The Levitron™
A Counter-Gravitation Device for ECE-Theory Demonstration

Galactican Group

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5840 Cameron Run Terrace
Suite 320
Alexandria, VA 22303

Phone; 703-960-0443
c.kellum@verizon.net
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The Levitron™: *A Counter-Gravitation Device for ECE-Theory Demonstration*

Charles Kellum
Galactican Group, 5840 Cameron Run Terrace, Suite 320, Alex., VA, USA
E-mail: c.kellum@verizon.net

ABSTRACT. The Levitron is a small, inexpensive, anti-gravity device consisting of a base magnet and a top with a magnetic ring attached. The spinning top can be made to "*float/levitate*" above the magnetic base. Although the Levitron is viewed by some as a toy, it can be used to demonstrate anti-gravity aspects of ECE-Theory. The ECE-Theory is used to explain the dynamics of the Levitron, including the spin requirement for the top. While the Levitron dynamics have defied quantitative analytical explanation, an attempt was made (circa 1995) by M.V. Berry, then of the Wills Physics Laboratory, UK. Without the benefit of ECE-Theory, Berry attempted to focus on mechanical principles to explain Levitron operation. The ECE-Theory however, provides a quantitatively accurate description of Levitron dynamics. The Levitron is thus a counter-gravity, ECE-Theory demonstration device. It can easily be obtained and operated by those new to and/or requiring experimental proof of ECE-Theory. ECE-Theory is a combination of the geometric approach of Einstein for describing nature, the mathematical methods of Cartan, and the combination of both, formally introduced in 2003, by Dr. Myron W. Evans. Einstein, in his General Relativity Theory of 1915, used the Riemann geometry, in which space is curved. Cartan, in the twenties, showed that Riemann's description of geometry was incomplete. Cartan added torsion (i.e. the concept of spinning spacetime) to the Riemann description. Dr. Evans found the missing piece, that Einstein gravitation is described by curvature, and Cartan Torsion describes the laws of electrodynamics. The same set of equations describe both.

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1.0 Introduction

The Levitron [1] is a device consisting of a top (s), with an attached ring magnet (M_1), and a magnetic base (M_2). It operates on magnetic-levitation (mag-lev)/counter-gravity principles. The spinning top (i.e. the rotating M_1) can float stably above M_2 , the magnetic base. A generic configuration is illustrated in Figure 1 below. Items M_1 (i.e. M_L) and M_2 (i.e. M_B) are magnetic devices. Figure 2 shows the precession of the top, as its spin degrades.

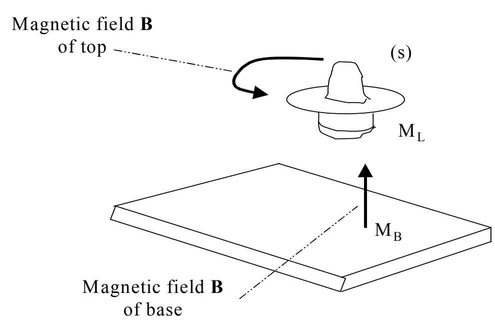

Fig. 1 Generic LEVITRON

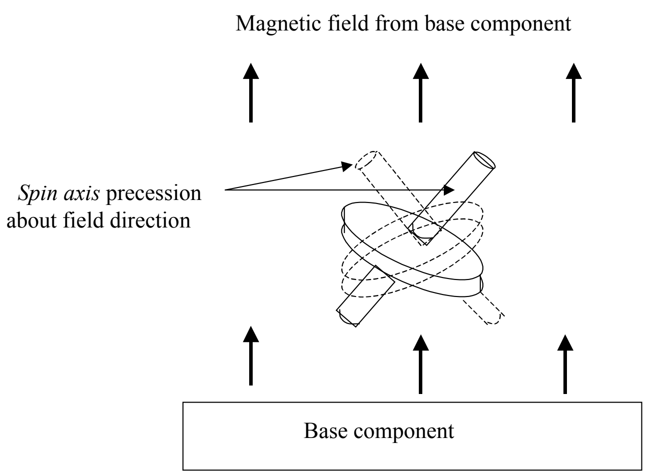

Fig. 2 Precession of Top

The Levitron dynamics has defied a quantitatively accurate explanation until that attempted in [1]. The most definitive paper on Levitron dynamics [1], examines *the mechanics* of the device as a rotating dipole, in a magnetic field. However, ECE-Theory easily explains the Levitron. Thus, the Levitron can be viewed as a demonstration-device for ECE-Theory. The Levitron employs counter-rotating magnetic fields to achieve its counter-gravity effect. It falls in the class of devices defined in [2], [3], and [4].

1.1 *A Note on Counter-Rotation*

We note once again that, for the Levitron, M_1 is attached to the top (s), M_2 is the base. Device operation shows the top must spin to levitate stably above the base. More correctly, M_1 is required to spin.
Let:

$\boldsymbol{v}_{M1}$, $\boldsymbol{v}_{M2}$ $\rightarrow$ rotational velocities of the magnets
for counter-rotation ($\boldsymbol{v}_{M1} + \boldsymbol{v}_{M2}$) $\rightarrow$ $\boldsymbol{v}_r$ relative velocity.

If $\boldsymbol{v}_{M2} = 0$, then we have the Levitron case. For levitation, $\boldsymbol{v}_r$ must be positive. Thus, one argues the Levitron top must spin. However, it is M_1 that is required to spin.

It is useful to note that the explanations of the Faraday disk generator [8], are similar to those of this section. The explanations of the Faraday disk (*homopolar*) generator incorporate ECE-Theory. It has been fully explained by ECE-Theory.

2.0 The Spin/Rotation Requirement

For the Levitron, a spin component is needed to couple with spacetime torsion, to achieve spin-connection-resonance (SCR). This spin component must exceed some β to maintain SCR and stability. Stated more precisely, from the above discussion;

$\boldsymbol{v}_r \geq \beta \rightarrow$ stability of top above the base
$\boldsymbol{v}_r < \beta \rightarrow$ instability of top, causing it to fall

If the Levitron's $\boldsymbol{v}_{M1}$ spin/rotation component is less than β, the top falls away along a geodesic path induced by the anti-gravity condition caused by the interaction of the Levitron's ring magnet (M_1), and magnetic base (M_2). This factor is exploited as a propulsion system concept in [3].

2.1 *Quantitative Analysis Using ECE-Theory*
Starting with the ECE Poisson equation:

$$\nabla \cdot (\nabla \Phi + \boldsymbol{\omega} \Phi) = -\rho / \varepsilon_0$$
$$\nabla^2 \Phi + \boldsymbol{\omega} \cdot \nabla \Phi + (\nabla \cdot \boldsymbol{\omega}) \Phi = -\rho / \varepsilon_0 \qquad \text{9.6 of [5]}$$

From section 4.3 of [3], we have the following;

$$(\nabla \boldsymbol{\mu}_1 (t) \cdot \mathbf{B}_1 (r) + \nabla \boldsymbol{\mu}_2 (t) \cdot \mathbf{B}_2 (r)) = \Phi_\lambda$$

From [6] we have the following resonance equation;

$$d^2\Phi / dr^2 + (1/r - \omega_{int})\, d\Phi / dr - (1/r^2 + \omega_{int}/r)\, \Phi = -\rho / \varepsilon_0 \qquad \text{14.32 of [6]}$$
Where; $\omega_{int} \rightarrow$ the interaction spin connection

From Coulombs Law $\nabla \cdot \mathbf{E} = \rho / \varepsilon_0$, one also has $\mathbf{E} = \nabla \Phi$. Using Φ_λ one has the following;

$$\nabla^2 \Phi_\lambda = \rho / \varepsilon_0 \quad \text{(where } \Phi_\lambda \text{ is the driving function)}$$

The driving function Φ_λ determines the degree of induced curvature $\boldsymbol{F} (\boldsymbol{\mu}_i , \mathbf{B}_i)$.
Let;

$$(\nabla \boldsymbol{\mu}_1 (t) \cdot \mathbf{B}_1 (r) + \nabla \boldsymbol{\mu}_2 (t) \cdot \mathbf{B}_2 (r)) = \Phi_\lambda \qquad (1)$$
$$\nabla (\boldsymbol{\mu}_1 (t) \cdot \mathbf{B}_1 (r)) + \nabla (\boldsymbol{\mu}_2 (t) \cdot \mathbf{B}_2 (r)) =$$
$$M_1 (r) + M_2 (r) =$$

$$d\Phi_\lambda / dr = dM_1 / dr + dM_2 / dr \qquad (2)$$

$$d^2\Phi_\lambda / dr^2 = d^2M_1 / dr^2 + d^2M_2 / dr^2 \qquad (3)$$

substituting in 14.32 of [6], one has the following;

$$-\rho / \varepsilon_0 = (d^2M_1 / dr^2 + d^2M_2 / dr^2) + (1/r - \omega_{int}) (dM_1 / dr + dM_2 / dr) - (1/r^2 - \omega_{int}/r) (M_1 (r) + M_2 (r)) \quad (4)$$

5840 Cameron Run Terrace
Suite 320
Alexandria, VA 22303
Phone; 703-960-0443
c.kellum@verizon.net

$$-\rho/\varepsilon_0 = d^2M_1/dr^2 + d^2M_2/dr^2 + dM_1/rdr - \omega_{int}\, dM_1/dr + dM_2/rdr - \omega_{int}\, dM_2/dr - M_1/r^2 - M_1\omega_{int}/r - M_2/r^2 - \omega_{int}M_2/r \quad (5)$$

From section 4.1 of [3], we use the expression derived for $\boldsymbol{H}$, the geodesic-fall path velocity of a vehicle;

$$M_1M_2/\boldsymbol{r}^2 \approx -K\,T_{\mu\nu}$$

$$= \boldsymbol{H}$$

We then have the following;

$$\left.\begin{aligned} M_1 &\approx -\boldsymbol{r}^2 K\,T_{\mu\nu}/M_2 \\ dM_1/dr &\approx -\boldsymbol{r} K\,T_{\mu\nu}/2M_2 \\ d^2M_1/dr^2 &\approx -K\,T_{\mu\nu}/2M_2 \end{aligned}\right\}\ \text{substituting into eq. (5)}$$

after some algebraic simplification, one has the following;

$$d^2M_2/dr^2 + (1/r - \omega_{int})\, dM_2/dr + \omega_{int}\, K\,T_{\mu\nu}\,(r+2)/2M_2 - (M_2 + r\,M_2\omega_{int})/r^2 = -\rho/\varepsilon_0$$

$$d^2M_2/dr^2 + (1/r - \omega_{int})\, dM_2/dr - (1 + r\,\omega_{int})\, M_2/r^2 = -\rho/\varepsilon_0 + \mathit{Constant} \qquad (6)$$

Equation (6) is a resonance equation in M_2

An expression for a resonance equation in M_1 , can also be derived in a similar manner. Considering the ECE Poisson equation;

$$\nabla^2\Phi + \boldsymbol{\omega} \bullet \nabla\Phi + (\nabla \bullet \boldsymbol{\omega})\,\Phi = -\rho/\varepsilon_0$$

Arguably, SCR can be achieved relative to M_1 , M_2 , or Φ*.* The counter-rotation of M_1 and M_2 is needed to amplify Φ *via SCR.* This provides the counter-gravitation effect, and is thus the reason why the magnet (M_1), must spin, if counter-gravitation is to be maintained. This is a direct consequence of ECE-Theory.

5840 Cameron Run Terrace
Suite 320
Alexandria, VA 22303

Phone; 703-960-0443
c.kellum@verizon.net

3.0 Quantitative Basics

The primary objective is to show the Levitron as an example of geodesic-fall. Aspects of the ECE-Theory are used to analytically define a spacetime curvature framework for discussions below. The following steps are taken;

--- define a coordinate system for the Levitron-top
--- define a coordinate system for the Levitron-base
--- show gamma-connection between coordinate systems of base and top

Using Bianchi identities (where possible), one can derive gamma-connections between the coordinate systems of the base and the top, where;

$(x_b, y_b, z_b, t_b) \rightarrow$ base ; $(x_p, y_p, z_p, t_p) \rightarrow$ top

Using for example Cartesian coordinates for the base, and spherical coordinates for the top

From [7], the definitions in this section are used. The general framework of this exercise is taken as two coordinate systems. Generally, an affine connection exists on a smooth manifold, and connects nearby tangent spaces (e.g. coordinate systems) to that manifold. In oversimplification, a Cartan connection is a generalization of an affine connection. The coordinate systems of the top and of the base are considered. An affine connection is;

$$\boldsymbol{\Gamma}_{\lambda\nu}{}^{\mu} = \{{}_{\lambda}{}^{\mu}{}_{\nu}\} = (\partial x^{\lambda} / \xi^{\alpha})(\partial^2 \xi^{\alpha} / \partial x^{\mu} \partial x^{\nu})$$

Where;

$\rightarrow$ x_μ , x_ν are the (*translation* and *rotation*) coordinates of the base
$\rightarrow$ ξ^α is a free falling coordinate system

$\boldsymbol{\Gamma}_{\mu\nu}{}^{k}$ is a gamma connection of differential geometry

$\boldsymbol{\Gamma}_{\mu\nu}{}^{k} \neq \boldsymbol{\Gamma}_{\nu\mu}{}^{k}$ $\rightarrow$ gamma connection is not symmetric in Cartan geometry
(*Cartan geometry is a generalization, of the Riemann geometry used in Relativity theory, and the above definition of the affine connection is no longer valid*.)

From the Cartan geometry [9], the antisymetric connection defines spacetime torsion, which can be represented by the torsion tensor ($T^{\lambda}{}_{\mu\nu}$) where;

$$T^{\lambda}{}_{\mu\nu} = \Gamma^{\lambda}{}_{\mu\nu} - \Gamma^{\lambda}{}_{\mu\nu}$$

$T^{\lambda}{}_{\mu\nu} = q^{\lambda}{}_{a} \; T^{a}{}_{\mu\nu}$ $\rightarrow$ torsion tensor (where q is a tetrad/frame-field)

At this point we consider some of the primary operational details of the Levitron device, in the context of the ECE-Theory. With the discussions of this section, the result should be a quantitatively accurate description of the Levitron device dynamics.

5840 Cameron Run Terrace *Phone; 703-960-0443*
Suite 320 *c.kellum@verizon.net*
Alexandria, VA 22303 G2/WP03

3.1 *Aspects from Differential Geometry*

To begin, we take the conceptual approach of [9], and [10] and set up a basis for the Levitron's top, and a basis for the Levitron's base. We then take the following steps;

-- define covariant derivatives for a vector in the top's vector space
-- define covariant derivatives for a vector in the base's vector space
-- take commutator of the covariant derivatives
(2 torsion tensors should result, considering eq. 9 of [11])

Let:

$(x_b, y_b, z_b, t_b) = \mathcal{V}^b \rightarrow$ base ; $(x_z, y_z, z_z, t_z) = \mathcal{V}^z \rightarrow$ top

be base vectors for the coordinate systems of the Levitron base and top, respectively.

Since a vector is a tensor of rank 1, the covariant derivatives of $\mathcal{V}^b$ and $\mathcal{V}^z$ are;

$$D_\mu \mathcal{V}^b = \partial_\mu \mathcal{V}^b + \Gamma_{\mu\theta}{}^b \mathcal{V}^\theta$$

$$D_\mu \mathcal{V}^z = \partial_\mu \mathcal{V}^z + \Gamma_{\mu\theta}{}^z \mathcal{V}^\theta$$

As the commutator of covariant derivatives operates on vectors $\mathcal{V}^b$ and $\mathcal{V}^z$ we have the following;

$$[D_\mu, D_\nu]\,\mathcal{V}^b = R^b{}_{\sigma\mu\nu}\,\mathcal{V}^\sigma - T^\kappa{}_{\mu\nu}\,D_\kappa \mathcal{V}^b \quad \text{and} \quad [D_\mu, D_\nu]\,\mathcal{V}^z = R^z{}_{\sigma\mu\nu}\,\mathcal{V}^\sigma - T^\kappa{}_{\mu\nu}\,D_\kappa \mathcal{V}^z$$

Substituting $D_\mu \mathcal{V}^b$ and $D_\mu \mathcal{V}^z$ in the expressions for $[D_\mu, D_\nu]\,\mathcal{V}^b$ and $[D_\mu, D_\nu]\,\mathcal{V}^z$ respectively, yields the following 2 torsion tensors;

$T_{\mu b}{}^\theta = q^\theta{}_a\ T^a{}_{\mu b}$ $\rightarrow$ torsion tensor (from [9]) for the Levitron's base

$T_{\mu z}{}^\theta = q^\theta{}_a\ T^a{}_{\mu z}$ $\rightarrow$ torsion tensor (from [9]) for the Levitron's top

(where: (q) --- is a tetrad/frame-field,
(a) --- is the index of the tangent space

Realizing that Levitron anti-gravity is enabled by induced curvature of spacetime, the interaction of the magnetic fields of its base-component and its top (i.e. the magnetic ring around its top), should be considered. One can replace the connection coefficients Γ with the interactive spin connection ω_{int} which (*simplifying indices*) results in the following basis vectors;

$$D_\mu \mathcal{V}^b = \partial_\mu \mathcal{V}^b + \omega_{int} \mathcal{V}^b$$

$$D_\mu \mathcal{V}^z = \partial_\mu \mathcal{V}^z + \omega_{int} \mathcal{V}^z$$

Under ECE-Theory & technology, a primary method for achieving counter-gravity effects is to use the electric field to induce a Newtonian force of sufficient magnitude, and in the opposite direction of gravitational forces. We define:

ω_{int} $\rightarrow$ the interactive spin connection between the Levitron's base & top
Φ $\rightarrow$ the spacetime electric potential energy

The electric field can be defined as ;

$$\mathbf{E} = -(\nabla + \boldsymbol{\omega})\,\Phi$$

The ECE Poisson equation is:

$$\nabla^2\Phi + \boldsymbol{\omega}\cdot\nabla\Phi + (\nabla\cdot\boldsymbol{\omega})\,\Phi = -\rho/\varepsilon_0$$

this leads to;

$$d^2\Phi/dr^2 + (1/r - \omega_{int})\,d\Phi/dr - (1/r^2 + \omega_{int}/r)\,\Phi = -\rho/\varepsilon_0 \qquad \text{14.32 of [6]}$$

which is a resonance equation in Φ.

In section 2.0, of the main document, an expression for Φ is derived. *The requirement for the spinning, of the Levitron-top's magnetic ring, is then established*.

3.2. *Generic Counter-Rotation*

For the Levitron case, M_1 is attached to the top (s), M_2 is the base. A generalization of this concept is an object (e.g. the Levitron's top) spinning between the M_1 and M_2 magnetic sources. If the object is magnetized (i.e. M_3), one has M_3 rotating relative to M_1 , and M_3 rotating relative to M_2 simultaneously. Thus, counter-rotation of M_3 and M_1 , and of M_3 and M_2 is realized. This results in levitation of the object. Analytically, from section 1.1 above, where;

$\boldsymbol{v}_{M1}$, $\boldsymbol{v}_{M2}$ $\rightarrow$ rotational velocities of the magnetic sources

$\boldsymbol{v}_{M3}$ $\rightarrow$ rotational velocity of the object

If $\boldsymbol{v}_{M1} = \boldsymbol{v}_{M2} = 0$, and $\boldsymbol{v}_{M3} > 0$, anti-gravity regions are produced between (counter-rotating) M_3 and M_1 , and between (counter-rotating) M_3 and M_2 , causing the object to levitate.

5840 Cameron Run Terrace
Suite 320
Alexandria, VA 22303
Phone; 703-960-0443
c.kellum@verizon.net

4.0 Some Levitron Operational Details

In this section, examining the force on the top, a gravitation (i.e. mechanical) problem and an electromagnetic problem must be solved. Defining Φ_{top} as the scalar potential energy of the top, it is shown (from [1]) that equilibrium is achieved if $\nabla \Phi_{top} = 0$. If $\partial^2\Phi_{top} / \partial z^2 > 0$, vertical stability is achieved. Horizontal stability is achieved when $\partial^2\Phi_{top} / \partial x\partial y > 0$. Considering the field equations of the ECE-Theory, we can write them in a simplified Einstein-like form from [7];

$$G_{\mu\nu} = - K\, T_{\mu\nu} + \ell T^{\lambda}{}_{\mu\nu}$$

where; --- the torsion/spin $T^{\lambda}{}_{\mu\nu}$ is accounted for in the ECE-Theory
--- K and ℓ are constants
--- $T_{\mu\nu}$ is the energy-momentum density

If ;

$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu}$, with Ricci tensor $R_{\mu\nu}$ and metric tensor $g_{\mu\nu}$ asymmetric (as defined in the ECE-Theory)

Then;

Their components are anti-symmetric, representing spin. We then have equivalencies;

$$\boldsymbol{F} \approx G_{\mu\nu} \rightarrow \ell T^{\lambda}{}_{\mu\nu} \approx \nabla \boldsymbol{\mu}(t) \bullet \mathbf{B}(r) = \Phi_{\lambda}$$

Where Φ_{λ} is the scalar potential due to counter-rotation of M_1 and M_2 . The rotation of M_1 acts as a driving function to amplify Φ_{λ} . The magnitude of M_1 and its rotation ($\boldsymbol{v}_{M1}$) determine the SCR.
Thus, the spin and magnitude of M_1 can be independently adjusted to achieve maximum SCR. Therefor, spin, $|\mathbf{B}(r)|$, and curvature are related. QED

The greater the spin and/or the greater the **B** field strength, the greater the induced curvature that causes these conditions. The top's spin acts as a *driving function* to amplify Φ (the scalar potential), and thus enhance counter-gravitation between the top & base, at resonance. Going back to equation (1);

$$(\nabla \boldsymbol{\mu}_1(t) \bullet \mathbf{B}_1(r) + \nabla \boldsymbol{\mu}_2(t) \bullet \mathbf{B}_2(r)) = \Phi_{\lambda} \qquad (1)$$

Adding rotation vectors gives maximum relative rotation, and implies the rotating magnets are *counter-rotating*. Obviously, if the magnets (M_1 and M_2) are rotating in the same direction, the vectors ($\boldsymbol{v}_{M1}$, $\boldsymbol{v}_{M2}$) must be subtracted, thus minimizing the rotation effect, *and consequentially any counter-gravitation effect*. In the case of the Levitron, $\boldsymbol{\mu}_2(t) = 0$. Thus, Φ_{λ} is derived solely from the rotation ($\boldsymbol{v}_{M1}$) of M_1 (the magnet attached to the Levitron's top).

4.1 *Vector Potential* $\mathbf{A}_{\lambda}$

With the scalar potential Φ_{λ} defined, the vector potential $\mathbf{A}_{\lambda}$ is now derived. Using the ECE field equations from [7], one can define a curvature-based analysis of the Levitron. Focusing on <u>*functional equivalencies*</u> of $\boldsymbol{F}$ and $G_{\mu\nu}$ we have

$$\int \boldsymbol{F}\, dq_i = \Delta\Phi_{top} \quad ; \quad \text{where } \Phi_{top} \text{ is the potential energy of the top}$$

5840 Cameron Run Terrace
Suite 320
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c.kellum@verizon.net

From [1], the forces $\boldsymbol{F}$ on the Levitron top (*gravitational and magnetic*) can be defined as follows;

$$\boldsymbol{F} = -mge_z + \nabla \boldsymbol{\mu}(t) \bullet \mathbf{B}(r) \quad ;$$

where: $\boldsymbol{\mu}(t)$ is the top's vector moment (*the top considered as a magnetic dipole*)
$\boldsymbol{\mu}(t) \times \mathbf{B}(r)$ is the magnetic torque

Equilibrium is achieved if $\nabla \Phi_{top} = 0$. If $\partial^2 \Phi_{top} / \partial z^2 > 0$, vertical stability is achieved. Horizontal stability is achieved when $\partial^2 \Phi_{top} / \partial x \partial y > 0$. Considering the field equations of the ECE-Theory, we can write them in a simplified Einstein-like form from [10];

$$G_{\mu\nu} = -K\, T_{\mu\nu} + \ell T^{\lambda}_{\mu\nu}$$

where; --- the torsion/spin $T^{\lambda}_{\mu\nu}$ is accounted for in the ECE-Theory
--- K and ℓ are constants
--- $T_{\mu\nu}$ is the energy-momentum density

If ;

$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu}$, with Ricci tensor $R_{\mu\nu}$ and metric tensor $g_{\mu\nu}$ asymmetric (as defined in the ECE-Theory)

Then;

Their components are anti-symmetric, representing spin. We then have equivalencies;

$$\boldsymbol{F} \approx G_{\mu\nu} \rightarrow \ell T^{\lambda}_{\mu\nu} \approx \nabla \boldsymbol{\mu}(t) \bullet \mathbf{B}(r)$$

Thus, spin, $|\mathbf{B}(r)|$, and curvature are related. QED

The greater the spin and/or the greater the **B** field strength, the greater the induced curvature that causes these conditions. The top's spin acts as a *driving function* to amplify Φ (the scalar potential), and thus enhance counter-gravitation between the top & base, at resonance. This spin connection resonance (SCR) is defined in [6] thru [8]. As shown above, it too is needed to counter $G_{\mu\nu}$. References [6], [10], and [14] also provide insight as to which kind of resonances can be expected. The induced curvature counters gravitation, in this Levitron case. Changes in spin, due to friction and other mechanical forces, reduce induced curvature. This causes instability in the Levitron device, resulting in the Levitron's top to fall away form its equilibrium position above the Levitron's base. The observed behavior of the device conforms to this analysis, and the analysis given in [1].

4.1.1 *Derivation of* $\mathbf{A}_{\lambda}$ *Using ECE-Theory*

In the above discussion of section 4, the old Einstein Equation $G_{\mu\nu}$ was used. While this is obsolete under the new ECE-Theory, it illustrates that the new ECE-Theory accommodates the Einstein Equation, as a special case of the more general case, under the Cartan Geometry base of the ECE-Theory. This illustration might be useful to those engineers unfamiliar with (or new to) ECE-Theory. Also, as shown below in this section, and section 5.0, use of ECE-Theory greatly simplifies the process for design & analysis of electromagnetic devices. This process simply involves derivation of the vector potential (**A**) from the force expression (**F**) of a device (in this case the Levitron). With (**A**) defined, the angular momentum (**L**) is derived [16]. Finally, the momentum representations of the "*ECE-Field Equations of Dynamics*" from [15] are used to derive the equations-of-motion. For the Levitron case, the torque on the Levitron's top is used to illustrate this analysis process.

Considering the magnetic torque on the Levitron top, one can start with the following magnetic force expression;

$$\mathbf{F}_{mag} = \boldsymbol{\mu}_1(t) \times \mathbf{B}_1(r) + \boldsymbol{\mu}_2(t) \times \mathbf{B}_2(r)$$

and the gravitational (i.e. mechanical) force $\mathbf{F}_{grv} = mg\mathbf{z}$ **,** the total force is obviously given as

$$\mathbf{F}_{tot} = \mathbf{F}_{grv} + \mathbf{F}_{mag}$$

This expression can be used to derive the vector potential. From Schrodinger's theory of quantum mechanics, the relation between the potential energy **A** of an object moving under the force $\mathbf{F}(q_i)$ is defined as;

$$\mathbf{F}(q_i) = \partial\mathbf{A}/\partial q_i$$

Integrating, the expression for the vector potential is;

$$\int \boldsymbol{F}\, dq_i = \mathbf{A}$$

Thus $\mathbf{A}_\lambda$ can obviously be defined as:

$$\int \mathbf{F}_{tot}\, dq_i = \mathbf{A}_\lambda$$

With the force, the scalar potential, and the vector potential defined, the *equations of motion* (i.e. momentum, spacetime torsion, torque) can be derived using the ECE force equations from the ECE-Theory Engineering Model [15]. For angular momentum **L**, the following is used;

$$\mathbf{L} = (\nabla \times \mathbf{A}_\lambda - \boldsymbol{\omega} \times \mathbf{A}_\lambda)$$

The torque $\boldsymbol{T}$ is defined as;

$$\boldsymbol{T} = \partial\mathbf{L}/\partial t - \boldsymbol{\mu} \times \mathbf{L}$$

Using the Torsional Force Law of [15] ;

$$\boldsymbol{T}^{\lambda}{}_{\mu\nu} = \boldsymbol{F}/E_0 \quad \text{<where } E_0 \text{ is the rest energy>}$$

The field equations are defined as follows, again from [15];

$$\mathbf{E} = -\nabla\Phi - \partial\mathbf{A}_\lambda/\partial t + \boldsymbol{\omega}_E$$
$$\mathbf{B} = \nabla \times \mathbf{A}_\lambda + \boldsymbol{\omega}_B$$

The ECE-Theory thus provides a quantitatively accurate description of the dynamics of the Levitron device.

5840 Cameron Run Terrace
Suite 320
Alexandria, VA 22303
Phone; 703-960-0443
c.kellum@verizon.net

4.2 *An Application Extension*

A propulsion concept can utilize induced spacetime curvature, similar to the Levitron mag-lev process. Thus the Levitron's *instability-behavior* (i.e. the top's *fall* away from the base, along the magnetically induced geodesic path) is similar to the fall of a vehicle along such a magnetically induced geodesic path. This fall could constitute vehicular propulsion. However, said vehicle's fall along a geodesic path can be controlled, and *not be a random instability condition*. The parameters governing the instabilities exhibited by the Levitron can be properly controlled to provide a command & control method for such a propulsion process. Overall, the Levitron illustrates an application of induced spacetime curvature. ***It should be clear that magnetic forces are <u>not used "directly"</u> to drive the vehicle.***

5840 Cameron Run Terrace
Suite 320
Alexandria, VA 22303
Phone; 703-960-0443
c.kellum@verizon.net

5.0 Application of ECE Antisymmetry Laws

To simplify this analytical process of section 4, the new ECE Antisymmetry laws can be applied. For simplicity, we can concentrate on the electromagnetic portion of the force equation defined in section 4, above.

Given;

$$\mathbf{F}_{mag} = \boldsymbol{\mu}_1(t) \; X \; \mathbf{B}_1(r) + \boldsymbol{\mu}_2(t) \; X \; \mathbf{B}_2(r) \quad \text{and} \quad \int \boldsymbol{F} \, dq_i = \mathbf{A}$$

Let;

$$\boldsymbol{\mu}_1(t) \; X \; \mathbf{B}_1(r) = \zeta_1 \rightarrow \text{ the magnetic torque due to } M_1 \text{ rotation}$$

Next, the covariant derivative of $\boldsymbol{\zeta}_1$ in the field of M_2 is defined. Considering the covariant derivative of $\boldsymbol{\zeta}_1$ at a point *p* (in the field of M_2) we have;

$$\zeta_1 = (\mathbf{B}_2^{\,i} \, \zeta_1^{\,j} \, \Gamma^{k}_{ij} + \mathbf{B}_2^{\,i} \, \partial \zeta_2^{\,k} / \partial x^i) \, \mathbf{e}_k$$

$$= \mathbf{B}_2^{\,i} \, (\zeta_1^{\,j} \, \Gamma^{k}_{ij} + \partial \zeta_2^{\,k} / \partial x^i) \, \mathbf{e}_k$$

$$= \mathcal{V}^{\rho}$$

Using the notation of equations (1) thru (4) of [12], for consistency & clarity; the commutator of covariant derivatives operates on vector $\mathcal{V}^{\rho}$, as follows;

$$[D_\mu , D_\nu] \, \mathcal{V}^{\rho} = R^{\rho}{}_{\sigma\mu\nu} \, \mathcal{V}^{\rho} - T^{\lambda}{}_{\mu\nu} \, D_\lambda \, \mathcal{V}^{\rho}$$

Using equation (78) of [12], for $\mathbf{B}_1(r)$ and $\mathbf{B}_2(r)$, we have;

$$\mathbf{B}_1 = (\nabla X \, \mathbf{A}_2 - \boldsymbol{\omega} \; X \; \mathbf{A}_2)$$

$$\mathbf{B}_2 = (\nabla X \, \mathbf{A}_1 - \boldsymbol{\omega} \; X \; \mathbf{A}_1)$$

$$\text{where;} \left\{ \begin{array}{l} \mathbf{A}_2 \text{ is the potential due to } \mathbf{B}_2 \\ \mathbf{A}_1 \text{ is the potential due to } \mathbf{B}_1 \end{array} \right.$$

For the scalar potential we use the following;

$$\Phi_\ell = \boldsymbol{\mu}_1(t) \cdot \mathbf{B}_1(r) + \boldsymbol{\mu}_2(t) \cdot \mathbf{B}_2(r)$$

Substituting Φ_ℓ into equation (134 of [12], and equation (9.6) of [10]), leads to resonance solutions in Φ_ℓ for the scalar potential of the Levitron. Thus, $\Phi_\lambda \equiv \Phi_\ell$, and the Levitron is functionally & operationally equivalent to counter-rotating magnetic sources. This shows how *The Antisymmetry Laws of the ECE-Theory* can be applied to simplify the analysis process. These laws can be used to design, simulate, and optimize devices whose dynamics are describable by ECE-Theory.

5840 Cameron Run Terrace
Suite 320
Alexandria, VA 22303
Phone; 703-960-0443
c.kellum@verizon.net

6.0 Conclusions

The ECE-Theory is a new unified field theory of physics & cosmology. It answers most questions remaining in cosmology, and has wide application to energy in the areas of electromagnetism and gravitation. One application, *a focus of this document*, is providing a quantitatively accurate description of Levitron dynamics. The Levitron device is ideal as a mechanism to demonstrate the utility of the ECE-Theory. It is a simple magnetic device. As such, the process of utilizing the ECE-Theory to quantify the dynamics of the Levitron, is straightforward and simple, as shown in this document.

7.0 Summary

. It has been shown in [2], [3], and [4] that counter-rotating magnetic fields enhance SCR, in accordance with ECE-Theory. Such devices are examples of the *counter-gravitation* and *electrical-energy generation* potential of this technology. The discussion in this paper shows the Levitron could be such a device. More in-depth investigations of Levitron dynamics would focus on counter-rotating magnetic fields, and on an *optimal* theoretical approach. The ECE Coulomb-Law was used in section 2, as an initial theoretical approach for explaining Levitron dynamics.

The Levitron demonstrates the anti-gravity aspects of ECE-Theory in a concise and straightforward manner. The SCR effects, necessary for counter-gravitation are achieved via the rotation of the magnet attached to the Levitron's top, relative to the base magnet of the Levitron. This is the reason why the top (more precisely, the magnet (M_1) attached to the top) is required to spin. Mechanical forces, including atmospheric friction, eventually retard the rotation to a value below that required to maintain SCR and stable anti-gravity conditions. The top then falls away, having lost the ability to couple with the torsion of spacetime, in accordance with ECE-Theory. Thus, the Levitron dynamics can be fully explained, *in a quantitatively accurate manner*, by the ECE-Theory.

The Levitron is a small, simple, inexpensive, readily available device that is easy to operate. It can fully demonstrate the anti-gravity aspects of the ECE-Theory. This fact should save much cost and effort that might otherwise be expended, trying to construct demonstrations of the ECE-Theory & technology. Fundamentally, the Levitron should not be viewed as just a mere toy. As discussed above, the Levitron is shown to demonstrate the new ECE-Theory. It is a valuable scientific tool, highlighting ECE-Theory, and pointing the way to a new era in physics & cosmology.

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5840 Cameron Run Terrace
Suite 320
Alexandria, VA 22303
Phone; 703-960-0443
c.kellum@verizon.net

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Notes