Warp-Drives: The Dreams and Realities
Part II: Potential Solutions

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Abstract. The theoretical basis for warp drive devices, reviewed in Part I, reveals that three basic schemes require a negative stress-energy tensor to solve Einstein’s field equations implying the use of negative or exotic matter to reach near light speeds. These propulsion approaches create a curvature in space-time at relativistic conditions inferring that gravity is also altered. The accumulated knowledge on sensing a gravitational potential at relativistic speeds is currently inadequate and with so much uncertainty, contrary theoretical outcomes result. Even so, another potential way of remedying the negative stress-energy conditions may require an approach akin to the Yilmaz description to compensate for Einstein’s shortcomings in describing gravity. The issue of exceeding light speed from Einstein’s original formulation is examined as well as the possibility that electric and magnetic fields may be redefined by introducing additional vector and scalar potentials. Thus, if an approach suggests generation of negative energy is feasible by exploiting the electric scalar potential, then addition of a magnetic scalar potential may also mitigate the problem. New formulations and the definition of suitable experiments to examine these premises are discussed. Such analyses are crucial to validate that these shortcomings, involving exotic matter, are not imaginary and that the concepts can be placed upon a more stable scientific footing.

INTRODUCTION

Science fiction is replete with Warp-drive driven spacecraft capable of traveling faster than the speed of light. Are these psychotic, meaningless notions about violating the theory of relativity delusions of grandeur? The first part of this paper involved a literature search where the background and crucial issues are hopefully identified to give the reader the depth of conviction and understanding that lies within this problem and to document the serious scientific attention given to the subject. Major issues arise based upon the need for exotic matter. Moreover, the basic premise in these schemes is a reduction of a space-time metric and its relation to Einstein’s field equations. Very few investigators tend to look at alternative approaches from this scheme and even if such an approach is valid, how can it be implemented within the realm of existing or even projections of future technologic capabilities? These are difficult questions to answer and any devotee may be cautious about getting involved because the popularity of such an approach may be outside of the mainstream of scientific thought and could be akin to touching a live third rail!

Thus caution would be the by-word toward providing any meaningful contribution with respect to identifying new ideas that may diverge from the conventional wisdom. In some previous efforts by the author, the concern about gravitational models was raised where an obvious bias led toward Jeffimenko’s approach where gravity may no longer be solely a function of only position but is a function of both position as well as velocity at relativistic speeds. In addition to inducing a force, Jeffimenko’s gravity model also includes imparting angular momentum to a body in the field. These issues should, if they are experimentally verified, be included within any navigation scheme. For example, in plotting a superluminal trajectory, changes in gravity of nearby planets or star could result in unpredictable attractions and yield catastrophic results. Moreover, some findings permit superluminal speeds in the context of Special Relativity and, as others have shown, this may not be a ‘real’ limitation. Finally, the author previously examined electric and magnetic fields with the objective of developing a traversable Black Hole using field propulsion. These approaches (Murad 2003 and 1999) would create electric, magnetic, or gravitational vortices that may have a propulsive application. More recent work (Murad 2004) suggests that the elusive Russian spin field could be Jeffimenko’s co-gravitational field. If no solution is forthcoming regarding wrap drives, it appears that such a task may be beyond current or future mainstream...
technology and travel to the stars may be possible only at sub-light speeds. At least such interstellar travel may not become a reality for the duration of most of our lifetimes unless some agile and creative mind finds an alternative view to resolve these challenges.

**DISCUSSION**

What is the current depth of our understanding of gravitational effects and are energy sources available in natural phenomenon that is not normally considered such as ball lightning? The issue is to see if these may offer a partial solution to either understanding the problem or provide a potential resolution. If a resolution is found, then the issue becomes less of an intellectual challenge but more of trying to create the necessary technology.

**Gravity and Potential Superluminal Effects**

Let us examine some sophisticated gravity models. Gonzales-Mestres (1996) suggests, from solutions of Lorentz-invariant equations, that matter would feel relativistic space-time even if actual space-time had a different geometry. Superluminal sectors of matter may exist as new degrees of freedom that are not yet experimentally discovered and these particles may not be tachyons. At superluminal speeds, such particles are expected to release “Cherenkov” radiation in a vacuum. Moreover, gravitation as a given geometric description in Minkowski space, will undergo important modifications at superluminal speeds. The Big Bang and other scenarios would strongly be influenced by such particles. Lorentz invariance can be viewed as symmetry of the motion equations with no reference to absolute properties of space or time.

Gonzales-Mestres suggests soliton solutions of the sine-Gordon equation exhibit relativistic particle properties. Wave solutions could be developed as solutions to the Klein-Gordon equation for scalar particles. Apart from space rotations, no linear space-time transformation can preserve invariance of the Lagrangian densities for two different sectors (luminal and sub-luminal). Therefore, it will be impossible to identify the rest mass. Moreover, in this approach the Michelson-Morley experiment is not incompatible with the existence of an ether. If superluminal particles weakly couple with ordinary matter, their effect will occur at higher energy over short distances far from the domain of conventional tests used for Lorentz invariance. Gravitation is a gauge interaction related to invariance under local linear transformations of space-time. If a graviton is a massless ordinary particle propagating at light speed, it is Lorentz invariant and may exist in the presence of the superluminal conditions. If the lightest superluminal particle is stable, it is not unavoidable that we may be in a sea of very long-lived superluminal particles that may decay into ordinary particles or even lighter superluminal particles. The Cherenkov radiation would be a clear signature regarding coupling of superluminal particles with ordinary matter. Moreover, such interactions could influence our understanding of black-hole dynamics. A detectable flux of magnetic monopoles (which can be superluminal) is not excluded as part of the ‘horizon’ problem, can be eliminated as part of the standard inflationary scheme. Superluminal matter may presently be dark with unknown coupling with gravity and ordinary matter by new unknown forces. The presence of coupled gravitational singularities may involve several sectors to reasonably assume that the gravitational role of galactical haloes may be due to superluminal particles. Gravitational collapse may be a signature of superluminal particles. Annihilation of pairs of superluminal particles can release large kinetic energies and a new source of high-energy cosmic rays.

**Yilmaz Theory of Gravitation**

In the Yilmaz’s theory of gravitation (Misner, 1995) the far universe, although at infinity, takes on the appearance of an asymptotically thin, dense, and infinitely red-shifted shell sitting at a finite distance. The essential difference between this and Einstein’s theory is the addition of a localized field stress-energy tensor. Mass, m, in Einstein’s theory varies as $m = \gamma m_0$, where $\gamma = (\sqrt{1 - \frac{v^2}{c^2}} - 1)^{1/2}$ and $m_0$ is the rest mass, as a dynamic quantity that does not behave like electrical charges and currents or even mass as viewed from a Newtonian perspective. Gravity must be modeled as a curved space-time because we need curvature of space to account for the observed gravitational red-shift. Moreover, Einstein’s theory does not include conservation of rest mass. Gravitational bodies accelerate toward each other through an intermediary, a gravitational field due to the interaction. The passive gravitational mass of an object equals the inertial mass. This leads to experimental observations that rest masses are not conserved. Thus additional terms are needed in Einstein’s theory. The density divergence of the stress-energy tensor of the field supplies the needed forces for an interactive theory.
Thus, gravitation is due to space-time curvature responding to a localized field that is the source of the interaction. The essential difference between the Yilmaz theory and Einstein’s theory (Lorentz, 1952) is the addition of a localized gravitational field stress-energy tensor $T_{\mu}^\nu$ that is added to the right side of the equation:

$$R_{\mu}^\nu - 1/2 g_{\mu}^\nu R = 2 \kappa T_{\mu}^\nu,$$

**setting:** $R_{\mu}^\nu - 1/2 g_{\mu}^\nu R = G_{\mu}^\nu$ , then: $1/2 G_{\mu}^\nu = T_{\mu}^\nu.$ 

(1)

where $\kappa = 4\pi G/c^2 = 1$.

In Einstein’s theory the stress-energy tensor $T_{\mu}^\nu$ can be expressed as $\sigma = u_{\mu} u^\nu$ where $\sigma$ is the rest mass density and $u$ are the components of the four-velocity vector. Note that $\sigma$ has to be negative for the three warp concepts mentioned in Part I to work. By Einstein’s postulate, the trajectory of a point particle in a gravitational field is a geodesic. From Einstein’s special relativity theory (Einstein, 1905), mass is a dynamic quantity that varies as $m = \gamma m_0$ and does not behave like electric charges and currents or even as mass as visualized in Newtonian mechanics. Gravity should then be modeled as a curved space-time because such curvature would account for the observed gravitational field red-shift as well as predict mass conservation. This and other conditions are satisfied in the formulation:

$$D_{\nu} T_{\mu}^\nu = -\Gamma_{\kappa\lambda\mu}T^{\kappa\lambda\rho} = -\Gamma_{\kappa\lambda\mu}u^{\kappa}u^{\lambda} = \sigma d^2 x_{\mu}/ds^2 = 0,$$

and: $d^2 x_{\mu}/ds^2 = 0.$

(2)

Although Special Relativity describes the space-time surrounding N active gravitational masses, these masses do not accelerate or have forces acting between them in these formulations as does General Relativity (Einstein, 1915). If we place test particles near each of these gravitating masses, the particles should follow geodesic equations of motion. The Yilmaz theory (Misner, 1995) resolves this problem by introducing a different definition for the stress-energy tensor that requires the density divergence of the tensor to treat these additional degrees of freedom that accounts for the missing accelerations due to these forces or:

$$1/2G_{\mu}^\nu = \tau_{\mu}^\nu + t_{\mu}^\nu, D_{\nu}(\tau_{\mu}^\nu + t_{\mu}^\nu) = 0, \text{and } d\mu_{\nu}/ds = 1/\sqrt{-g\partial_{\mu}(\sqrt{-g}t_{\mu}^\nu)} .$$

(3)

What is proposed here for the warp-concept exotic matter, is that an additional term is again added to the stress-energy tensor. This may be similar to the use of electric fields suggested by Desiato (2003) or the use of including the total stress-energy tensor and removing a portion of it to account for this negative effect. This term could possibly be accounted for with a magnetic field or go a step further to include Jeffimenko’s co-gravitation field, or as the author would suggest the ‘spin’ field to produce these effects.

**Gravitational Anomalies**

Ning Wu (2003) states that under certain conditions ceramic superconductors with composite structures have revealed weak shielding properties against gravitational force. In both Newton’s theory of gravity and Einstein’s general theory of gravity, there are no theoretical grounds for gravitational shielding effects. Quantum gauge theory suggests gravitational interactions of complex scalar fields can be formulated based upon gauge principles. If the vacuum of the complex scalar field is not stable and uniform, a mass term appears in the gravitational gauge field and gravitational propagation in this unstable complex scalar field vacuum, will decay exponentially. Ning Wu proposed a completely new quantum gauge theory of gravity based upon renormalization of the 4-dimensional Minkowski space-time. Interactions are treated in flat space-time, not space-time geometry. A complex scalar field is derived considering a Bose condensation of Cooper pairs in superconductivity. Ning Wu analyzes Podkletnov’s experiment to understand gravitational shielding effects. It is found that the earth’s gravitational field decreases exponentially in an inhomogeneous superconductor. Moreover, there were three zones with different crystal structure and the shielding was due to the transition part of the disk and the supercurrent was disturbed by the high frequency magnetic field that influenced the penetration depth. When all is said and done, Ning Wu’s results imply superconductors warp space-time by virtue of gravitational shielding. The issue is whether or not superconductors can produce exotic matter?

Ning Wu’s results imply that in phase transition, an ordinary supercurrent may reveal gravitational shielding effects although no such effects occur in the stable superconductor state, as the supercurrent is strongly unstable. An inhomogeneous superfluid can also demonstrate gravitational shielding effects under stable conditions.
Quark-Gluon Plasma (QGP), a special state of matter, also reveals gravitational shielding effects. In its early stage, our universe was in the QGP State where long-range gravity can be shielded by an inhomogeneous vacuum. Local fluctuations of matter can cause instabilities of gravity, which will enlarge fluctuations of matter that is favorable to the formation of a galaxy.

Frolov (1997) suggests gravity is an induced effect that exists due to natural forces on a quantum level. What is the reason for gravity to exist without quantum mechanics for macro systems such as planets? Frolov states that the technology for compensation of gravity is through inertial propulsion. He implies that inertia may be created as an inner property as the energy of a body increases or decreases. This could be considered as similar to electromagnetic induction due to a charge in a magnetic field. Thus electromagnetic induction may be analogous to inertia. A flow of anti-photons is derived as coming from the future, and seen in past time. We are unable to observe the flow of photons in electric potential fields because they are in equilibrium with anti-photons in the time axis. Both exist in the structure of potentials. Thus, it should be impossible to generate propulsion force as a motion in space alone by means of inertia. The propulsion force also has a time-component and should demonstrate a chorial effect.

Ohtski and Ofuruton (1997) describe the thunderstorm season that results in St. Elmo’s fire displays on Mount Kirin. This is traditionally known as foxy fire. Current ball lightning models fundamentally disagree in the primary source of energy that range from vortex motion, chemicals mixing in air, charged aerogels or polymers, magnetic plasma loops, trapped microwaves, to nuclear power. There is a need for further investigation but the statistics have problems. For example, fair weather ball lightning appears in Japan and nowhere else. One model, for example by Arnhoff, looks at a radiation bubble solution of the Maxwell equations where the Poynting vector vanishes everywhere on the spherical surface for zero energy loss. N. Kondo, examining a 1-D numerical solution of the ionospheric wave equation found an electric field concentration inside fireball plasma in a microwave resonator preventing its de-excitation. One has to ask the question does ball lightning produce negative or exotic matter?

Halerewicz, Jr. (2001) indicates that the Van Den Broeck metric shrinks the size of the warp bubble to microscopic proportions to negotiate around the negative energy condition. It acts like a multiplier. This affects the external region of the warp bubble while internally, the effects of the bubble are as large as one desires and the overall approach may, because of reduced negative mass/energy, appear more reasonable. A point needs to be raised regarding this multiplier that Van Den Broeck applies to the Alcubierre metric top-hat function. From the UFO mythology, there are speculative reports that these crafts appear to be larger on the interior than the exterior dimensions suggest. If true, could this be similar to a space-time multiplier that is made a function of the geometry of a spacecraft? Several investigators (Bisnovatyi-Kogan, 2004) claim the existence of microscopic black holes. Are such entities, if they exist, also subject to a space-time multiplier?

Crawford (1995) suggests that there are reasons to assume that faster than light or FTL interstellar travel may be consistent with the laws of physics while not necessarily being in conflict with special relativity while being consistent with general relativity. Tachyons are FTL particles that violate the theory of relativity and require the notion of causality in physics. They may have imaginary rest mass. Wormholes are topological tunnels through space-time that permits FTL travel as a short-cut that could be used by a spaceship. Wormhole solutions are, however, unstable against small perturbations and passage of anything to include a photon may cause it to collapse before emerging on the other side. If they remain open, they would impose a modest tidal force and radiation fluxes on a spacecraft passing through it. To keep it open, it is necessary to thread it with matter or fields having a non-zero stress-energy tensor where its tension exceeds its total mass-energy density or it is negative and exotic. Casimir’s effect also requires a negative stress-energy tensor.

**Einstein’s Light Speed Limitation**

Faster-than-light speed is essential if space travel is to become a viable economic venture. Nevertheless, the conventional wisdom based upon Einstein’s *Special Theory of Relativity* (SRT) says light speed or faster travel is impossible. If a mass increases as one approaches the speed of light due to the singular behavior of the relativity factor, one must have infinite sustained thrust or else forego space travel. But what if the conventional wisdom is wrong? Although questionable, some data suggests space travel is feasible within intervals that defy current theories or thinking. It is our responsibility to cautiously examine these effects and if commonly accepted
notions cannot explain them, to devise additional hypotheses, test and acceptance thus creating newer theories. The author's papers in this series (Murad 1996, 1997, 1998, 1999) hopefully attempts to answer this question; however, each study may have answered some questions while raising several more. The last paper (Murad 1999) and Murad (2002) expand the problem to treat the serious consequences placed upon us by SRT.

A major concern is to look into the validity of deriving SRT using an admissible relativity factor whose velocity is greater than the speed of light. To extend it any further, the conventional wisdom states everything to include the velocity addition theorem becomes imaginary. If a pulse of light is emitted, the length of the pulse gives a stationary observer the sense of a specific dimension and the time required to traverses that distance. To the sublight moving coordinate system, the pulse is foreshortened in the direction of the coordinate system’s velocity vector but here too, similar information could be obtained. Einstein was very careful about stating his assumptions for analyzing this situation. In the analogy of using a stationary or reference coordinate system, a moving coordinate system, and a pulse of light, his description of the view of the pulse of light from the moving coordinate system is as if the moving system was inside the pulse. If this is so, then the moving system must move at sub-light speed. This was not stipulated in his assumptions. If the moving system moved at the speed of light, it would ride on the spherical pulse and if faster, the light pulse would never reach the moving coordinate system. Thus, nothing can or needs to be said about the constancy of the speed of light in the moving coordinate system in these latter two situations. Whether one looks at the light pulse from within the bubble of light or from its exterior is really our concern.

If we are looking at modifying Einstein’s SRT, what results should we expect when the speed is greater than light speed? Einstein uses the velocity addition theorem to rationalize why light speed is impossible. If one adds two angles together to define a rotation, the result resembles the velocity-addition theorem or:

\[ \theta = \theta_1 + \theta_2, \quad \text{where} \quad s = \tan \theta, \quad \text{and} \quad s = \frac{s_1 + s_2}{1 - s_1 s_2}. \]  

Changing coordinates, one may expect:

\[ \alpha = \alpha_1 + \alpha_2, \quad \text{where} \quad \beta = \tanh \alpha, \quad \text{and} \quad \beta = \frac{\beta_1 + \beta_2}{1 + \beta_1 \beta_2}. \]  

The velocity-addition theorem for sub-light resembles the latter equation. Should we expect an expression such as either of these to allow for hyper-light speeds?

Using the same terminology as in Einstein’s original derivation, let us assume that there is a stationary coordinate system along with a coordinate system that moves at hyper-light speeds when a pulse of light is emitted from the stationary system at the instant they pass each other. The equation relating these actions is:

\[ \frac{v}{\sqrt{v^2 - c^2}} \frac{\partial \tau}{\partial t} = \frac{\partial \tau}{\partial x^1} + \frac{1}{\sqrt{v^2 - c^2}} \frac{\partial \tau}{\partial t}. \]  

Here, \( v \) is the forward velocity of the moving coordinate system moving in the \( x \) direction. This differs from Einstein's original formulation in that \( v \) is greater than \( c \) and we are measuring infinitesimal quantities with respect to each coordinate system. Using Einstein's nomenclature, the transformation satisfying this equation is:

\[ \tau = u[1 - v/\sqrt{v^2 - c^2}] x', \quad x' = vt - x = [v - c] t. \]  

The distance traversed by the pulse of light from the moving coordinate system is:

\[ \xi = c \cdot \tau = ac[t - \frac{v}{\sqrt{v^2 - c^2}} x']. \]  

Moreover, the remaining coordinates are:

\[ \eta = \frac{acy}{\sqrt{v^2 - c^2}}, \quad \xi = \frac{acz}{\sqrt{v^2 - c^2}}. \]
Which, after manipulations results in:

\[
\tau = \phi(v) \beta \left[ \frac{v x}{c^2} - t \right], \quad \zeta = \phi(v) \beta \left[ v t - x \right], \quad \eta = \phi(v) y, \quad \zeta = \phi(v) z, \quad \text{where: } \beta = \frac{c}{\sqrt{v^2 - c^2}}. \tag{10}
\]

In Einstein's original sub-light derivation, he assumed a value for the variable as a function of velocity that introduces the Lorentz transformation. Other solutions exist:

\[
\phi(v) \cdot \phi(-v) = 1, \quad \phi(v) = \phi(-v) = \pm 1. \tag{11}
\]

*Einstein selected the positive value although the negative value is applied in this effort.* When substituted into the equation for the light pulse spherical geometry as observed by the moving coordinate system, this yields:

\[
-\xi^2 + [\eta^2 + \zeta^2] = -c^2 \tau^2 + r_c^2. \tag{12}
\]

Where \(\xi, \eta,\) and \(\zeta\) are the moving system's transformed coordinates. This is different from Einstein's original formulation that transforms a sphere in one coordinate system to an ellipsoid in another. There is no flat image of the light pulse, as we never reach the pulse or the speed of light. This equation is for a hyperboloid whose base is the initial sphere diameter. A value for radius accounts for time at sub-light speeds to reach these conditions. Once hyper-light, the observer sees a light spike as the radius of the sphere decreases with increasing time. This is not time reversal but that the hyperboloid radius decreases relative to the moving system with time.

If we transform one coordinate system with velocity \(V\), to another moving with velocity \(W\), we get:

\[
\begin{bmatrix}
 x \\
 t
\end{bmatrix}
 = -\gamma \begin{bmatrix}
 +1 \\
 +V/\gamma \sqrt{c^2 - 1}
\end{bmatrix}
 + \begin{bmatrix}
 +1 \\
 +W/\gamma \sqrt{c^2 - 1}
\end{bmatrix}
 \begin{bmatrix}
 \xi \\
 \tau
\end{bmatrix},
\]

\[
\gamma = \left( \frac{V^2}{c^2} - 1 \right)^{-\frac{1}{2}}, \quad \bar{\gamma} = \left( \frac{W^2}{c^2} - 1 \right)^{-\frac{1}{2}}. \tag{13}
\]

Where \(x\) and \(t\) are within the original coordinate system and both \(V\) and \(W\) are super-luminal. To reference the first coordinate system based upon the last results in:

\[
\begin{bmatrix}
 x \\
 t
\end{bmatrix}
 = -\bar{\gamma} \begin{bmatrix}
 +1 \\
 +U/\sqrt{1 + \frac{W^2}{c^2}} \sqrt{1 + \frac{W}{c^2}}
\end{bmatrix}
 \begin{bmatrix}
 \xi \\
 \tau
\end{bmatrix},
\]

With:

\[
\bar{\gamma} = -\gamma \left( \frac{W}{c^2} \right)^{\frac{1}{2}} = -\left( 1 - \frac{U^2}{c^2} \right)^{\frac{1}{2}}, \quad \text{where: } U = \left( \frac{W+V}{1+\frac{W}{c^2}} \right). \tag{15}
\]

This last expression is still the conventional velocity addition theorem but uses super-luminal velocities \(W\) and \(V\). The new relativity factor, however, is not imaginary at super-luminal speed. Hence, it is shown that the new Lorentz transformation, \(\beta\), for super-luminal speed is admissible and is used in a similar fashion as the Lorentz transformation for sub-light speeds. Thus, the premise of looking at an expanding light bubble from its exterior traveling at super-luminal speeds is thus theoretically feasible in contrast to the conventional wisdom.

A rationale is difficult to devise why the final velocity \(U\) is still sub-light despite the coordinate systems moving away from each other at super-luminal speeds. One view is that the object may have traversed a fold in spatial geometry *blinking-out* and is no longer visible. Another view is that a stationary observer only sees \(U\) when looking at the moving system within its cone of light. Hence, the observer only sees the moving system's past and never sees its *true* position.

What is the significance of this? A singularity occurs due to a coefficient that is a function of Mach number, in supersonic flow. The physical observations do not match the mathematics because bullets fly supersonically without problems. The result was to simply multiply this coefficient by minus one. The same situation exists except that the mathematics to do this is not yet that obvious. There are some more straightforward applications of interest. For example, the *Theory of Relativity* field equation (Lorentz, Einstein et al. (1952)) is:
\[
G_{\mu\nu} - \frac{1}{2} g_{\mu\nu} G = -k T_{\mu\nu} , \text{where } : g_{\mu\nu} = \text{varies} .
\]

Einstein surmised that the universe may be regarded as spatially finite with a uniform distribution of matter. With these thoughts, the energy-momentum tensor now becomes:

\[
T_{\mu\nu} = \gamma \rho c^2 u^\mu u_\nu , \text{ where: } \gamma^2 = \pm \frac{1}{1-\beta^2} , \beta = \frac{u}{c} .
\]

Whereas the conventional wisdom only considered the plus sign, which is for sub-light speeds, the minus sign is now also valid and represents conditions at hyper-light or faster than light speed. This may offer a solution to the negative matter problem as well. It is not our intention to be an iconoclast regarding Einstein or the Theory of Relativity. He does state three times, however, that based upon his assumptions one could not travel faster than the speed of light. His analysis based upon his assumptions is true only for the sub-light case and his subsequent conclusions are correct. This analysis only extends his initial approach by finding an admissible Lorentz transformation to treats hyper-light conditions. This new transformation allows investigating other problems within these speed ranges and treatment of such problems directly using the field equations.

**A Possible Way Out....**

Desiato (2003) raises the bar regarding the negative energy issue. His approach is to take advantage of the scalar potential used in the conventional means of identifying an electric and magnetic field that solves Maxwell’s equations. Murad (1999) offers a different approach. If the electric field scalar potential has any value according to Desiato, is it feasible to include a magnetic scalar potential as well as see if the combined effects are noteworthy? That will not be presented here. However, the method will be briefly described for identifying a magnetic scalar potential. The basic premise is that there is a large amount of symmetry between electricity and magnetism in a mathematical sense and, if true, this can be used to define additional scalar and vector potentials.

With these views, the electric and magnetic fields are redefined with \( \alpha \) as an arbitrary constant in the following:

\[
\vec{E} = -\frac{\partial \vec{A}}{\partial t} - \nabla \varphi_e + \alpha \, \varepsilon^2 \nabla \times \vec{C} \text{ and} \]

\[
\vec{B} = \nabla \times \vec{A} + \nabla \varphi_m + \alpha \frac{\partial \vec{C}}{\partial t} .
\]

The vector \( \vec{A} \) and \( \varphi_e \) have the standard definitions whereas the vector \( \vec{C} \) and \( \varphi_m \) represent a new vector and scalar potential used to more accurately define the magnetic field. The symmetry between these relations is obvious and a second Lorentz condition exists that identifies a relationship between these two new potentials in the form:

\[
\nabla \cdot \vec{C} = -\frac{1}{\alpha \varepsilon^2} \frac{\partial \varphi_m}{\partial t} .
\]

With manipulation, the two vectors and scalar potentials can be separated out and are reduced to wave equations as follows:

\[
\nabla^2 \vec{A} - \frac{1}{\varepsilon^2} \frac{\partial^2 \vec{A}}{\partial t^2} = -\mu J_e , \quad \nabla^2 \vec{C} - \frac{1}{\varepsilon^2} \frac{\partial^2 \vec{C}}{\partial t^2} = -\frac{1}{\alpha \varepsilon^2} J_m ,
\]

\[
\nabla^2 \varphi_e - \frac{1}{\varepsilon^2} \frac{\partial^2 \varphi_e}{\partial t^2} = -\frac{\rho_e}{\varepsilon} , \quad \nabla^2 \varphi_m - \frac{1}{\varepsilon^2} \frac{\partial^2 \varphi_m}{\partial t^2} = \rho_m .
\]

Interestingly, the vector potentials are functions of the electric and magnetic currents while the scalar potentials are only functions of electric and magnetic sources or density respectively. If no source or current exists, it is possible that these terms will still be non-zero due to boundary conditions. In these expressions, the value of the constant \( \alpha \) is inconsequential and does not affect these equations directly except for the magnetic vector potential; it has no nonlinear effect upon the other vector or scalar terms. Finally, for the above situation where there is no currents or sources, it is also feasible to have these relationships in such an agreement that neither electric nor magnetic field could be identified in the Bohm-Aharonov effect but the potentials may still not vanish. Returning to Desiato, a similar relationship could be derived for the Lorentz force that depends upon the charge to mass ratio to produce negative energy. However, it is speculated that this would not only depend upon an electric but also a magnetic scalar potential.
CONCLUSIONS

The author’s approach taken in this paper has been one of cynical doubt. However, in better understanding the warp-drive efforts of many others, they extended this body of technical work as well as work on traversable wormholes and the Krasnikov tunnel, it appears these efforts may be sound and obviously require further investigations and understanding. Primary amongst this is to define a new class of space-time metrics that may provide solutions without any negative energy requirement as the ideal or desired case. The other perplexing issue is how to divine suitable experiments and develop devices that take advantage of space-time curvature to understand these anomalous effects and what occurs during normal conditions. This is a far larger challenge that may provide significant insights into other mysteries of our universe to include identifying black holes with and without event horizons or even improving such black-hole metric models that possess jets of matter that leave along the centerline. Such peculiarities add complexity to the notion of singularities and the need to be fully understood before we can fully grasp the significance of altering space-time at near light speed conditions.

"Views expressed in this article are those of the author and do not reflect the official policy or position of the U.S. Government."

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