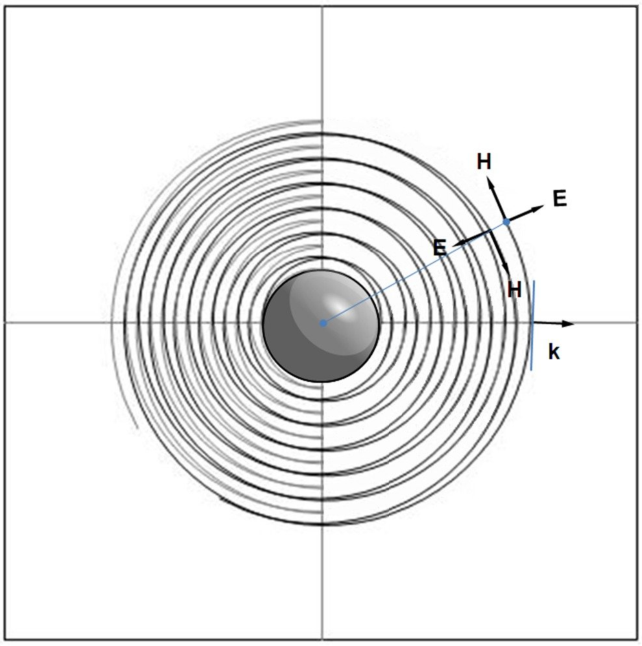
The relatively high, finite velocity of light in vacuo indicates a medium with a high bulk modulus K_B (= $\Delta P/(\Delta V/V$ = $-V(\Delta P/\Delta V)$ with large elastic, but finite stiffness or restoring force. The energy density of the vacuum by some estimates is very high ($u_P = c^7/\hbar G^2 = 4.632 \times 10^{113}$ J/m^3) whereas the observable energy density of the universe (i.e., energy possessing angular momentum) in the current epoch is of 122-130 orders of magnitude less. With a zero-point energy cutoff at the Planck length l_P, the mass density of the vacuum may be expressed as $\rho_{vac} = m_p/r_p^3 = c^5/G^2\hbar \approx 10^{98}$ kg/m^3. For comparison, this calculated mass of 10^{98} kg is larger than the estimated mass of the visible universe (~1.2-1.7 x 10^{53} kg). The bulk modulus K, a measure of compressional stiffness, and shear modulus G, a measure of shear stiffness, are defined in terms of condensed matter. Thus, K and G for a vacuum by such definition are zero. However, the physical vacuum has definite physical properties including a relatively high, but finite velocity of electromagnetic wave propagation c, radiation resistance Z_0 (antenna impedance) and a calculable Planck energy density ρ_P. Faraday maintained there is a tension along field lines and a pressure orthogonal thereto. In general, wave speed is controlled by tension and is proportional to tension.

According the generalized Hooke's law, the modulus of elasticity or Young's modulus E is defined as $E = \Delta\sigma/\Delta\epsilon$ where σ = stress and ϵ = strain. The modulus of elasticity corresponds to the linear portion of the uniaxial stress-strain curve. and is a measure of the tensile stiffness of the material. Most engineering materials are homogeneous and isotropic to a large degree. The tensile modulus of elasticity usually has the same value as the compressive modulus. As in the case of uniaxial stress, the shear stress generally is proportional to the shear strain. The shear modulus G, also known as the modulus of rigidity, is defined as $G = \Delta\tau/\Delta\gamma$ where τ = shear stress less than the proportional limit and γ = shear strain. The relation of shear stress to shear strain can be obtained from a plot of torque on a circular cylinder vs. resulting angle of twist. For homogeneous isotropic materials $E = 2G(1 + \nu) = 3K(1 - 2\nu)$ where E = Young's modulus, G = Shear modulus, K = bulk modulus and ν = Poisson's ratio. Electrical permittivity ϵ in units of farads/m with dimensions [$M^{-1}L^{-1}T^2Q^2$] which in terms of the derived units kg·rad^2/m^2 or [$M\Theta^2L^{-2}$], is dimensionally equivalent to mass times torsion squared (kg·rad/m·rad/m). Classical action of torsion involves contact interaction between spins. Effective mass m_i is associated with a change in torsion τ due to increased energy density. As change in torsion (rad/m) is related to a change in pitch, mass is analogous to resistance to change in frequency (1/s). The derived dimensions of magnetic permeability μ (henrys/m) [MLQ^{-2}] becomes (m·sec^2/kg·rad^2) or [$\Theta^{-2}M^{-1}LT^2$], which corresponds to compressibility times magnetic field squared. The units and dimensions of magnetic vector potential **A** (V·s/m) or [$MLT^{-1}Q^{-1}$] becomes m/rad [$L\Theta^{-1}$]. The derived mechanical dimensions of electric charge in (Coulombs) [Q] are equivalent to (kg·rad/s) [ΘMT^{-1}], a measure of rotational mass motion which appears to represent rate of precession.

The bulk modulus of elasticity K (= $\Delta P/\Delta V/V$) has dimensional units of pressure (kg/m·s^2). The characteristic impedance of the vacuum Z_s (= $m_P/t_P = c^3/|G|$) is very high (= 4.0302E35 kg/s). Spacetime stiffness $k_{vac} = c^4/8\pi G$ = 5.998E6 N/m represents energy density/unit curvature. In analogy to sound waves where Young's velocity is proportional to the square of the speed of sound velocity, the modulus of elasticity for the vacuum may be expressed as $E = \rho_{vac}c^2$ = 8.87337E-10 kg/m·/s^2 (= N/m^2 = Pa) where ρ_{vac} = vacuum energy density and c = celerity of light. Compressibility $\beta = 1/K = 1/\rho_{vac}c^2$. The experimental value of electric permittivity of the vacuum $\epsilon_0 = \mu_0/Z_0^2 = e/K = \epsilon/\sqrt{K_{PV}} = 1/\mu_0c^2 = e\sqrt{g_{00}} = \Gamma\epsilon_{00}$ = 8.854187817E-12 Farad/m = Coul^2/N·m^2. In terms of mechanical units ϵ_0 = 1.725E8 kg·rad^2/m^3. The defined magnetic permeability of the vacuum $\mu_0 = Z_0/c = 1/\epsilon_0c^2 = \mu/\sqrt{K_{PV}} = \mu\sqrt{g_{00}} = \Gamma\mu_{00}$. = 4πE-7 Weber/amp-m = Henrys/m). In terms of mechanical units μ_0 = 6.4498E-26 m·s^2/(kg·rad^2).

Velocity of pressure (longitudinal) waves is a function of the elastic restoring force of the bulk modulus K, $v_p = K/\rho_0$. The higher the bulk modulus, the greater the velocity, the greater the density the slower the velocity. Shear wave velocity of transverse waves is proportional to the square root of the shear modulus G. For isotropic materials the longitudinal and transverse waves are uncoupled and their velocity is independent of direction. In terms of Lamé material dependent parameters, the square of longitudinal wave velocity $c_l^2 = (\lambda + 2\mu)/\rho$ where $\lambda = E\nu(1 + \nu)(1 - 2\nu)$ and $\mu = G = E2(1 + \nu)$. For transverse waves, the square of shear wave speed $c_s^2 = \mu/\rho = G/\rho$ where ρ = density.

Tesla Scalar Wave Construction



Vacuum impedance (Hertzian waves – far-field) $Z_0 = |\mathbf{E}|/|\mathbf{H}| = \sqrt{(\epsilon_0\mu_0)} = \mu_0 c = zZ_s = 376.7\ \Omega$

Planck impedance $Z_P = 1/4\pi\epsilon 0c = \mu_0 c/4\pi = 29.97\ \Omega$

Spacetime impedance $Z_s = m_P/t_P = c^3/G = c\Sigma(r_i/m_i) = 4.0302E35$ kg/s

Spacetime stiffness $k_{vac} = c^4/8\pi G = 5.998E6$ N/m

Group velocity $v_g = \beta\cdot c = c^2/v_g = 1/\epsilon_0\mu_0 v_p = c/(\Delta\phi/\pi)$

Phase velocity $v_p = c/\beta = c^2/v_g = c/(\Delta\phi/\pi) = \sqrt{(K/\rho)} = \sqrt{(\delta p/\delta\rho)}$

Longitudinal EM wave celerity $c_l = \pi\cdot c/2 = 1.50707$ c

Poynting vector $\mathbf{S} = \mathbf{E} \times \mathbf{H} = \mathbf{E}/\mu_0 \times \mathbf{B}$

Fig. 5. Illustration of construction a Tesla longitudinal scalar wave emitted from a monopole antenna. The radiation pattern is formed by an overlay of two opposed Archimedean spirals. The phase velocity of longitudinal waves in a homogeneous, isotropic medium is determined by the bulk modulus $v_p = \sqrt{(K/\rho)} = \sqrt{(\delta p/\delta\rho)} = c/\beta$.

Scalar wave matter interactions

Scalar waves are reputed to be impervious to EM shielding[6,7,10-12]. For example, anomalous effects have long been reported during solar eclipses affecting detectors enclosed with Faraday and Mu-metal enclosures. Anomalous effects on charged torque pendulums and spurious voltages appearing on dielectrics that exhibit daily and sidereal variations have been observed. Some researchers argue that scalar longitudinal waves have no **B**-field component and cannot propagate in a vacuum.[9,12,13] A patent by Puthoff[14] teaches that scalar and vector fields in the far-field break away from the antenna structure and propagate as independent entities and decline more slowly varying as 1/r as the signals are said to convey only information and do not carry energy. Hence, scalar waves cannot be detected directly as they do not impart energy and momentum to matter. However, scalar waves impart phase shifts to matter via the A-B effect and may be detected by interference means. The **E**- and **B**-fields act as force carriers between charged particles and are detectable by observing their effects on motion of charged particles according to the Lorentz force equation ($\mathbf{F} = q^+\mathbf{E} + q^+\mathbf{v} \times \mathbf{B}$).

A notable example of longitudinal EM scalar wave interactions is Tesla's Wardencliffe tower for through the Earth wireless communications. Tesla's 3rd patent[3] was for a large 'Magnifying' transmitter based on a 10 MW power transmission system constructed at Shoreham, Long Island, NY on a 200-acre site named Wardencliffe. The transmitter was designed to transmit electric longitudinal waves through the Earth for wireless communication. Begun in 1901 with modest funding of $150,000, the tower was nearly completed in 1903 when J.P. Morgan withdrew financial support. Tesla initially stated the Wardencliffe tower would merely transmit radio signals across the Atlantic, however, when usurped by Marconi in this regard with transmission of a three dot Morse code signal for the letter S from Poldhu in Cornwall to an aerial kite at Signal Hill, Newfoundland on 12 December, 1901, Tesla confided that the transmitter also was designed to wireless transmit energy worldwide. While studying the periodicity of lightning strikes in tests of a 160 ft tower with a 30" dia. ball at an experimental site in Colorado Springs in 1899, Tesla noticed an apparent Earth resonance in response as electrical impulses travelled longitudinally through the Earth to the antipode and reflected back. Tesla had previously found air, normally a good insulator, becomes a good conductor at high frequencies and voltages at a reduced atmospheric pressure of about 75 mmHg[15]. Accordingly, the Earth and the upper atmosphere could comprise a giant capacitor for high voltage electric currents with Wardencliffe transmitter serving as the pump oscillator resonantly 'magnifying' the oscillating currents. To Tesla's surprise, earlier experiments in Colorado demonstrated that more energy was received than transmitted owing to parametric amplification. The greater the distance between the transmitter and receiver, the greater the returned energy, hence, the term 'Magnifying Transmitter'. The measured degree of effectiveness was greater than 100 per cent leading Tesla to infer that 'free' energy was being captured from vibration resonance with the Earth. The elevated terminals of the transmitter act as storage capacitors with a terminal voltage of 1-4 million volts. The wooden tower was 187 ft (57 m) tall with a 67.5 ft. (20.5 m) dia., 57-ton steel-framed toroidal electrode composed of a plurality of aluminum cups of 0.5-1 ft dia. The above ground transmitter was connected via a 12 ft square vertical shaft to radial ground wires forming a ground current antenna at a depth of 120 ft (36 m)[15, 16]. Sixteen iron pipes were driven down another 300 ft (91 m) through cretaceous clay for grounding into bedrock. Ground level at Shoreham was about 150 ft (45) above sea level while most of Long Island is only about 40 ft (12 m) above sea level. 'In this system that I have invented', Tesla remarked, 'it is necessary for the machine to get a grip of the Earth … so that the whole of the globe can quiver.'[16]

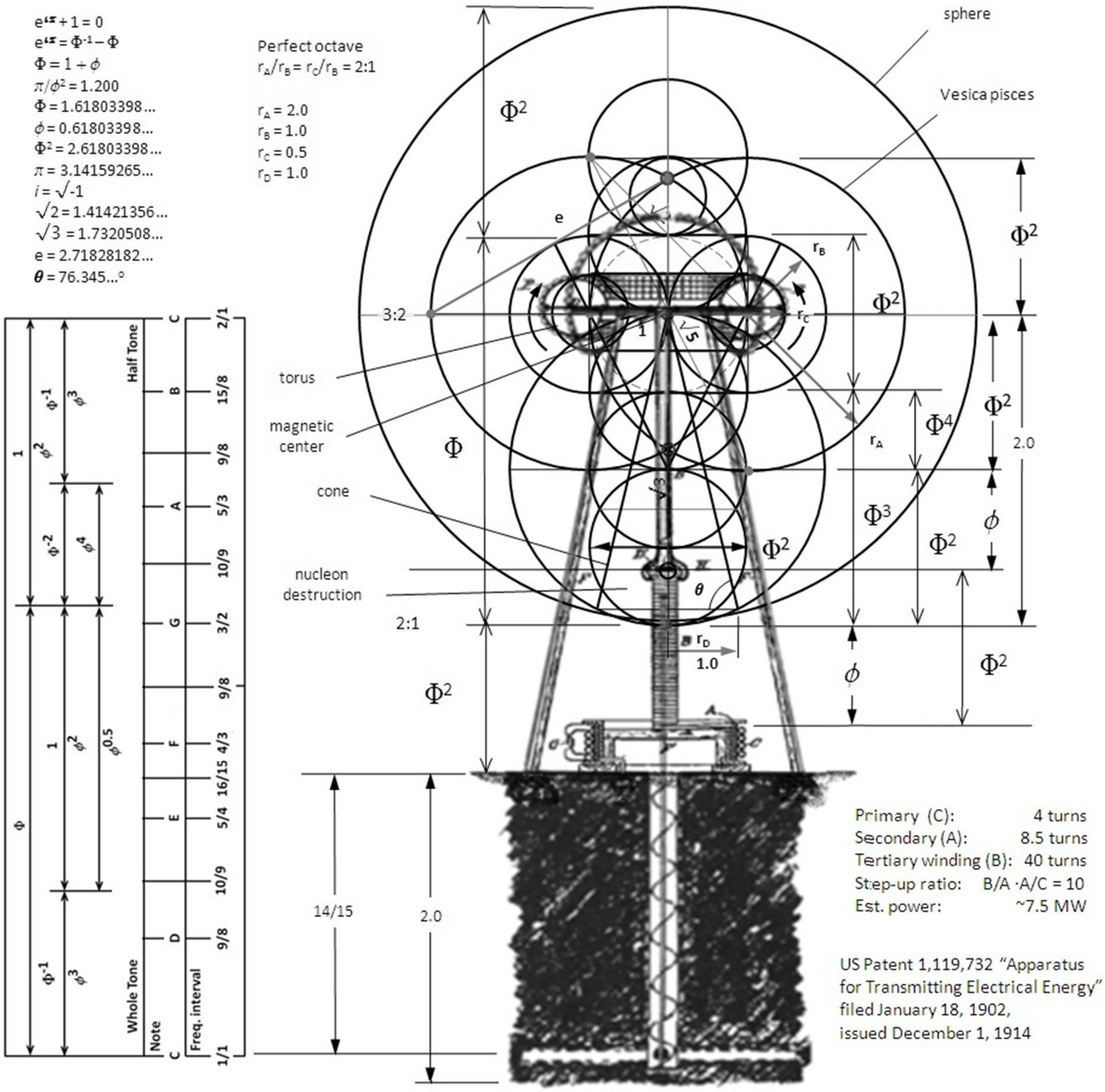
Housed in the tower building was a 400-horsepower Westinghouse engine and a smaller 35-kW engine to drive the lightning dynamo, four large oil-immersed 60 kV transformers, condensers, regulators, two 300-hp boilers, two 16,000 gal water tanks, and a 100-hp motor powered rectifiers for converting AC to DC current for the condensers. The primary and secondary coils were adjustable over a frequency range of ~10-250 kHz and resonantly tuned to the low end at ~11.8 Hz to minimize Hertz radiation losses and maximize longitudinal radiation for long distance communication through the Earth[13]. The transmitter resonance frequency is close to the Earth's Schumann vibrational resonance of ~7.9 Hz. The upper terminal was charged via a tertiary solenoidal coil at high potential sufficient for air ionization and production of soft x-rays. The top load tertiary inductance was greater than the secondary to reflect power vertically back to ground. The short duration, high current pulses would also likely have generated the strange, highly-penetrating radiation objects (aka plasmoids, EVOs) which Tesla had earlier discovered. These would have been capable of transmutation of matter, particularly near the bottom of the funnel cone. To obtain high voltages and high frequencies, necessitated minimization of capacitance of the upper terminal, optimization of $\delta\phi/\delta t$ and reduction of ground return resistance. Although, not specified in the Tesla patent, Greenyer[16] notes additional geometric features of the Long Island Wardencliffe tower design which appear to be significant for minimizing losses and incorporate various Fibonacci damping ratios associated with a scale invariant plasmoid fractal toroidal moment. See Fig. 6. The upper terminal was carefully designed to withstand high pressures (voltages) with cups designed to increase surface area reducing charge density thereby minimizing leakage. The cups were apparently designed to focus energy inwards toward the magnetic center and somehow to be used in conjunction with a large number of double focus platinum target x-ray tubes to presumably augment ionization enhancing conductivity. The Ref 3) Patent states "A BALL OF FIRE MIGHT BREAK OUT AND DESTROY Support F or anything else in its way…the destructive action may take place with inconceivable violence."

At the end of 1903, the magnifying transformer was briefly operated. Local villagers heard the rumble and observed a strange glow above the mushroom-shaped cupola. The light could be seen on the shores of Connecticut on the other side of Long Island Sound. Soon after, creditors from Westinghouse carted off the equipment as J.P. Morgan scuttled plans for alternate funding from Wall Street financiers apparently over concerns of free energy and free communication. How would corporate moguls charge for the electricity? To quote from a Tesla article in *Electrical World* and *Scientific American*: "The results attained by me have made my scheme of intelligence transmission, for which the name 'World Telegraphy' has been suggested, easily realizable. It constitutes a radical and fruitful departure from what has been done before…it involves the employment of a number of plants, all of which are capable of transmitting individualized signals to the uttermost confines of the earth. Each of them will be preferably located near some important centre of civilization and the news it receives through any channel will be flashed to all points of the globe. A cheap, simple device, which might be carried in one's pocket, may be then set up somewhere on sea or land, and it will record the world's news or such special messages as may be intended for it. Thus the entire earth will be converted into a large brain, as it were, capable of response in every one of its parts. Since a single plant of but one hundred horsepower can operate hundreds of millions of instruments, the system will have a virtually infinite working capacity, and it would immensely facilitate and cheapen the transmission of intelligence. The first of these central plants would have been already completed had it not been for unforeseen delays… – *Electrical World and Engineer*, March 5, 1904.

As a deterrent for war, Tesla envisioned a sort of 'Death Ray' defensive weapon to make war impossible. The invention was inspired by an incident when he was experimenting with a cathode ray tube. At times, a form of penetrating, strange particle radiation, now understood to be plasmoid electron clusters, would erupt from the cathode and pass out of the tube striking him and causing a sharp, stinging pain as it passed through his body. A chief distinction between this radiation and x-rays was that this radiation was produced outside of the vacuum tube. Tesla devised a method to produce such particles by means of a spark discharge within a high velocity steam jet produced by a Tesla turbine. Although the Wardencliffe tower was designed as a worldwide communication device, it also had the capability of producing copious quantities of electron clusters. Like Tesla scalar waves (with a longitudinal **B**-field component and increased celerity) and neutrinos (without electrical charge), this strange radiation had great penetrating power owing to an anapole moment which couples weakly to electromagnetic fields.

Academicians at the time did not understand or accept Tesla's concept of longitudinal electric waves despite Tesla's numerous innovative experiments, demonstrations and inventions. Scientific skepticism and ridicule has been attributed to 1) claims that Tesla longitudinal scalar waves contradicted Maxwell/Heaviside equations describing transverse EM waves in terms of **E**- and **B-**fields while ignoring Maxwell's original equations which included effects of potentials, 2) contradictions to Einstein's theory of special relativity velocity of light limit – Tesla claimed measured superluminal velocity of propagation of 1.5c, 3) Insufficient theoretical foundation – Lack of comprehensive mathematical framework that could be integrated into existing physics models, 4) Lack of publication in peer-reviewed scientific publications detailing patented proprietary technology, 5) Energy conservation concerns over lossless energy transmission over great distances despite experimental demonstrations to the contrary and 6) Tesla's often secretive nature arising from repeated theft of his ideas and inventions and lengthy litigation. Standard texts omit discussion and even today the concept remains shrouded in mystery spurring speculation. Most of Tesla's documents were seized on Tesla's death by the Government and classified Secret including an elaborate technical paper 'The New Art of Projecting Concentrated Non-Dispersive Energy Through Natural Media' containing the first technical description of a particle beam weapon. A central problem in understanding of Tesla scalar waves has been the lack of visualizable description of the formation and geometry of such waves facilitating analysis and experimentation thereof. Hence, this monograph is intended to address this deficiency and challenge established dogma. Tesla's vision of wireless, superluminal communication and transmission of energy, abundant energy supplies, non-invasive healing technology, etc has remained obscured for well over a century. Scalar wave technology may enable novel methods of interference-free, super-luminal communication and encryption, longitudinal **E**-field modulation and detection, reduced radiation resistance approaching Planck impedance, scalar wave radar, deep through-wall and underground penetration sensing, novel interferometry means, reduced power distribution losses, radiation pressure effectors and sensors, electron cluster re-arrangement of matter, electron/proton accelerators and beam weapons, non-invasive surgical means, through-wall inter-penetration of matter, tractor and repulsion beams, and EM wave-based propulsion. With the recent surge of interest in plasmoids in LENR reactions involving transmutation of matter such as illustrated in Fig. 7 and 8, an understanding of scalar longitudinal electromagnetic waves may be useful in technological development of new applications.

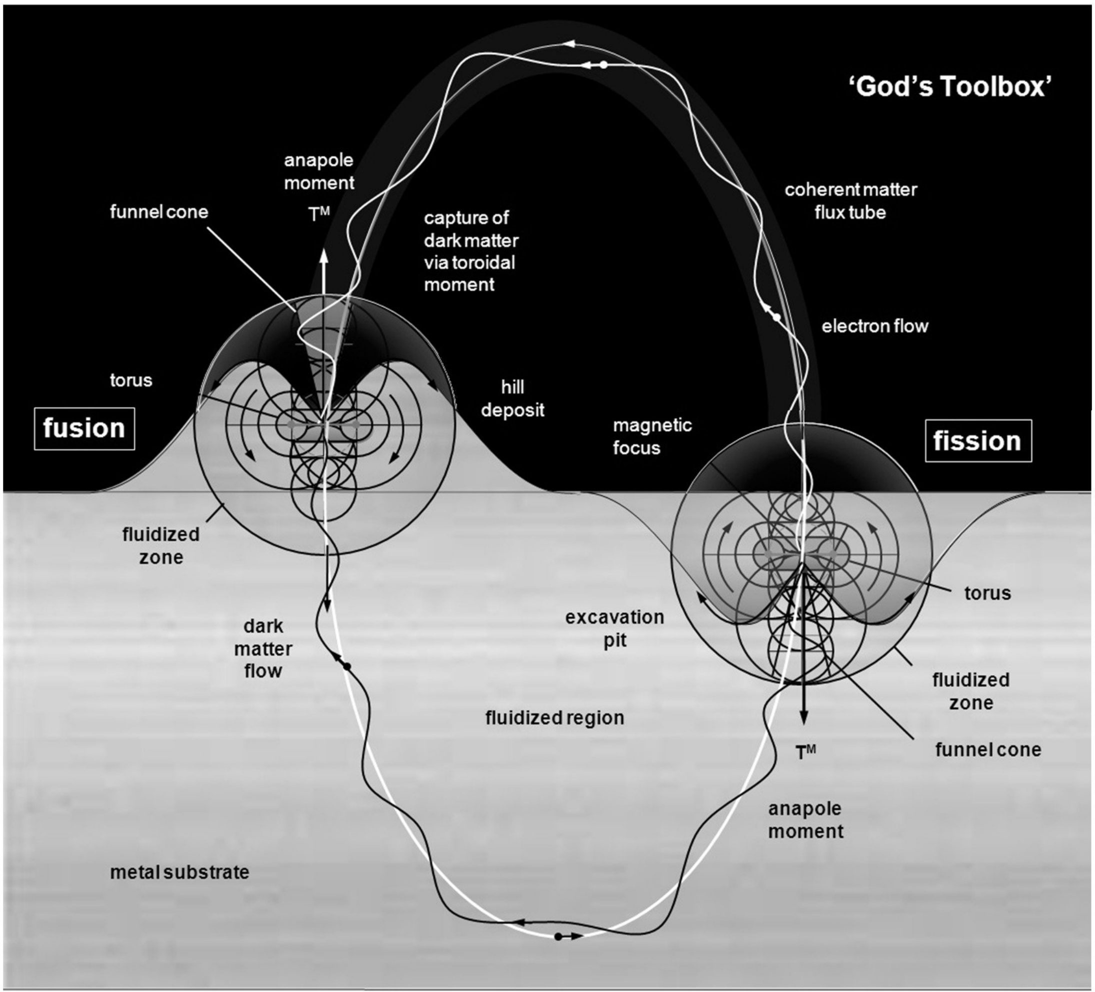
Geometric ratios apparent in design of Wardencliffe Tower



Credit: R. Greenyer, MFMP

Fig. 6. The transmitter consists of three transformer coils connected to a mushroom-shaped electrode and is energized by a high frequency lightning generator and is resonantly coupled with the earth. The upper toroidal electrode is comprised of aluminum parabolic reflector cups focused at the magnetic center which appear to have been designed to bleed off excess charge accumulation to prevent the production of a 'ball of fire'. Phi damping ratios appear to have been incorporated into the design of the Tesla "Magnifying" transmitter to minimize radiation losses and enhance resonance coupling. Hertzian, transverse EM waves would be emitted largely in a direction parallel to the ground whereas non-Hertzian, longitudinal EM waves were emitted perpendicular to the surface. For comparison, shown superimposed is a Greenyer scale invariant EVO model geometry and associated Pythagorean and Fibonacci phi/Phi ratios which may have been contributing design factors for parametric amplification performance optimization.

Plasmoids - Exotic vacuum objects (EVOs)



Credit: R. Greenyer, MFMP

Fig. 7. Illustration of a fusion (make)/fission (break) quantum-locked exotic vacuum object (EVO) vortex pair (Greenyer model). Strong plasma spark discharge of high current, short pulse duration generates micro-ball lightning (MBL) in the form of a magnetic flux loop which provides a scaffolding for entrained wrap-around chain of spin-aligned electrons. The ejected plasmoid is a Beltrami spherical vortex which carries along a toroidal magnetic field which maintains its form. The overlapping magnetic fields of adjacent electrons undergo magnetic flux reconnections reinforcing coupling overcoming Coulombic repulsion and enabling formation of long ergodic chains of electrons leading to formation of charge clusters. An EVO charge cluster consists of a self-assembled group of an arbitrary number of magnetically-coupled electrons which can grow to macroscopic size. The EVO monopoles tend to reside on the surface while the connecting flux loop can easily penetrate the metal substrate. EVOs occur in pairs (Make/Break) inter-connected by coherent non-thermal fluidized channels in solid media or vortical flux tubes for transport of electrons and ions. Fission or fusion reactions occur in the central region around the magnetic charge center which lies at the focus of a vortical destruction beam. During fusion, iron-oxygen rich, crenellated spheres encapsulating fusion products tend to form at the magnetic charge center. EVOs are attracted to metal and remain indefinitely embedded until re-energized by an influx of electrons.

Matter interpenetration and tunneling effect

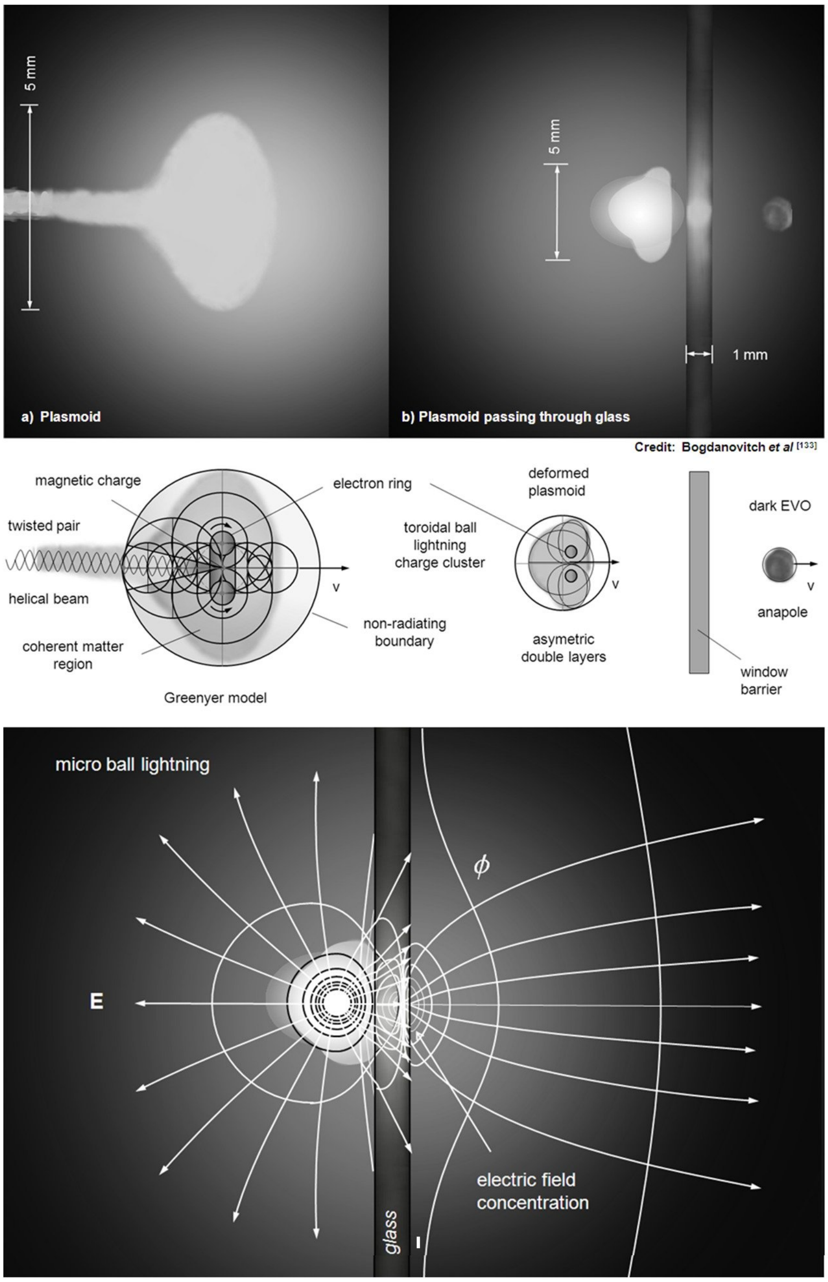


Fig. 8. a) Plasmoid ejected from a high current pinch discharge. b) Dark charge cluster emitted from the plasmoid passing through a glass plate. A collection of charges on the left side of the glass results in a localized **E**-field concentration on the opposite side sufficient to ionize the air. A highly charged cluster can puncture through the glass. Electron charge clusters in the form of 'white' EVOs can easily bore through matter as a result of LENR fission and fusion reactions transmuting matter. Electron charge clusters in the form of 'dark' EVOs exhibit a fractal toroidal anapole moment which interacts weakly with matter and, hence, can pass through matter unaffected.

Scalar wave applications

The high frequency, short duration, high current electrical discharges associated with Tesla coils are known to create strange, highly penetrating, non-x-ray radiation which Tesla discovered and form the basis of the famous 'Tesla Death Ray', an offensive and defensive weapon such as suggested in Fig. 9. These strange radiation objects were subsequently named Exotic Vacuum Objects (EVOs) by experimental researcher Ken Shoulders[20]. These objects are able to encapsulate and transport matter and are able to effect transmutation of matter by fission and/or fission via Low Energy Nuclear Reactions (LENR). Shoulders speculates that dark, weakly-interacting EVOs apparently alter the local vacuum permeability μ_0 altering the velocity of light c_0 (= $1/\sqrt{(\epsilon_0\mu_0)}$ and inertial mass including the condensed nuclear contained within. Electron and itonic (proton) charge clusters responsible for such electro-nuclear collapse (ENC) do not appear sufficient to result in 'flattening' or collapse of the existing dyadic vacuum state into a primordial true vacuum or null-space. Tesla's experiments demonstrating superluminal signal velocities of longitudinal scalar waves $v_p = \sqrt{(K/\rho)} = 1.57$ c in condensed matter is determined by the bulk modulus K ($\Delta\sigma/\Delta\epsilon = \rho_0\delta P/\delta\rho$), a measure of compressibility. The superluminal velocities of transverse EM waves $v_p = \sqrt{(G/\rho)} = c/\beta = \sqrt{2}c$ is determined by the shear modulus G (= $\Delta\tau/\Delta\gamma$), a measure of transverse elasticity, and corresponds to Weber's constant $c_W = \sqrt{2}c$. Meyl[8] notes that transmission of power by scalar waves via non-decaying ring-like vortices is optimal at $\beta = v/c = \Phi{\cdot}c = 1.616$ c in accordance with wave lengths of the Fibonacci Golden ratio (scalar vortex wavelength $\lambda_{vortex} = \Phi\lambda_{wave}$).

Tesla's claims of a 'magnifying' transmitter effect of greater energy measured at the receiver vs. energy input to the transmitter using longitudinal scalar waves in an apparent regenerative, self-excited feedback oscillation were reported to have been confirmed by a series of laboratory experiments by Meyl *et al* [6] using a small-scale version of a Tesla transmitter in 1999. With a transmitter input power of 233 mW at 10 v and a frequency of 6.7 MHz with a receiver turned-on with a load of 100 Ω vs. an input power of 223 mW with the receiver switched-off, an output power of 40 mW was received at a distance of 2m. With a net power difference of 10 mW of power transmitted in the resonant condition, a transmission line efficiency of 490% was recorded for an over-unity gain of 4.9.

Scalar waves have long been proposed as a method for long distance communication resistant to shielding including underwater signaling. Two Tesla wave generators in quadrature may be used to create helical or chirplet scalar longitudinal waves. Two or more opposed scalar wave generators of disparate frequency may be used to create contracted moving standing waves suitable for self-induced motion of matter, EM wave-based propulsion or manipulation of objects via tractor or repulsor beams. Tesla waves may conceivably be used to facilitate LENR reactions. Superposition of a Tesla wave and its phase conjugate result in zero momentum transfer. Propagation of scalar waves in LH metamaterials (LHM) or negative index materials (NIM) may enable inverse Lorentz-Doppler effects. Scalar waves may possibly be utilized to direct the motion of white and dark exotic vacuum objects which on occasion interact weakly with transverse EM fields. Three or more scalar wave frequency sources may be superimposed in an amplitude-modulated, phased overlap to produce a Shepard-Risset tone sequence. Such a glissando effect may be advantageously used for EM propulsion. Acceleration is proportional to frequency difference ($\mathbf{a} = 2c{\cdot}\Delta\nu{\cdot}\hat{\mathbf{r}}$) while phase is proportional to phase difference ($\mathbf{v}_g = c{\cdot}(\Delta\phi/\pi){\cdot}\hat{\mathbf{r}}$). Multi-frequency spectral sweeps would enable high-power, high acceleration EM propulsion. With tailored onset frequency sweep ramp rates, jerk may be minimized thereby avoiding catastrophic structural failure or jellification of biologics due to excessive rate-of-change of acceleration. With six or more scalar wave generators with a common focus enables simulation of tensor modes of gravitational waves with greater amplitude and displacement than naturally-occurring low frequency gravity waves. A phased antenna array of scalar longitudinal wave generators can provide agile beam steering and focusing for signal communication or energy transmission. – L. J. Reed

Tesla defensive and offensive particle beams

Fig. 9. The fantastic future imagined by Tesla included wireless transmission of power, worldwide communications, abundant energy supplies, medical healing technologies, robotics, defensive energy screens, penetrating particle beam weapons, etc. Electron charge clusters, otherwise known as strange radiation objects, exotic vacuum objects (EVOs) or plasmoids discovered by Tesla enable transmutation of matter via fusion and fission in low energy nuclear reactions (LENR).

References

1	U.S. Patent 645576A, "System of transmission of electrical energy", 1897 – N. Tesla
2	U.S. Patent 11203400A, "Art of transmitting electrical energy through the natural mediums", 1900 – N. Tesla
3	U.S. Patent 787412A, "Art of transmitting electrical energy through the natural mediums", 1900 – N. Tesla
4	Oleg D. Jefimenko, *Causality Electromagnetic Induction and Gravitation*, 2nd ed., Electret Scientific Co., Star City, WVA , 2000, ISBN 0-917406-23-0
5	Oleg D. Jefimenko, *Electromagnetic Retardation and Theory of Relativity*, 2nd ed., Electret Scientific Co., Star City, WVA , 1997, 2004, ISBN 0-917406-24-9
6	Konstantin Meyl, *Scalar Waves*, INDEL GmbH, Verlagsabteilung, Villingen-Schwenningen, 1996-2003, ISBN 3-9802 542-4-0
7	Konstantin Meyl, *Documentation on Scalar Wave Technology for the Transmission of Scalar Waves using the Experimental-Kit* , INDEL GmbH, Verlagsabteilung, Villingen-Schwenningen, 2000-2014, ISBN 978-3-940 703-21-7
8	Koen J. van Vlaenderen, "A generalization of classical electrodynamics for the prediction of scalar field effects", arXiv:physics/0305098, 2003
9	Donald Reed and Lee M. Hively, "Implications of Gauge-Free Extended Electrodynamics", researchgate.net publication 347844420, Dec. 2020
10	Thomas Valone, *Scalar Potentials, Fields and Waves*, Integrity Research Institute, Washington, DC 20005, 2001
11	Guiliano Bettini, "Can electromagnetic waves be radiated by a metal sphere?", vixra.org/pdf/1109 0034v1.pdf
12	Scalar Waves, Central Intelligence Agency Doc. CIA-RDP96-00792R000500240001-6, Mar 7, 2001
13	André Wasser, "Nikola Tesla's Wireless Systems", researchgate.net/publication 288824068, May 8, 2000
14	Harold E. Puthoff, "Communication Method and Apparatus with Signals Comprising Scalar and Vector Potentials without Electromagnetic Fields', U.S. Patent No. 5,845,220 , issued 1 Dec. 1998
15	ES Staff, "Tesla's Tower – Wardencliffe', Electric Spacecraft Journal, p. 13-22, April 1991 https://teslauniverse.com/nikola-tesla/articles/teslas-tower-wardencliffe
16	Nigel Cawthorne, *Tesla. The Life and Times of an Electric Messiah*, Chartwell Books, Quarto Publishing Group, New York, NY, ISBN 10:0-7858-2944-X, 13: 978-0-7858-2964-7, Apr 5, 2014
17	Robert Greenyer, "I was wrong – but I am so happy", Martin Fleishmann Memorial Project https://youtube.com/watch?v=2KGb6DYY7aU remoteview.substack.com/p/I-was-wrong
18	Friedwardt Winterberg, *The Planck Aether Hypothesis: An Attempt for a Finististic Non-Archimedean Theory of Elementary*, C.F Gauss Academy of Science Press, January 1, 2002
19	Larry J. Reed, *Quantum Wave Mechanics*, 4th ed, Booklocker.com, ISBN 978-1-63492-964-6, 2019-2022
20	Kenneth R. Shoulders, *EV-- A Tale of Discovery*, Jupiter Technologies, Austin TX, 1987