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Apertures for Excitation of Algebraically Self-Dual E/M Fields

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We propose a technique for setting up parallel (self-dual) stationary electromagnetic fields in the context of transformation optics. Several paradoxes that may appear in this regime are discussed. A particular type of communication based on stationary patterns through Aharonov-Bohm interferometry is also introduced as an alternative to a previous proposal by Putthof.

1. Introduction

In a series of previous report [1 - 3] we presented certain theoretical arguments on the possibility of creating E/M fields with parallel electric and magnetic components. Previous search was based on the notion of so called "Beltrami" flows [5 - 7] that represent eigen-modes of the rotation operator of which the application has shown similar theoretical results with controversial interpretation [8 - 11]. Till now there is a limited applicability of such results and only in very high frequencies as in laser cavities [12]. It is also expected that similar solutions of Maxwell equations are not general enough and they can only exist in closed regions or in plasma and astrophysical states with very special boundary conditions [13].

Despite this, we have recently shown [4] that there exist special solutions inside spherical shells that satisfy a radiation condition due to their overall inverse radius dependence thus leading to the possibility of their existence in open space once the outer spherical wall gets removed towards infinity. Similar results with self-dual fields have appeared in Chubykalo et al. [14]. To avoid misunderstanding we have to make clear that any such E/M configuration is necessarily a set of stationary waves as the Poynting vector gets cancelled. Thus any such pattern once established is basically an accumulation of electromagnetic energy around the near field.

Yet, there are still open problems with respect to the transient phase during establishment of such a pattern in the open space and the type of perturbation that this represents. To better understand the nature of this problem we present a very special aperture in which there are two symmetric ("*dual*") types of radiation sources. In [2] we have shown that some of the Beltrami flows may be associated with the so-called self-dual solutions of Maxwell equations.

Given such a double set of apertures it is in principle possible to perform the following experiment. When the first aperture starts operating it establishes a certain radiation pattern in the open space. After a while the second aperture starts operating and establishes a second radiation pattern in the open space. During a transient time interval all radiation must cancel as long as the superposition of the two fields leads to a perfect parallelization of the electric and magnetic components. It is quite obvious that such a cancellation cannot happen instantaneously –in which case we would have had a type of superluminal signaling- thus there must be a kind of "solitonic" cancellation front that propagates in the open space during the transient time interval.

Such a type of propagation has never been tried experimentally before and in this report we present a preliminary examination of the equipment required for a subsequent experiment of this kind. It is also interesting to combine this with previous experiments on superluminal polarization sources with "synchrotron"-like spiral wave fronts of increased coherency that have been recently proved by Ardavan et al. [15]. This type of experimentation may lead to an entirely new class of communication channels.

In section 2 we recall the necessary definition of self-duality in the context of Maxwell equations. In section 3 we give a simple prescription for setting up finite apertures based on ordinary dipolar sources and in section 4 we argue on the applicability of the above results on the case of weak linearized gravity in which the Weyl version of Einstein equations results in a set o Maxwell equations albeit with different source terms. The possibility of "latent" communication channels that make direct use of the phase shift in Aharonov-Bohm interferometry [27 - 30] based antennas are further discussed in section 5.

2. Algebraically self-dual parallel electric and magnetic fields

The notion of dual and self-dual fields and sources in classical electromagnetism was first introduced by Helmholtz [18, 19] at 1880s. In its most general form a duality transformation can be expressed as a linear transformation of the electric and magnetic components (***E*** and ***B*** → ***E'*** and ***B'***) that leave Maxwell equations invariant. This bears some resemblance to the generic case of *Lorentz* transforms that also mixes electric and magnetic components but with a non linear structure in as much it involves the exterior products $\mathbf{v}\times\mathbf{E},\ \ \mathbf{v}\times\mathbf{B}$.

The simplest case of duality appears in the form of the simple exchange $\mathbf{E}\to-\mathbf{B},\mathbf{B}\to\mathbf{E}$. The fields are called self-dual if they further satisfy $\mathbf{E}=\pm\mathbf{iB},\mathbf{B}=\pm\mathbf{iE}$ the simplest case being that of circularly polarized plane waves. A generic form of self-dual transform is given by the 2x2 matrix

$$\begin{pmatrix} 1 & \pm\mathbf{i} \\ \pm\mathbf{i} & 1 \end{pmatrix} \tag{1}$$

Despite its elegant symmetry, ordinary multipole solutions require also a similar symmetry of the sources which is reflected to a generic reformulation of Maxwell equations which includes magnetic monopole currents. As far as these remain elusive it seems impossible to construct such solutions in actual experiments. This is mostly reflected in the so called Beltrami-Maxwell reformulation first given by Lakhtakia [6, 20, 21] for applications in chiral media. In this rephrasement, Maxwell equations are given in terms of complex combinations of the electric and magnetic components which then become eigen-functions of the rotation operator (Beltrami flows), thus naturally including the duality symmetry.

We will now show that it is possible to construct *algebraically self-dual* combinations of electric and magnetic components that are based on special permutation symmetry of the scalar components of the fields thus allowing parallelization of electric and magnetic components.

First of all we observe that given a generic transformation matrix with complex components there is a possibility of a complete parallelization of the resulting field components due to mixing thus ending with $\mathbf{E}'=\lambda\mathbf{B}'$. While this might be impossible with simple multipoles or other modes one can envisage a superposition sequence of sources $\{\rho_i,\mathbf{J}_i\}$ and their resulting fields converging towards a set of parallel electric and magnetic components thus satisfying the generic algebraic condition

$$\sum_i\left(a_i\mathbf{E}_i+b_i\mathbf{B}_i\right)=\lambda\sum_i\left(c_i\mathbf{E}_i+d_i\mathbf{B}_i\right) \tag{2}$$

or in terms of the field scalar components

$$\left\{ \sum_i z_i^e \mathrm{E}_i^j = \sum_i z_i^m \mathrm{B}_i^j \right\}_{j=1}^3 \qquad (3)$$

$$z_i^e = (a_\iota - \lambda c_i), \quad z_i^m = (b_i - \lambda d_i)$$

Given an arbitrary length vector of complex coefficients $\boldsymbol{z}$ and a similar triplet of vector of all the separate scalars per coordinate $\{\mathbf{e}^j, \mathbf{b}^j\}_{j=1}^3$ we may rewrite the above in the algebraically interesting form

$$\frac{\mathbf{z}^e \bullet \mathbf{e}^j}{\mathbf{z}^m \bullet \mathbf{b}^j} = 1 \qquad (4)$$

In case we have the additional algebraic condition

$$\begin{pmatrix} a_i & \lambda c_i \\ \lambda d_i & b_i \end{pmatrix} = 1 \qquad (5)$$

there is a connection of the procedure represented by (4) with the projective Mobious group. McDonald in [19] gives an example of two ideal electric and magnetic dipoles superposed with electric and magnetic dipole moments $\boldsymbol{p}$ and $\boldsymbol{m}$ respectively, satisfying $\mathbf{m} = \pm \mathbf{ip}$ which results in circularly polarized radiation. This example hides more than it shows because in an actual experiment with two radiators we can have two independent oscillators with independent phase control, a fact that makes the phase factor misleading in the sense that it hides certain purely algebraic symmetries that appear especially in the case of dipolar fields. In particular, we may see that given both electric and magnetic ideal Hertzian dipoles their real parts can be written in the following abstract - so called *TE* and *TM* - form as

$$\begin{aligned} \mathbf{E}_{TE} &= f(r,t)\hat{r} + g(r,t)\hat{\theta}, \quad \mathbf{H}_{TE} = h(r,t)\hat{\varphi} \\ \mathbf{E}_{TM} &= -h(r,t)\hat{\varphi}, \quad \mathbf{H}_{TM} = f(r,t)\hat{r} + g(r,t)\hat{\theta} \end{aligned} \qquad (6)$$

where *f, g, h* are functions of both current amplitudes and wavevectors (see [17], [19]) taking units such that $|\mathbf{p}|=|\mathbf{m}|=1/2$. It is now easier to see that simple superposition of the real parts that are the actually measured fields results in

$$\begin{aligned} \mathbf{E} &= f\mathbf{e}_r + g\mathbf{e}_\theta - h\mathbf{e}_\varphi \\ \mathbf{H} &= f\mathbf{e}_r + g\mathbf{e}_\theta + h\mathbf{e}_\varphi \end{aligned} \qquad (7)$$

We are now a step closer to making the fields to obtain the desirable alignment and it is only a matter of appropriate choice of phase factors or more generally of complex coefficients in (2) to do so especially in the much simpler far-field limit. Before showing this in the next section we discuss some further implications of the technique introduced as well as some more general incomplete types of symmetry that may appear in case of more complex multipole combinations that deserve further attention.

The essence in the above technique is slightly different from what Helmholtz originally thought and it is based on a *functional symmetrization* of the spatial field components. Essentially we ask from the transformed electric and magnetic components to adopt the form of a *purely diagonal field* $\phi(r,t)\mathbf{D}$ where $\mathbf{D} = [\mathbf{e}_1, \mathbf{e}_2, \mathbf{e}_3]$ in a particular curvilinear coordinate system into which alignment becomes natural for purely geometrical reasons. We should though note with caution that such coordinate systems may not belong to the subset for which the wave equation is separable. Given that such transformation may result in severly distorted coordinate systems analytical approximations may be difficult but there is a strongly related numerical method known as *Transformation Optics* first devised by Pendry [27, 28, 29].

Specifically, we derive a postulate according to which, *a given choice of coordinate system will be appropriate for our decomposition if it can effectively enclose all of the solenoidal magnetic flux* while leaving any other part of the electric flux projected to the complementary sub-manifold coordinates. The key in the above definition is that given a certain functional algebraic symmetry of the field components in such decomposition, successful application of (2) and (3) only in the closed sub-manifold might be trivial given an appropriate structure of the sources.

However, the result of such a superposition may result in a paradoxical situation where part of the radiation gets cancelled while the rest may appear as due to a purely scalar term depending on the measurement method. To explain the situation in simple terms, it is well known that the vector potential can be derived by another one called the Hertz potential as $\mathbf{A} = \nabla \times \mathbf{Z}$ which in its turn can be expressed through the Monge decomposition as $\mathbf{Z} \propto \xi \nabla \zeta$. There will now be cases where the Hertz potential in itself becomes a Beltrami flow [5-7] such that $\nabla \times \mathbf{Z} = \lambda \mathbf{Z}$ where λ the *eigen-vorticity* constant. In such a case it would be possible to express the total vector potential in the form of a generalized Euler-Clebsh-Monge [24 - 26] decomposition as

$$\begin{aligned} &\mathbf{E} \sim \mathbf{A} \propto \nabla \phi + \lambda (\nabla \xi \times \nabla \zeta) \propto \mathbf{A}_0 + \lambda \mathbf{H} \\ &\mathbf{H} \propto \lambda^2 (\nabla \xi \times \nabla \zeta) \end{aligned} \tag{8}$$

In fact, a similar treatment has been given by Ranada in [22], [23] and it has been recently associated with the so called *optical knots* in [35], while experimental verification for their existence is still waiting. In the generic case of (8) above, the radiation remnant will be of the form $\lambda^2 \nabla \varphi \times (\nabla \xi \times \nabla \zeta) \propto \lambda^3 \nabla \varphi \times \nabla \times (\xi \nabla \zeta)$. This may in some cases result in a paradoxical kind of which the first part will appear inseparable from a time-varying scalar potential with a *phenomenal longtitudinal* variation while the second will be the stationary part that can evade ordinary detection. To show this by example, it is sufficient to make the choice in spherical coordinates

$$\begin{aligned} &-\nabla \phi(r,t) - \partial_t (\xi(r,t) \nabla \zeta(r,t)) = r\rho(\theta,\varphi,t)\hat{\mathbf{r}} + \frac{e^{-\mathbf{i}\omega t}}{r^n}\left[e^{-\mathbf{i}\varphi/2}\mathbf{e}_\theta - e^{\mathbf{i}\varphi/2}\mathbf{e}_\varphi\right] \\ &\nabla \times \left[\xi(r,t) \nabla \zeta(r,t)\right] = g(\theta,\varphi,t)\hat{\mathbf{r}} + \frac{e^{-\mathbf{i}\omega t}}{r^n \omega}\left[e^{\mathbf{i}\varphi/2}\mathbf{e}_\theta + e^{-\mathbf{i}\varphi/2}\mathbf{e}_\varphi\right] \end{aligned} \tag{9}$$

That we can find source terms for which the above become compatible with Maxwell equations is due to the fact that we use 3 degrees of freedom given by the scalars $\{\phi, \xi, \zeta\}$. It is also implied that we assume radiation boundary conditions at infinity. It is now a trivial exercise to verify that the radiation term has a near field component proportional to

$$\mathbf{g} \propto \frac{\mathbf{e}_r}{\omega r^{n+3}} \tag{10}$$

The reader may see that the trick behind (9) was in properly splitting the *curvature* elements ($1/r\sin\varphi$) of the particular coordinate system that enter the cross-product, thus one has the freedom to choose appropriate field configurations in other curvilinear systems as well. It is also notable that symmetry enforces the use of a helf-angle (*φ/2*) in (9) which happens to be one of the standard characteristics in the *bosonic* Spin-Angular Momentum algebra . Whether or not this might have implications for unification theories with electromagnetic mass is left for another study.

3. Ideal and finite apertures

The simplest example of a mixture of fields as described above can be given with the aid of a combined system of radiators composed of an ideal Hertzian dipole which corresponds to an infinitesimally small antenna with current *I* in the centre of a current loop of current I_{loop} and radius R. In [16, 17] simple expressions for the far-field spatial configurations of finite length radiators of the above type assuming ordinary harmonic time dependence are given in the form

$$\begin{aligned} &\mathbf{E}^{H} = \mathbf{e}_{\theta}\mathbf{i}kF(r,\theta)\widetilde{I}(k\cos\theta),\ \ \mathbf{H}^{H} = \mathbf{e}_{\varphi}\mathbf{i}F(r,\theta)\widetilde{I}(k\cos\theta) \\ &\mathbf{E}^{loop} = \mathbf{e}_{\varphi}kmZF(r,\theta),\ \ \mathbf{H}^{loop} = -\mathbf{e}_{\theta}kmF(r,\theta) \\ &F(r,\theta) = \frac{ke^{-\mathbf{i}kr}}{4\pi r}\sin\theta \end{aligned} \tag{11}$$

where $Z = c\mu_0 \sim 376.73\Omega, m = \pi R^2 I_{loop}$ and the barred *I* is the Fourier transform of the source current

$$\widetilde{\mathrm{I}} = \int_{-L/2}^{L/2} dz' I(z') e^{\mathbf{i}kz'\cos\theta} \tag{12}$$

We also take *θ* as the azimuthal angle. Superposition of both fields results in

$$\mathbf{E} = \mathbf{i}F(r,\theta)\widetilde{I}\left[Z\mathbf{e}_{\theta} + \mathbf{e}_{\phi}\right],\ \ \mathbf{H} = kmF(r,\theta)\left[\mathbf{e}_{\theta} - \mathbf{e}_{\phi}\right] \tag{13}$$

For an ideal Hertzian dipole with current $I(z) = Il\delta(z)$ we get $\widetilde{I} = Il$. Thus we can make the amplitudes of the electric and magnetic components identical by choosing $km = Il = \mathrm{K}$ which results in

$$I = \frac{\pi R^2 \omega}{c} I_{loop} \tag{14}$$

The magnitude of the above coefficient depends not only on the frequency used but also on whether we ask from the loop antenna to be resonant which puts restrictions on the radius *R*. We are now asked to find a way to apply the generic condition (2) which corresponds to an appropriate set of four complex numbers for the transformation matrix. We first observe that the imaginary unit in front of the electric part in (13) corresponds to a phase factor that can be removed if the two feeding oscillators are to be set in anti-phase condition. Secondly only the vectorial part of the two components in (13) is important as long as we have equilibrated the currents through (14) and set the common factor in the form $F' = KF$. Hence conditions (2) and (3) result in the transformation sequence

$$\begin{pmatrix}\mathbf{E}\\ \mathbf{H}\end{pmatrix}=\mathbf{I}\begin{pmatrix}\mathbf{E}^{loop}\\ \mathbf{H}^{loop}\end{pmatrix}+\overline{\mathbf{R}}\begin{pmatrix}\mathbf{E}^{H}\\ \mathbf{H}^{H}\end{pmatrix}=F'\left\{\mathbf{I}\begin{pmatrix}-\mathbf{ie}_\theta\\ Z\mathbf{ie}_\varphi\end{pmatrix}+\mathbf{R}\begin{pmatrix}\mathbf{e}_\theta\\ \mathbf{e}_\varphi\end{pmatrix}\right\} \tag{15}$$

In the above, ***I*** is the identity matrix and ***R*** is an effective rotation matrix which alters the polarization state apart from the need for some amplitude and imaginary phase correction factors. To simplify we consider only three free parameters in the form

$$\mathbf{R}=\begin{pmatrix}a\cos\gamma & \sin\gamma\\ -\sin\gamma & \beta\cos\gamma\end{pmatrix} \tag{16}$$

In the spirit of (3) we get

$$(a\cos\gamma+\lambda\sin\gamma-\mathbf{i})\mathbf{e}_\theta+(\sin\gamma-\lambda\beta\cos\gamma-\lambda Z\mathbf{i})\mathbf{e}_\varphi=0 \tag{17}$$

from which we deduce that

$$\begin{aligned}a&=-\lambda\tan\gamma+\mathbf{i}\sec\gamma\\ \beta&=\lambda^{-1}\tan\gamma+\mathbf{i}Z\sec\gamma\end{aligned} \tag{18}$$

The matrix elements above represent the adjustments including amplitudes and phases that should be imposed in the separate electric and magnetic components inside an appropriate medium. To actually construct an equivalent configuration we may make use of the method of "*Transformation Optics*" [27]. In this method, an appropriate metamaterial with properly chosen functions of a variable permittivity and permeability must be designed based on the transformation law of the desired field configuration.

For this we can use a spherical shell surrounding the dipole radiator with a radius *R'* sufficient for the far-field approximation to hold true as shown in Fig. 1. According to Pendry's main result, the transformed Maxwell equations to a new, distorted coordinate system remain invariant apart from a change in the ε and μ that carry the geometric distortion through. In a generic coordinate system of which the Jacobian is given as $\mathbf{J}^i_j=\partial X^i/\partial x_j$ the new values are given as

$$\begin{aligned}\varepsilon'^{ij}&=\|\mathbf{J}\|^{-1}\left(\mathbf{J}\mathbf{J}^T\right)\varepsilon^{ij}\\ \mu'^{ij}&=\||\mathbf{J}|^{-1}\left(\mathbf{J}\mathbf{J}^T\right)\mu^{ij}\end{aligned} \tag{19}$$

The spherical shell acts as a modulator of the field streamlines and subsequent refraction causes them to align with the external loop streamlines. In our case (15) implies an affine coordinate transformation given by either

$$\mathbf{e}_\theta\to(a\cos\gamma-\mathbf{i})\mathbf{e}'_\theta,\quad \mathbf{e}_\varphi\to\sin\gamma\mathbf{e}'_\varphi \tag{20a}$$

or

$$\mathbf{e}_\theta\to\sin\gamma\mathbf{e}'_\theta,\quad \mathbf{e}_\varphi\to(\beta\cos\gamma+Z\mathbf{i})\mathbf{e}'_\varphi \tag{20b}$$

We will not pursue this strategy further as this is only a feasibility report. Instead we are looking at the next paragraphs for appropriate geometric complementation strategies for achieving a full alignment.

In particular, if we analyze (11) back in Cartesian coordinates we may observe that alignment can be achieved by simply taking linear combinations of as many copies of the original system as necessary, each rotated by an angle γ_i, that is by moving the loop including the vertical dipole at the centre. We note here that moving the sources this way is equivalent to moving the dipolar fields as if they were solid bodies.

The reasoning behind this strategy is that successful application of rotation matrices produce linear combinations of the scalar functions defining the fields thus bringing them close to the purely diagonal form $\phi(r,t)[\hat{\mathbf{x}},\hat{\mathbf{y}},\hat{\mathbf{z}}]$. From the expressions of the unit vectors we see that there are five scalar functions of the coordinates thus we should devise a sequence of transformations that results in an expression

$$\phi(r,t) = c_1 \cos\varphi \cos\theta + c_2 \sin\varphi \cos\theta + c_3 \sin\varphi + c_4 \cos\varphi + c_5 \sin\theta \qquad (21)$$

For this we may write the transformation sequence as

$$\begin{pmatrix} \mathbf{E} \\ \mathbf{H} \end{pmatrix} = \sum_i \overline{\mathbf{R}}(\gamma_i) \begin{pmatrix} \mathbf{E}^{loop} \\ \mathbf{H}^{loop} \end{pmatrix} + \sum_j \overline{\mathbf{R}}(\gamma_j) \begin{pmatrix} \mathbf{E}^{H} \\ \mathbf{H}^{H} \end{pmatrix} \qquad (22)$$

A special symbolic algorithm is under construction for exploring the sequence (22) that will be available in the author's site [36]. If the above procedure does not reach absolute convergence there is a second possibility of introducing translations apart from rotations in a second loop.

Despite the phenomenal simplicity of (22) the engineering problems of setting up all these sources especially in case the index j runs in very large numbers to achieve convergence may be higher than in the case of the transformation refractive sphere. Hence, for all practical purposes, the solution of transformation optics appears to be much more elegant and practically feasible.

4. Helicity Modulators and latent communication channels

In [2] we argued on the possibility of a new type of modulation based on local alteration of *helicity* which is normally defined in a volume Ω through

$$h = \int_{\Omega} dV \mathbf{A} \bullet \mathbf{B} \qquad (23)$$

For simple monochromatic harmonic time dependence, this becomes analogous to the average over Ω of the first electromagnetic invariant $\mathrm{I}_1 = \mathbf{E} \bullet \mathbf{B}$. The meaning of invariance here should not be taken without certain precautions as it depends on where we put the boundaries of the system and what conditions we apply to them.

While the total helicity of a certain flow on a closed isolated volume with well defined boundary conditions may be considered as a global invariant – a result that links Maxwell electrodynamics with Euler ideal hydrodynamics – it is not with the same ease that we can agree on what is an electromagnetically isolated system. This of course may be crucially dependent on the frequency range we examine. Consider for a moment the ULF –ELF range as it appears inside the ionospheric waveguide and it will be immediately obvious what the connection with frequency band really is! As nowadays RF engineering is moving to higher and higher frequencies this might appear a little odd, but it is not when one thinks of the connection between helicity and certain topological quantities (like the *linking* and *writhing* numbers) related to the recombination of the flux streamlines, especially in a dynamical situation.

In high frequencies as in optics, it is preferable to understand helicity as the difference between the average populations of left and right polarized photons. For the same reason, helicity can also be expressed through the so called *Pauli-Lubanski* vector $\vec{s} \bullet \vec{p}$ or $\vec{s} \bullet \vec{k}$ in the microscopic regime. On the other hand this may not be helpful in case one would like to find the appropriate frequency range to transmit a message through some mechanism of direct manipulation of the field geometric structure if not the field topology directly. In such a case, the overall image would most probably spread in an entire range of frequencies so that reception by an ordinary dipole antenna would not be efficient. There are of course by now broadband antennas including even fractal antennas as well as phased arrays that might be useful unless one would really like to move to a true ELF-ULF range for very special applications.

There is now an interesting result that comes as a consequence of Stokes theorem applied in the case of an Euler-Clebsch-Monge decomposition of the electric and magnetic vector fields according to which whenever there exist a triplet of scalars such that $\mathbf{A} = \nabla\Phi + a\nabla\beta$ we may replace (24) with an average over the surface of a ball enclosing the volume *Ω*. In fact for an ideal inviscid flow it holds that $h = \nabla(\Phi\mathbf{A})$ so that for every vortex tube it cancels out exactly. The situation differs in electromagnetism due to the presence of polarization and a type of modulation that can be used in high frequencies in optical fibers has already appeared in the form of a skrew-like helical configuration of the polarization plane. In the general case one can write

$$h = \int_{\partial\Omega} dS \phi \mathbf{B} \qquad (24)$$

Then for an equipotential surface we should have $h \propto \phi_s \Phi_M$ where Φ_{M} the magnetic flux through the surface. According to this a recipe for setting up a generic *helicity modulator* is given simply by any method that manipulates the magnetic flux through say a charged sphere or any other appropriate surface of constant potential. This method would be easily applicable in the case of low frequencies. Such a case is presented in Fig. 2 with the situation of Fig. 1 inverted. A current ring now lies inside a conducting spherical surface. This situation can be analyzed with the aid of the initial loop dipolar field superposed over an image dipole coming from an image of the ring current.

If we want to modulate the magnetic flux from the interior we must arrange for a number of “holes” or “cuts”. One way to achieve this is to construct a type of Fresnel sphere using the image of some Fresnel diffraction zones cut into copper in which case the sphere will act as a grating. An example of such a possibility is shown in Fig. 3 without the sources in the interior.

There is now no reason to assume that the sphere potential is constant in time. In fact, one may use an old construct first tried by Tesla as shown in Fig.4. Although, in this circuit there is no return current, a fact that has led to a lot of misunderstandings with respect to what Tesla was actually trying to achieve, the important is that even in the case of absence of radiation, the vector potential cannot be blocked as we now know from Aharonov research and its subsequent experimental verification with electron interferometry. Things were more complicated due to the fact that Tesla himself declared in his US patent [33] that he does not intend to use “*Hertzian waves*”! This caused lot of misunderstandings which were all the more amplified by the fact that Tesla was very secretive on his own work.

In another much more recent case, Puthoff first presented a patent [34] for an invisible communication channel based on variations of vector potential. Is it possible that Tesla was the first to envision this possibility long before Aharonov and Puthoff? Whatever the case, it seems now possible that by setting appropriate types of sources causing *parallelization of electric and magnetic components* a resulting world-wide system of stationary earth waves could resemble the original idea of the genius Nicola Tesla.

While in [34], Puthoff presents a simplicial system, it is quite possible that a more proper passive detector of a vector potential based latent communication system would come in the form of Aharonov-Bohm interferometers that are now fabricated on chips in various labs worldwide. In the simplest case of a rectangular interferometer loop, the affection of both the electric and magnetic components is summarized as

$$\Delta\phi = \frac{\sigma}{\hbar}\left(|\,\mathbf{B}\,|\,S - \phi t\right) = \frac{\sigma}{\hbar}\left(|\,\Phi_{\mathrm{M}} - \phi t\right) \qquad (25)$$

where S is the loop surface, t is the exposure time depending on the electron velocity in the loop conductor used, σ is the surface charge density and φ is the electric scalar present. In (25) we have the same factors involved also in a basic helicity modulation scheme thus allowing for a passive reception scheme. In particular by setting two interferometers with opposite electron trajectories and orientations we can infer both factors through their linear relationship with the associated shifts $\Delta\varphi_{1,2}$ thus writing the local helicity in the form

$$h \propto \Delta\varphi_2^2 - \Delta\varphi_1^2 \qquad (26)$$

It might though be possible to use a slightly more cunning method where a *single electron interferometer* with an internal asymmetry would be possible with the topology of a Moebius strip as shown in Fig. 5. Although just a schematic, what is implied in Fig. 5 is an inversion of the electron trajectory inside the double loop conductor together with a difference in the radii ratio r_1/r_2 of the two loops.
Whether this is sufficient to set up a latent communication channel –leaving aside engineering questions on the bit rate possible and thus the necessary bandwidth – is a matter of future experimental research.

5. Conclusions

The author hopes that the present exposition was sufficient to prove that the field of Maxwell dynamics is more than closed and that proper exploration of the macroscopic regime of field geometry and topology instead of the reductionistic photon-particle approach hides many treasures for the future researcher.
It is also suggested that a reexamination of the microscopic regime of Maxwell dynamics might be able to answer questions even at the realm of the elusive nucleus dynamics. We remind that laws of macroscopic, classical electromagnetism are in fact empirical postulates as already mentioned in [6] and thus it is not at all necessary that they should not admit certain modifications at the extreme limits of the Planckian or the cosmic scale.
It is quite possible that introduction of a natural self-duality in the sub-atomic regime including the presence of some form of *nuclear magnetic monopoles confinement* in association with the presently acclaimed quark-gluon confinement could offer alternatives that are totally unexplored that they would lead to more natural and realistic interpretation of nuclear dynamics. Evidence towards this direction already exists in the work of other researchers like Hillion, Kiehn and others that have revived the Einsteinian spinorial version of Maxwell equations.
Finally, it is hoped that similar contributions will aid the appearance of a more natural and realistic unified field theory.

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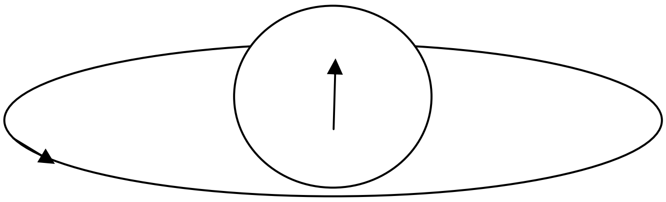

Fig. 1

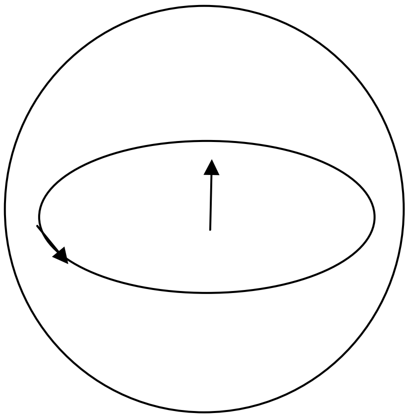

Fig. 2

Fig. 3

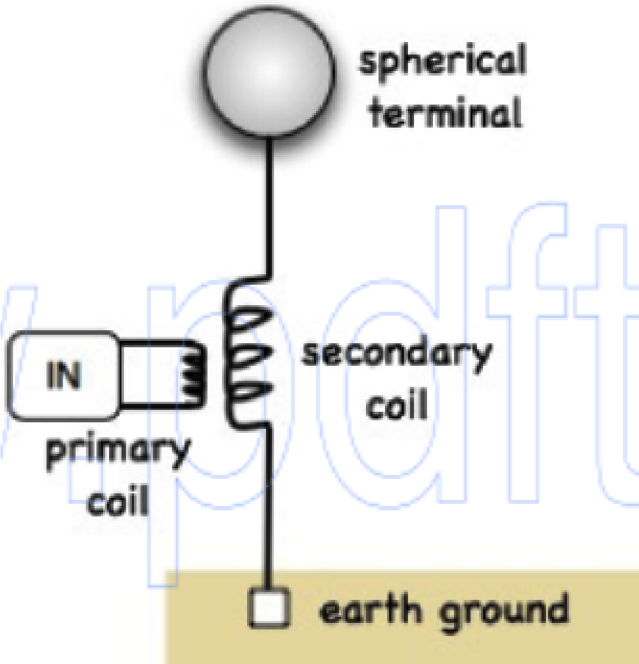
spherical
terminal
IN
secondary
coil
primary
coil
earth ground

Fig. 4

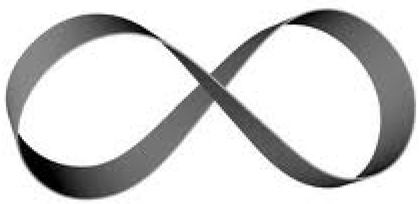

Fig. 5