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A Poynting vector/field conservation equation and gravity-The Murad-Brandenburg equation

Abstract

A corollary of the 'Big Bang' theory is that in the beginning, there was only one separate kind of force that suddenly evolved into gravity, nuclear, electric and magnetic forces. Is it conceivable that the Poynting vector is a separate intermediate entity before this separation of forces occurred? This is proposed within the GEM unification theory and suggests that Poynting vectors are present in both gravity wave fields as well as EM fields. An obvious conclusion is that since the Poynting vector consists of the cross product of the electric and magnetic fields, of which each obeys wave equations, then it is reasonable to assume that conservation of the Poynting vector itself should also obey a wave equation. Moreover, by converse reasoning, this Poynting field mathematically further establishes that either a torsion field or gravitational field may be directly coupled that also obeys a wave partial differential equation. This derived Poynting equation uses two different formalisms, and surprisingly a Poynting field may also offer a new path for investigating physics and electrical engineering as well as create consequences for a new methodology to expand advanced propulsion systems.

Keywords

Poynting vector; Magnetic field; Electric field; Torsion; Gravitation; Waves.

INTRODUCTION

There are many theories describing the onset of the cosmos. One such theory is that all of the mass, energy and momentum was interjected into our conventional space-time continuum from another dimension. Another view is that the Big Bang is the most popular of these theories, tends to describe events as they unfold at extremely small time scales. A major issue is that there is initially only one type of force. When the small time span of creation is completed, this force is broken down into nuclear forces both at near and far distances, gravitational forces, electric and magnetic forces. If this is true, is it conceivable that some of these forces undergo an intermediate step? If such a step exists, what is its value and how does it help simplify problems of mathematical physics? Moreover, how does it interface with respect to Einstein's field equations?

If electric and magnetic forces are separate entities, then it is reasonable to assume that the Poynting vector may represent that intermediate step of evolution during the Big Bang process. Two separate derivations are offered to derive a conservation equation for the Poynting vector. An obvious conclusion should represent that since the Poynting vector consists of the cross product of the electric and magnetic field. Both of these separate fields obey wave equations, then it should be reasonable to assume that the Poynting vector should also obey a wave equation.

The requirement for defining a conservation equation for the Poynting vector is unusual. We do not intend to prove the theory that the Poynting vector is an intermediate step to go from the original force element into forces that break down into electric and magnetic fields. This unfortunately appears to be intuitive. The motivation for this problem is based upon understanding the nonlinear behavior of the Morningstar Energy Box[1] that consists of a body with a three-dimensional rotating magnet field that resulted in a weight reduction or increase. This device uses rollers that move about a ring

and both contain laminated structures that enhance the electric and magnetic field, which somehow impacts gravity. Of the various postulates concerning the Energy Box, one hypothesis assumes that a Poynting field creates a force that influences the system. On the basis of these results, the authors derived these conservation laws to establish the results and possibly understand the unusual events.

The Poynting vector[2-4] is present in all EM waves as shown in Figure 1. Moreover, other terms in this conservation equation should represent a vorticity or curl operator as well as a possible source term regarding generation of the Poynting vector that can be characterized in an idealized context. The Poynting vector is a key ingredient in the GEM theory, which proposes to unify electromagnetism and gravity. In the GEM theory, the Poynting vector carries momentum and energy in both gravity and EM fields, so a wave equation for the Poynting field may describe both gravity and EM waves. Finally this equation should have some usefulness to unravel realistic problems that currently are in the purview of solving the basic Maxwell-Heaviside equations. Finally, is it possible to more readily identify this equation with gravity than expected in a unification theory approach that treats the electric and magnetic fields as separate entities?

These are all important issues that affect many technical disciplines. Another issue worth mentioning is if the combination of electric and magnetic forces conceivably represent a Poynting vector as a separate entity that may be more easily allied with gravity? In the context of derivations by Gertsenshtein where he relates light or electromagnetism to gravity using Einstein's Field Equations. This is under the assumption that if these fields all move at the speed of light, then they must be coupled, is there such coupling with the Poynting vector? A year after Gertsenshtein's 1962 paper[5], Robert Forward[6] parroted similar notions in a technical paper as well. Is the Poynting vector the missing ingredient to solve the unification mystery?
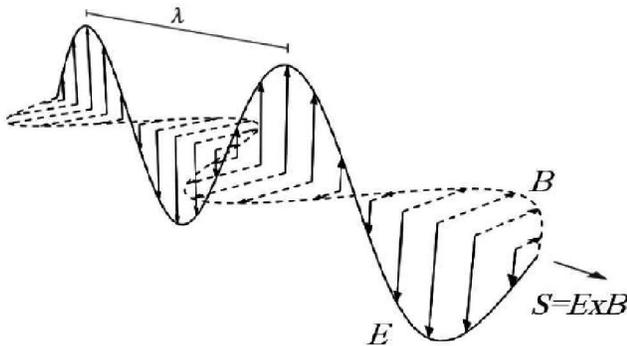

Figure 1 : An EM propagating wave showing the E and B fields as well as the Poynting vector $S = E \times B$ that points in the direction of the wave propagation.

RESULTS AND DISCUSSION

The following sections present two separate derivations with relevant assumptions and conclusions. If the Poynting vector consists of the electric and magnetic field vectors of which both obey wave equations, then it is feasible that the S vector also obeys a wave equation. The issue is to understand the source terms and how they impact the results as well as further other findings.

A wave equation approach-The field equations

In several early efforts, Murad[7-9] identified a generalized form of the wave equations for the electric and magnetic fields. These wave partial differential equations are easily derived directly from Maxwell-Heaviside's equations; however, for completeness, the approach will retain several terms that are usually ignored. For example, magnets should be treated as a magnetic *source term*. In reality, they represent dipoles and one can create pseudo-monopoles with the correct terminology. Thus monopoles represent a first-order eigenvalue solution to the equations whereas a dipole is a second-order eigenvalue. Moreover, since magnets produce lines of force, the effects are never really included in a realistic analysis. Here, we shall assume that the magnetic field lines represent conduits for the transport of some as of yet undefined substance that constitutes a *magnetic current*. Usually one likes to think of a current as a particle with some coherent velocity and a specified direction of some quantity. If one looks at electrons trapped in the van Allen belts around the Earth, this definition for a magnetic current is physically satisfied. This has to be considered as a magnetic effect because the magnetic field is far stronger by orders of magnitude than, say the Earth's electric field. If in the end, these additional terms represent magnetic properties as inadequate, they can always be set equal to zero. Normally the standard convention usually does not use magnetic currents and magnetic source terms because such terms disappear in the standard definitions for the electric and magnetic fields using a potential and a vector with:

$$-\overline{E}=\nabla\varphi+\frac{\partial \overline{A}}{\partial t} \text{ , and } \overline{B}=\nabla\times\overline{A}. \text{ Additionally the desire}$$

is to include these extra terms that may provide insights into the increase or control of the magnitude and direction of the Poynting vector to say, transfer energy or create an antenna. Thus the basic Maxwell-Heaviside equations are modified with these magnetic terms treated as follows:

$$\nabla\cdot\overline{E}=4\pi\rho_e \text{ , } -\nabla\times\overline{E}=\frac{\partial \overline{B}}{\partial t}+4\pi\overline{J}_m \text{ and}$$

$$\nabla\cdot\overline{B}=4\pi\rho_m \text{ , } \nabla\times\overline{B}=\frac{\partial \overline{E}}{\partial t}+4\pi\overline{J}_e \qquad (1)$$

Capital letters will refer to vector quantities; *E* and *B* are the electric and magnetic field respectively, *J* values are currents and ρ values are source terms. Subscripts m and e imply magnetic and electric fields respectively. The conservation of charge equations can be immediately derived from these expressions by taking the gradient operation on the curl equations resulting in:

$$\frac{\partial \rho_m}{\partial t} + \nabla \cdot \overline{\mathbf{J}}_m = 0. \quad \text{and}$$

$$\frac{\partial \rho_e}{\partial t} + \nabla \cdot \overline{\mathbf{J}}_e = 0 \tag{2}$$

Taking the curl of the curl of the electric field and using known vector identities results in:

$$-\nabla \cdot \left(\nabla \cdot \overline{\mathbf{E}}\right) + \nabla^2 \overline{\mathbf{E}} = \frac{\partial^2 \overline{\mathbf{E}}}{\partial t^2} + 4\pi \left[\nabla \times \overline{\mathbf{J}}_m + \frac{\partial \overline{\mathbf{J}}_e}{\partial t}\right] \tag{3}$$

With proper substitutions, this results in a wave equation for the electric field:

$$\frac{\partial^2 \overline{\mathbf{E}}}{\partial t^2} - \nabla^2 \overline{\mathbf{E}} = -4\pi \left[\nabla \times \overline{\mathbf{J}}_m + \frac{\partial \overline{\mathbf{J}}_e}{\partial t} + \nabla \rho_e\right] \tag{4}$$

Using a similar procedure for the magnetic field results in:

$$\frac{\partial^2 \overline{\mathbf{B}}}{\partial t^2} - \nabla^2 \overline{\mathbf{B}} = -4\pi \left[-\nabla \times \overline{\mathbf{J}}_e + \frac{\partial \overline{\mathbf{J}}_m}{\partial t} + \nabla \rho_m\right] \tag{5}$$

Note that if there are no electric or magnetic currents (*J*), these two fields are totally uncoupled from each other. This means that without currents, one field cannot produce the other; an electric current can cause a magnetic field and a magnetic current can produce an electric field. Hence, one could have a pure electric or a pure magnetic field that may have propulsion implications. However, since these currents usually exist, both electric and magnetic are coupled; we are able to create one field from the other field. On this basis, we insist upon including the magnetic current and source terms though the final derivation. There is also another interesting point in these two wave equations. Note that the conservation of charge terms exist. However, there are different mathematical operations that act upon the current and source terms.

Poynting conservation

The issue is to use these wave equations to create a similar expression for the definition of the Poynting vector such that:

$$\overline{\mathbf{S}} = \frac{1}{\mu_o}\left(\overline{\mathbf{E}} \times \overline{\mathbf{B}}\right) \tag{6}$$

To do this we need to use the following mathematical identities:

$$\frac{\partial^2}{\partial t^2}\left(\overline{\mathbf{E}} \times \overline{\mathbf{B}}\right) = \frac{\partial}{\partial t}\left[\frac{\partial \overline{\mathbf{E}}}{\partial t} \times \overline{\mathbf{B}} + \overline{\mathbf{E}} \times \frac{\partial \overline{\mathbf{B}}}{\partial t}\right] = \mu_o \frac{\partial^2 \overline{\mathbf{S}}}{\partial t^2} = \left[\frac{\partial^2 \overline{\mathbf{E}}}{\partial t^2} \times \overline{\mathbf{B}} + 2\frac{\partial \overline{\mathbf{E}}}{\partial t} \times \frac{\partial \overline{\mathbf{B}}}{\partial t} + \overline{\mathbf{E}} \times \frac{\partial^2 \overline{\mathbf{B}}}{\partial t^2}\right] \tag{7}$$

This allows forming the basic definitions for relations of the electric and magnetic fields to produce the Poynting vector. A gradient for the Poynting vector is as follows:

$$\mu_o \nabla \cdot \overline{\mathbf{S}} = -\frac{1}{2}\frac{\partial}{\partial t}\left[\mathbf{B}^2 + \mathbf{E}^2\right] - 4\pi \left[\overline{\mathbf{B}} \cdot \overline{\mathbf{J}}_m + \overline{\mathbf{E}} \cdot \overline{\mathbf{J}}_e\right] \tag{8}$$

A second expression for the LaPlacian term using a vector definition results in:

$$\nabla^2 (\overline{\mathbf{E}} \times \overline{\mathbf{B}}) = \nabla \cdot \left[\nabla \cdot \left(\overline{\mathbf{E}} \times \overline{\mathbf{B}}\right)\right] - \nabla \times \nabla \times \left(\overline{\mathbf{E}} \times \overline{\mathbf{B}}\right) = \mu_o \nabla^2 \overline{\mathbf{S}} =$$
$$= -\frac{1}{2}\nabla \frac{\partial}{\partial t}\left[\mathbf{B}^2 + \mathbf{E}^2\right] - 4\pi\left[\nabla \left(\overline{\mathbf{B}} \cdot \overline{\mathbf{J}}_m\right) + \nabla \left(\overline{\mathbf{E}} \cdot \overline{\mathbf{J}}_e\right)\right] - \mu_o \nabla \times \nabla \times \overline{\mathbf{S}} \tag{9}$$

Result for this expression is:

$$\mu_o \nabla^2 \overline{\mathbf{S}} = -4\pi \left[\rho_e \nabla \times \overline{\mathbf{B}} - \rho_m \nabla \times \overline{\mathbf{E}}\right] - \mu_o \nabla \times \nabla \times \overline{\mathbf{S}} \tag{10}$$

The approach is to use the magnetic field cross product on the electric field wave equation and add to the electric field cross product of the magnetic field wave equation. Note that the curl term exists for the Poynting vector. This is a

circulation or vorticity effect. An intermediate step from the first equation involves:

$$2\frac{\partial \overline{\mathbf{E}}}{\partial t} \times \frac{\partial \overline{\mathbf{B}}}{\partial t} = \nabla^2 \overline{\mathbf{E}} \times \overline{\mathbf{B}} - \nabla^2 \overline{\mathbf{B}} \times \overline{\mathbf{E}} +$$
$$-4\pi \left[\nabla \times \overline{\mathbf{J}}_m \times \overline{\mathbf{B}} + \nabla \rho_e \times \overline{\mathbf{B}} - \nabla \times \overline{\mathbf{J}}_e \times \overline{\mathbf{E}} - \nabla \rho_m \times \overline{\mathbf{E}} - \overline{\mathbf{J}}_e \times \nabla \times \overline{\mathbf{E}} + \nabla \times \overline{\mathbf{B}} \times \overline{\mathbf{J}}_m - 8\pi \overline{\mathbf{J}}_e \times \overline{\mathbf{J}}_m \right] \tag{11}$$

This is substituted into the expression for the second derivative and takes the other cross-products:

$$\frac{\mu_0}{c^2} \frac{\partial^2 \overline{\mathbf{S}}}{\partial t^2} = -4\pi \left[\frac{1}{c^2} \frac{\partial}{\partial t} \left(\overline{\mathbf{J}}_e \times \overline{\mathbf{B}} + \overline{\mathbf{E}} \times \overline{\mathbf{J}}_m \right) \right] \tag{12}$$

Although this may not be considered as very rigorous, subtract the LaPlacian term from the above results in the desired equation for the conservation of the Poynting vector as a wave equation:

$$\mu_0 \left[\frac{1}{c^2} \frac{\partial^2 \overline{\mathbf{S}}}{\partial t^2} - \nabla^2 \overline{\mathbf{S}} \right] = -4\pi \left[\rho_m \nabla \times \overline{\mathbf{E}} - \rho_e \nabla \times \overline{\mathbf{B}} + \frac{1}{c^2} \frac{\partial}{\partial t} \left(\overline{\mathbf{J}}_e \times \overline{\mathbf{B}} + \overline{\mathbf{E}} \times \overline{\mathbf{J}}_m \right) \right] + \mu_0 \nabla \times \nabla \times \overline{\mathbf{S}} \quad \text{or}$$

$$\mu_0 \left[\frac{1}{c^2} \frac{\partial^2 \overline{\mathbf{S}}}{\partial t^2} - \nabla^2 \overline{\mathbf{S}} \right] = -4\pi \left[-\rho_m \left[\frac{\partial \overline{\mathbf{B}}}{\partial t} + 4\pi \overline{\mathbf{J}}_m \right] - \rho_e \left[\frac{\partial \overline{\mathbf{E}}}{\partial t} + 4\pi \overline{\mathbf{J}}_e \right] + \frac{1}{c^2} \frac{\partial}{\partial t} \left(\overline{\mathbf{J}}_e \times \overline{\mathbf{B}} + \overline{\mathbf{E}} \times \overline{\mathbf{J}}_m \right) \right] + \mu_0 \nabla \times \nabla \times \overline{\mathbf{S}} \tag{13}$$

This is the desired result. Note the symmetry of terms exist between the electric and magnetic effects on the RHS of the first equation. The large denominator in the RHS for a time derivative, these values may be inconsequential. Moreover, both currents and source terms play a role. This demonstrates that cross-coupling between the electric and magnetic fields creates Poynting vector components. The derivation also reveals that you can have a Poynting vector purely with situations where only an electric or magnetic field exists as separate entities if there are no currents as seen by the second equation. Using Maxwell's equations can produce terms that are purely due to the magnetic field or electric field as separate entities. This surprisingly suggests that a Poynting vector can be produced independent of any coupling of the fields. This could have unusual consequences where additional unaccounted forces may exist that can create unexpected problems and warrants further investigations. Furthermore, the results also depend upon alignment of both the fields and opposing field currents as well as the magnitude of the electric and magnetic source terms assuming that the curl terms are not zero. Finally, we see that the terms in the RHS with the curl of the Poynting vector are very prevalent.

EXPERIMENTAL SECTION

A possible torsion or gravitational field

An analytical function may be used for elliptical as well as wave partial differential equations to define additional terms. This is rather simple to determine such a relationship with this wave equation for the Poynting field's conservation. However, the large amount of variables in the RHS requires a different approach to this problem.

Let us assume that we are defining psuedo-analytical functions to consider these additional terms. The approach is similar to using Cauchy-Reimann conditions using complex variables. Variables will include V, u, and v. Moreover, vector gradients or the curl of a vector may also represent the variables for u and v. However, let us simplify this for an initial assessment as follows:

$$\nabla \cdot \overline{\mathbf{S}} + \frac{1}{c^2} \frac{\partial \overline{\mathbf{V}}}{\partial t} = \mathbf{u},$$
$$\frac{\partial \overline{\mathbf{S}}}{\partial t} + \nabla \cdot \overline{\mathbf{V}} = \mathbf{w}. \tag{14}$$

A wave equation for the Poynting conservation can be defined if the equations are subtracted with the first term used as a gradient and the second term involves a time derivative. The factors are straightforward to define both u and v. If the first equation is a time derivative and the second term is equal to the gradient, these equations are subtracted to remove the Poynting vector and result in a wave equation for the V field that becomes a wave equation as follows:

$$\frac{1}{c^2} \frac{\partial^2 \overline{\mathbf{V}}}{\partial t^2} - \nabla^2 \overline{\mathbf{V}} = \frac{\partial \mathbf{u}}{\partial t} - \nabla \cdot \mathbf{w},$$
$$\text{where: } \mathbf{w} = -4\pi \left[\overline{\mathbf{J}}_e \times \overline{\mathbf{B}} + \overline{\mathbf{E}} \times \mathbf{J}_m \right], \text{ and } \nabla \cdot \mathbf{u} = 4\pi \left[\rho_m \nabla \times \overline{\mathbf{E}} - \rho_e \nabla \times \overline{\mathbf{B}} \right] - \mu_0 \nabla \times \nabla \times \overline{\mathbf{S}} \tag{15}$$

If these terms are combined, the results are:

$$\frac{1}{c^2} \frac{\partial^2 \overline{\mathbf{V}}}{\partial t^2} - \nabla^2 \overline{\mathbf{V}} = \frac{\partial}{\partial t} \int_0^r \left[4\pi \left[\rho_m \nabla \times \overline{\mathbf{E}} - \rho_e \nabla \times \overline{\mathbf{B}} \right] - \mu_0 \nabla \times \nabla \times \overline{\mathbf{S}} \right] \cdot d\overline{r} + 4\pi \nabla \cdot \left[\overline{\mathbf{J}}_e \times \overline{\mathbf{B}} + \overline{\mathbf{E}} \times \mathbf{J}_m \right] \tag{16}$$

Now this new variable represents a tensor and may be a torsion field. Without details, we can only speculate that this

can also be a gravitational tensor. It is interesting that Gertsenshtein suggested coupling between gravity with both an electric and magnetic fields. What is of interest is that such a coupling may exist; however, we also include an impact with the Poynting field. This could be a considerable improvement or higher level of granularity over Gertsenshtein that is a function of electric/magnetic fields and sources as well as the vorticity of the Poynting vector. If one assumes a gravitational field that has a velocity that differs from the speed of light, this relationship will not work. On this basis, if gravitation fields move faster than light, then this is a second or torsional field that would resemble a field similar to electric and magnetic fields.

Further considerations for magnetic/electric field convection

There is a problem that may or may not resolve this issue. The question is if there are missing terms that may impact results. One specific problem is convection. Normally when convection is included, the thoughts treat movement of fluid dynamic or ionic flows. This is not the point of concern. For example, would the Energy Box strange behavior occur if the same events were performed in a vacuum chamber? Moreover, the convection velocity is not due to particles but rather the rotation induced by the Energy Box.

Tombe[10] and Pinheiro[11] offer a means for treating convection effects that account for a convection current. Tombe treats the convection term as the total derivative for the magnetic field; Pinheiro derives a different term. When this is achieved, the result is that the curl of the electric field from Maxwell's equation respectively becomes:

$$\nabla \times \overline{\mathbf{E}} = -\frac{\partial \overline{\mathbf{B}}}{\partial t} - \left(\overline{\mathbf{v}} \cdot \nabla \right) \overline{\mathbf{B}} \ ,$$

$$\nabla \times \overline{\mathbf{E}} = -\frac{\partial \overline{\mathbf{B}}}{\partial t} - \nabla \times \left(\overline{\mathbf{B}} \times \overline{\mathbf{v}} \right) \tag{17}$$

Basically these terms can be used throughout the previous derivation to establish the conservation equation. However, there is an easier way where these terms can be treated as additional terms. For example, these expressions can be viewed as magnetic currents. Similar terms can be expanded with similar logic to extend the additional terms regarding an electric current. This becomes:

$$\mathbf{J}'_m = \mathbf{J}_m - \nabla \times \left(\mathbf{B} \times \mathbf{V} \right) - \left(\mathbf{V} \cdot \nabla \right)\mathbf{B}, \ \text{ and}$$

$$\mathbf{J}'_e = \mathbf{J}_e - \nabla \times \left(\mathbf{E} \times \mathbf{V} \right) - \left(\mathbf{V} \cdot \nabla \right)\mathbf{E} \ . \tag{18}$$

Einstein's field equation approach-Poynting conservation

The second derivation assumes an approach to extend these results with respect to gravity. Plane EM waves are capable of carrying EM momentum and energy. The flux of this momentum and energy is the *S* or Poynting vector. The proof that such a wave equation exists is the objective of this analysis that will consider free space EM waves in cgs units.

Poynting's theorem used from standard EM theory is as follows:

$$\nabla \cdot \overline{\mathbf{S}} = -\frac{\partial}{\partial t}\left(\frac{\mathbf{E}^2}{8\pi} + \frac{\mathbf{B}^2}{8\pi} \right). \tag{19}$$

Let us begin with a different definition for the Poynting's theorem:

$$\overline{\mathbf{S}} = \frac{\mathbf{c}}{4\pi} \left(\overline{\mathbf{E}} \times \overline{\mathbf{B}} \right) \tag{20}$$

The standard Maxwell stress theorem (in cgs units) with the EM momentum density *P* can be defined in terms of the Poynting vector:

$$\overline{\mathbf{P}} = \frac{1}{4\pi \mathbf{c}} \left(\overline{\mathbf{E}} \times \overline{\mathbf{B}} \right) = \frac{\overline{\mathbf{S}}}{\mathbf{c}^2} \tag{21}$$

$$\frac{1}{\mathbf{c}^2}\frac{\partial \overline{\mathbf{S}}}{\partial t} = \nabla \cdot \overline{\mathbf{T}} - \rho \overline{\mathbf{E}} - \overline{\mathbf{J}} \times \overline{\mathbf{B}} = \nabla \cdot \left[\frac{1}{4\pi}\left[\mathbf{E}\,\mathbf{E} + \mathbf{B}\,\mathbf{B} \right] - \mathbf{\bar{I}}\left(\frac{\mathbf{E}^2}{8\pi} + \frac{\mathbf{B}^2}{8\pi} \right) \right] - \rho \overline{\mathbf{E}} - \overline{\mathbf{J}} \times \overline{\mathbf{B}} \tag{22}$$

We break up the tensor expression into two pieces:

$$\frac{1}{c^2}\frac{\partial \overline{S}}{\partial t} = \nabla \cdot \overline{T}* - \nabla\left(\frac{E^2}{8\pi}+\frac{B^2}{8\pi}\right) - \rho\overline{E}-\overline{J}\times\overline{B} \tag{23}$$

Where we have defined the tensor $T* = [EE+BB]/4\pi$. The time derivative of both sides is taken and, using Poynting's theorem in Eq. 1, yields:

$$\frac{1}{c^2}\frac{\partial^2 \overline{S}}{\partial t^2} = \frac{\partial}{\partial t}\left(\nabla \cdot \overline{T}*\right) - \nabla\frac{\partial}{\partial t}\left(\frac{E^2}{8\pi}+\frac{B^2}{8\pi}\right) = \frac{\partial}{\partial t}\left(\nabla \cdot \overline{T}* -\rho\overline{E}-\overline{J}\times\overline{B}\right) + \nabla\left(\nabla\cdot\overline{S}+\overline{J}\cdot\overline{E}\right) \tag{24}$$

Using the vector identity:

$$\nabla\times\nabla\times\overline{S} = -\nabla^2\overline{S} + \nabla\left(\nabla\cdot\overline{S}\right) \tag{25}$$

And upon simplification, we obtain:

$$\frac{1}{c^2}\frac{\partial^2 \overline{S}}{\partial t^2} - \nabla^2\overline{S} = \frac{\partial}{\partial t}\left(\nabla\cdot\overline{T}*\right) + \nabla\times\nabla\times\overline{S} + \nabla(\overline{J}\cdot\overline{E}) - \frac{\partial}{\partial t}(\rho\overline{E}+\overline{J}\times\overline{B})$$

$$\Uparrow \textbf{field\ \ sources}\Uparrow \qquad \Uparrow\textbf{current\ \ sources}\Uparrow \tag{26}$$

Therefore, the final results for the M-B equation have sources that are due to both field collapse and acceleration of charges and currents, as is reasonable for EM waves. Note that the source terms for current and charges are 3rd order in time.

Plane waves

For a plane wave in free space, we have variations in S only in the direction of the wave propagation and both the E and B fields that vary only at right angles to their direction. This means that the curl of the Poynting vector for a plane wave vanishes or:

$$\nabla\times\overline{S} = 0 \tag{27}$$

This holds everywhere and means that:

$$\nabla\cdot\overline{B} = 0, \ \ \nabla\cdot\overline{E} = 0, \ \ \overline{B}\cdot\nabla\overline{B} = 0, \ \ \overline{E}\cdot\nabla\overline{E} = 0 \tag{28}$$

The significance of some of these terms is that there are no electric or magnetic source terms for the plane wave. We expand the $T*$ term and find:

$$\frac{\partial}{\partial t}\left(\nabla\cdot\overline{T}*\right) = \frac{\partial}{\partial t}\left(\overline{E}\left(\nabla\cdot\overline{E}\right) + \overline{E}\cdot\nabla\overline{E} + \overline{B}\left(\nabla\cdot\overline{B}\right) + \overline{B}\cdot\nabla\overline{B}\right) = 0 \tag{29}$$

This term is generally zero in free space even for non-plane waves because E and B are always transverse to their propagation and varies only along their propagation direction, meaning that they do not vary along their direction. Therefore for plane waves moving in a vacuum, the S vector also propagates like a wave according to:

$$\frac{1}{c^2}\frac{\partial^2 \overline{S}}{\partial t^2} - \nabla^2\overline{S} = 0 \tag{30}$$

However, near a planar antenna, the curl $\nabla\times S$ term, which should be considered as the vorticity of S, is non-zero and is the source term for the S wave. Thus, we have in general the Murad-Brandenburg Equation for this situation:

$$\frac{1}{c^2}\frac{\partial^2 \overline{S}}{\partial t^2} - \nabla^2\overline{S} = \nabla\cdot\overline{T}* + \nabla\times\nabla\times\overline{S} \tag{31}$$

This equation shows that S can propagate as a wave and has the curl of the vorticity of S as its source term. Using the definition that the curl is the limit of a line integral around an area A that shrinks to zero:

$$\nabla\times\overline{Q} = \lim A\rightarrow 0 : \frac{A\oint\overline{Q}\cdot d\overline{\ell}}{A} \tag{32}$$

We can see that the curl of the curl is non-zero near an antenna. We can also see that near an antenna in the near field as shown in Figure 2, the Poynting field goes up and down parallel to the antenna as it is energized and becomes weaker away from the antenna. This means S has a curl and the curl vector runs in circles around the antenna as shown in Figure 3. Since the definition of the curl is a line integral around an area, this means that the curl of the curl ($\nabla\times\nabla\times S$) also exists near the antenna. The vorticity of S (vorticity = $2\nabla\times S$) is also important in gravity modification, so

we see, at the very least that gravity modification technology may have a special EM radiation signature when it operates.

Antennae effects

The MB equation is of great interest because its source term does not necessarily require explicit electric and magnetic fields, suggesting that the microscopic S fields created when neutral matter is accelerated can create Poynting waves. Such waves would fit theoretical description of gravity waves in a theory unifying EM and gravity. However, it is found that this effect cannot fly in the face of known physics: the source region is not the immediate regions of the moving charges themselves, but is actually the same size as the wavelength of the wave being radiated. Thus, without extended fields from electric charges, like on a radio antenna, no radiation zone exists to create long wavelength waves. Hence S waves, which still must be considered EM waves, are linked to the geometry of the source region by their wavelength. In neutral matter the particles are so close together that the extended fields cancel and no explicit radiation zone can occur. Thus the only S waves we can expect to result from the motion of individual charges in neutral matter are very short wavelength waves such as from a hot plasma in a star or in a magnetic field. That is, the EM waves emitted from neutral bodies, such as stars, comes not from gross motions of the plasma but from the relative motion of charges going past each other. With this said, however, we can still investigate the equation in both these limits and find results.
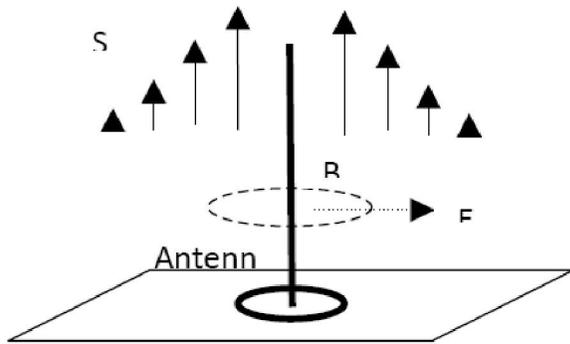

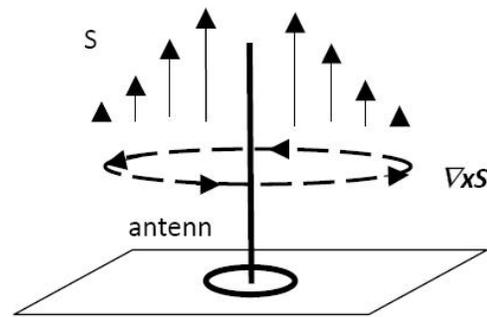Figure 2 : Near field vectors around a dipole antenna on a metal sheet. Circle is insulating gap in sheet.

Figure 3 : Near Field vectors around an antenna including curl of S showing that since it encircles the antenna, the quantity $\tilde{N} \times \tilde{N} \times S$ also exists.

We first investigate the conventional case of two similar charged spheres separated by a cross piece that is rotated about its center of gravity (shown in Figure 4). This will create a Quadrupole radiator. Normally if these charges were different and close to each other, they would represent a dipole radiator. We then use the equation to represent this quadrupole as:

This will create fields of Poynting vector, vorticity, and vorticity of the vorticity seen in Figures 5. A, B, and C.
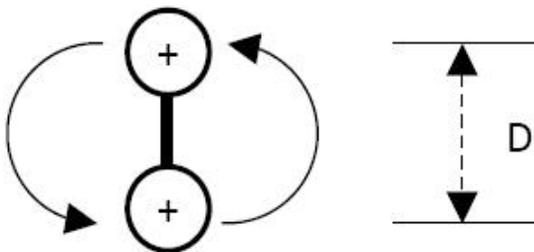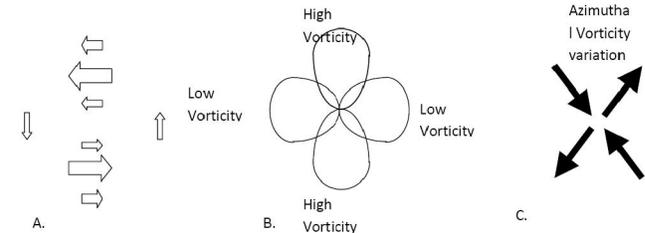

Figure 4 : Two similar charges being rotated with separation distance D creates quadrupole radiation.

Figures 5 : (A) Poynting vector from rotating charges, (B)Poynting Vorticity in the z direction. (C) Azimuthal Vorticity variations leading to radial curl of curl components.

Far away from the source region, we can make the approximation that the S vector is part of a plane wave and is purely radial. If we perform a surface integral over a large spherical shell in this limit, we find that the surface integral of S can be used for defining the total radiated power.

We will assume here that the important length of the radiation zone is 2λ and is approximately 10 times the size of D the rotating array so we have approximately:

$$\frac{2q^2}{\lambda^4} \omega r D^2 \cong \frac{1}{100} q^2 \lambda^4 \frac{\omega r}{\lambda^6} \cong \frac{1}{100} Q^2 \frac{1}{\lambda^6} \omega \lambda \Rightarrow \frac{1}{100} Q^2 k^6 c \tag{33}$$

This is approximately the right answer for the EM case. Let us suppose that the same answer is when two spheres are merely two neutral objects but full of dissimilar electrical charge. Obviously, the charges cancel and so do their electric and magnetic fields over most of the region, however, what about the S vectors that form whenever the molecules and atoms in the neutral masses move? The *S* vectors should also vanish because the electric and magnetic fields cancel. However, if quantum mechanics is correct, *S* is carried by photons so they are more fundamental than the electric and magnetic fields whose forces they mediate. Thus, *S* must disappear in classical field theory, but by quantum mechanics an *S* field must still exist at some level. Therefore, the *S* vector field must still exist and have a curl of a curl to form a source term for a far away *S* field. According to Sakharov, S mediates the gravity fields, this "GEM" *S* field must be associated with gravity radiation. Hence, the GEM *S* field is much weaker by approximately the factor:

$$\mathbf{K}_{\text{GEM}} = \frac{G\,m_p^2}{e^2} \approx 10^{-42} \tag{34}$$

The same equation can give both the radiated power from EM radiation and gravity radiation.
The suppression of fields results then in:

$$\overline{\mathbf{S}} \approx \mathbf{K}_{\text{GEM}}\,\lambda^2(\nabla\times\nabla\times\overline{\mathbf{S}})_r \approx \mathbf{K}_{\text{GEM}}\,\frac{2q^2}{r_o^4}\,\frac{\omega r \lambda^2}{\lambda^2} \tag{35}$$

Gertsenshtein's effect

Thus, we have an equation that appears that describe, under the GEM hypothesis that gravity waves carry an EM Poynting vector, a Poynting field wave equation for both phenomena. In the Gertenshtein effect, the mass density variation that is created by the constructive and destructive interference of an EM wave with an intense magnetic field should induce a gravity wave. We can now model this using the Murad-Brandenburg equation.
We begin with the M-B equation with its source terms, which are both assumed to be zero for an *EM* plane wave.

$$\frac{1}{c^2}\frac{\partial^2\overline{\mathbf{S}}}{\partial t^2} - \nabla^2\overline{\mathbf{S}} = \frac{\partial}{\partial t}\left(\nabla\cdot\overline{\mathbf{T}}*\right) + \frac{1}{c^2}\nabla\times\nabla\times\overline{\mathbf{S}} = \mathbf{0}. \tag{36}$$

Using the Einstein's field equation:

$$\overline{\mathbf{R}}_{\mu\nu} - \frac{1}{2}\,\mathbf{g}_{\mu\nu}\,\overline{\mathbf{R}} + \mathbf{g}_{\mu\nu}\Lambda = \frac{8\pi G}{c^4}\,\overline{\mathbf{T}}_{\mu\nu} \tag{37}$$
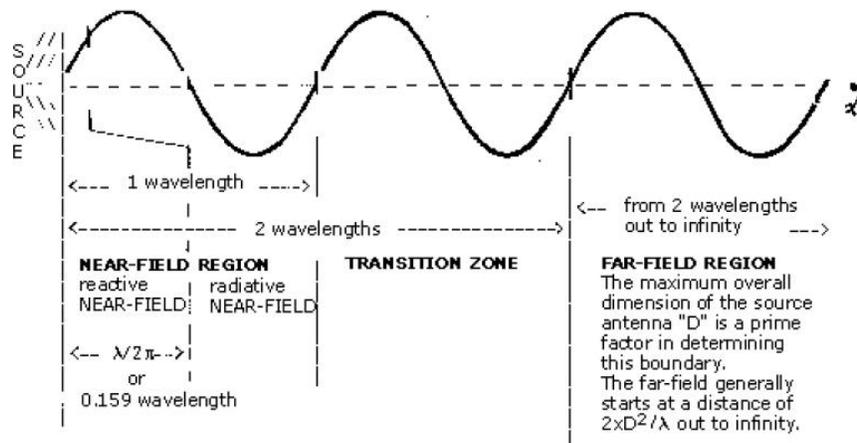

Figure 6 : A diagram showing the relative scales of radiation zones around an antenna.

Where the Stress Tensor used with Maxwell's equation is given by:

$$\mathbf{T}^{ij} = -\frac{1}{4\pi}\left[\mathbf{F}_k^{\,i}\mathbf{F}^{\,kj} + \frac{1}{4}\boldsymbol{\eta}^{\,ij}\mathbf{F}^{\,kl}\mathbf{F}_{kl}\right] \quad\text{where:}\quad \boldsymbol{\eta}_{ij} = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{38}$$

A strong magnetic field will create an energy density in space and using *E=mc²* where this forms a mass density and thus based upon the Einstein field equation, results in a curvature of space-time. We can thus write approximately, for

an intense DC magnetic field a radius of the curvature of space-time R_c, (here we use MKS units):

$$\frac{1}{R_c{}^2} \cong \frac{8\pi G}{c^4}\frac{B_o{}^2}{\mu_o} \tag{39}$$

$$\frac{1}{R_c} \cong \sqrt{\frac{8\pi G}{c^4}\frac{B_o{}^2}{\mu_o}} \tag{40}$$

We then use the fact that flat plane *EM* waves have no source terms in the M-B Equation, unless curvature is introduced as an initial condition. Therefore, the space-time curvature introduced by the intense magnetic field "switches on" the source term so we have:

$$\frac{1}{c^2}\frac{\partial^2 \overline{S}}{\partial t^2} - \nabla^2 \overline{S} \cong \omega \frac{\overline{B}_o \overline{B}_W}{\mu_o}\sqrt{\frac{8\pi G}{c^4}\frac{B_o{}^2}{\mu_o}} \tag{41}$$

Where B_W is the magnetic field of the wave. Interestingly, this appears to be stronger by a factor of $\sim 10^{20}$ above normal source term strength for weak gravity waves, which can be estimated based on the energy density of the interference pattern created by the EM wave on the magnetic field.

$$\frac{1}{c^2}\frac{\partial^2 g_{oo}}{\partial t^2} - \nabla^2 g_{oo} \cong \frac{8\pi G}{c^4}\frac{B_o B_W}{\mu_o} \tag{42}$$

We can compare energy densities near the source region, for the Murad Brandenburg Equation:

$$\frac{S}{\lambda^2} \cong \frac{c}{\lambda}\frac{B_o B_W}{\mu_o}\sqrt{\frac{8\pi G}{c^4}\frac{B_o{}^2}{\mu_o}}, \text{ and } \frac{S}{c} \cong \lambda\frac{B_o B_W}{\mu_o}\sqrt{\frac{8\pi G}{c^4}\frac{B_o B_W}{\mu_o}}\sqrt{\frac{B_o}{B_w}} = \frac{B_o B_W}{\mu_o}\frac{\lambda}{R_{ci}}\sqrt{\frac{B_o}{B_w}} \tag{43}$$

For conventional gravity wave generation via the Gertenshtein effect the source term energy density is:

$$g_{oo} \cong \frac{8\pi G}{c^4}\frac{B_o B_W}{\mu_o}\lambda^2, \text{ and } \frac{g_{oo}{}^2}{8\pi G\lambda^2} \cong \frac{8\pi G}{c^8}\left[\frac{B_o B_W}{\mu_o}\right]^2\lambda^2 = \frac{B_o B_W}{\mu_o}\frac{\lambda^2}{R_{ci}{}^2} \tag{44}$$

Assuming for high power lasers, we can achieve $B_w \sim B_o$. The M-B appears to predict a higher energy density wave by a factor of:

$$\frac{R_{ci}}{\lambda} = \frac{\lambda}{\sqrt{\frac{8\pi G}{c^4}\frac{B_o B_W}{\mu_o}}} \tag{45}$$

The radius of curvature created by the energy density of the magnetic interference field is very large compared to the laser wavelength, so this factor is very large. For 100 Tesla fields, the limit that we generate practically at this time, the energy density in cgs is 4×10^{10} ergs/cc, which translates to $\sim 4 \times 10^{-11}$ gm/cc, and assuming a laser wavelength of 1micron, we have the enormous factor of:

$$\frac{\left[8\pi G\frac{B_o^2}{\mu_o c^4}\right]^{-1/2}}{\lambda} \cong \frac{\left[6\times 10^{-15}\text{cm}^{-2}\right]^{-1/2}}{1\mu} \cong \frac{2.4\times 10^7\text{cm}}{10^{-4}\text{cm}} \sim 10^{11} \tag{46}$$

Therefore, based on this analysis, the M-B equation suggests that direct coupling exists between EM and gravity fields, leading to much stronger generation of high frequency gravity waves than previously thought possible.

CONCLUSIONS

Two different perspectives were identified that define conservation for the Poynting field. This equation creates a wave partial differential equation that should be an obvious consequence of both the electric and magnetic fields. The results also provide some possibilities where a coupling exists with the Poynting field combined with either a gravitational or a torsional field. Although Gertsenshtein implies that the coupling of E-M fields and gravity exists, different formulations using the Poynting field conservation also show details that has some more granularity to define gravitational coupling directly as a function of either electric or magnetic sources or currents. Moreover, the use of the

Poynting field can have important consequences for mathematical physics without treating an electrical or magnetic field.

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