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Biefeld-Brown Effect and Space Curvature of Electromagnetic Field

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ABSTRACT

With applying of new proposed electromagnetic gravity Lagrangian together with Einstein-Hilbert equation not zero space curvature was derived. The curvature gives "a priory" postulate of equivalence of mass and electro-magnetic field gravity properties. The non-zero trace of energy-stress tensor of electrical field changes space curvature of gravity mass, which yields to prediction of dependence of capacitor gravity mass from capacitor capacitance and voltage values, observed in Biefeld-Brown effect. The other, not observed prediction could be applied to coil gravity mass dependence from coil inductance and current values. New physical constant, electromagnetic field gravity constant α_g, was introduced to conform with theoretical and experimental data.

Keywords: Biefeld-Brown Effect; Space Curvature; Electromagnetic Gravity

1. Introduction

Biefeld-Brown's [1-6] effect has been known since 1928. Christensen and Møller [7] built a Biefeld-Brown electrode setup and published measurements of the obtained thrust in ambient air. They also compared their results with theoretical predictions of electric wind effects. The agreement was very good and tended to explain the Biefeld-Brown effect as a purely electric wind phenomenon. The other try to verify the adequacy of Biefeld-Brown effect with electric wind phenomena was made by Tajmar [8]. The author concluded in this article that electric wind phenomena can explain Biefeld-Brown effect. The results [8] suggest that corona wind effects were misinterpreted as a possible connection between gravitation and electromagnetism. Brown observed in [9] that thiseffect remained even if the ambient medium was a vacuum (up to 10^{-6} Torr). Talley [10,11] studied Brown's electrode configurations in vacuum chambers up to 10^{-6} Torrin great detail. He found no thrust in the case of a static dc potential applied to the electrodes. However, he noticed an anomalous force during electrical breakdowns when the current was flowing. This force, the result of currents in divergent electric fields (due to the asymmetrical electrode configuration) finds further support in five-dimensional theories coupling the gravitational and electromagnetic field. Williams [12] integrated amass dependent fifth dimension into the relativistic Maxwell theory and predicted the coupling between both fields. The newest references of investigations of electrodynamic lifter propulsion could be found in [13]. However, ambiguity of explanation of Biefeld-Brown effect indicates that new theoretical and experimental researches are needed.

2. Einstein's Field Equations

Suppose that the full action of the theory is given by the Einstein-Hilbert [14] term plus a term $\mathcal{L}_{\mathrm{M}}$ describing any matter fields appearing in the theory

$$S=\int\left[\frac{1}{2\kappa}R+\mathcal{L}_{\mathrm{M}}\right]\sqrt{-g}\,\mathrm{d}^4x\,. \tag{1}$$

The action principle then tells us that the variation of this action with respect to the inverse metric is zero, yielding

$$\delta S=\int\left[\frac{1}{2\kappa}\left(\frac{\delta R}{\delta g^{\mu\nu}}+\frac{R}{\sqrt{-g}}\frac{\delta\sqrt{-g}}{\delta g^{\mu\nu}}\right)+\frac{1}{\sqrt{-g}}\frac{\delta\left(\sqrt{-g}\mathcal{L}_{\mathrm{M}}\right)}{\delta g^{\mu\nu}}\right]\cdot\delta g^{\mu\nu}\sqrt{-g}\,\mathrm{d}^4x=0 \tag{2}$$

Since this equation should hold for any variation $\delta g^{\mu\nu}$, it implies that

$$\frac{\delta R}{\delta g^{\mu\nu}}+\frac{R}{\sqrt{-g}}\frac{\delta\sqrt{-g}}{\delta g^{\mu\nu}} = -2\kappa\frac{1}{\sqrt{-g}}\frac{\delta\left(\sqrt{-g}\mathcal{L}_{\mathrm{M}}\right)}{\delta g^{\mu\nu}}, \tag{3}$$

this equation of motion for the metric field could be found. The calculation of the left hand side of the equation for the variations of the Ricci scalar R and the determinant of the metric could be found in Carroll [15]. After having of all the necessary variations at our disposal, we can insert them into the equation of motion for the metric field to obtain

$$R_{\mu\nu}-\frac{1}{2}g_{\mu\nu}R=\frac{8\pi G}{c^4}T_{\mu\nu}, \tag{4}$$

which is Einstein's field equation [16,17] and constant

$$\kappa=\frac{8\pi G}{c^4} \tag{5}$$

has been chosen so that the non-relativistic limit yields the usual form of Newton's gravity law, where G is the gravitational constant and c is speed of light in vacuum. The right hand side of this equation is (by definition) proportional to the energy-stress tensor

$$T_{\mu\nu}=-2\frac{1}{\sqrt{-g}}\frac{\delta\left(\sqrt{-g}\mathcal{L}_{\mathrm{M}}\right)}{\delta g^{\mu\nu}} = -2\frac{\delta\mathcal{L}_{\mathrm{M}}}{\delta g^{\mu\nu}}+g_{\mu\nu}\mathcal{L}_{\mathrm{M}}. \tag{6}$$

The Lagrangian of mater must be chosen so, that it satisfy conservation lows.

3. Einstein's Field Equation for Gravity Mass in Electromagnetic Field

The electromagnetic tensor $F^{\mu\nu}$ in Cartesian coordinates is commonly written as a matrix:

$$F^{\mu\nu}=\begin{bmatrix} 0 & -E_x/c & -E_y/c & -E_z/c \\ E_x/c & 0 & -B_z & B_y \\ E_y/c & B_z & 0 & -B_x \\ E_z/c & -B_y & B_x & 0 \end{bmatrix}, \tag{7}$$

or

$$F_{\mu\nu}=\begin{bmatrix} 0 & E_x/c & E_y/c & E_z/c \\ -E_x/c & 0 & -B_z & B_y \\ -E_y/c & B_z & 0 & -B_x \\ -E_z/c & -B_y & B_x & 0 \end{bmatrix}, \tag{8}$$

where E is the electric field, B the magnetic field, and c the speed of light. The signs in the tensor above depend on the convention used for the metric tensor. The convention used here is $+---$, corresponding to the metric tensor:

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}. \tag{9}$$

From the matrix form of the field tensor, it becomes clear that the electromagnetic tensor satisfies the following antisymmetry properties $F^{ab} = F^{ba}$ (hence the name bi vector) of six independent components.

If one forms an inner product of the field strength tensor Lorentz invariant is formed:

$$F_{ab}F^{ab}=2\left(B^2-\frac{E^2}{c^2}\right)=\text{invariant}, \tag{10}$$

the Lagrangian of electromagnetic field in our model could be

$$\mathcal{L}_{em}=-\frac{\alpha_g c^2}{4\mu_0}F_{ab}F^{ab}. \tag{11}$$

Lagrangian $\mathcal{L}_{em}$ differs from classic electromagnetic field Lagrangian just with constant $\alpha_g c^2$, where α_g is electromagnetic field gravity constant with dimension s^2/m^2, which could be calibrated on experiment data.

According to [18], it is safer to rewrite inner product of field strength tensor as $F_{ab}F_{cd}g^{ac}g^{bd}$. This gives for the first term of sum of energy-stress tensor Equation (6).

$$2\frac{\delta F_{ab}F^{ab}}{\delta g^{\mu\nu}}=2\frac{\delta F_{ab}F_{cd}g^{ac}g^{bd}}{\delta g^{\mu\nu}}=-4F_{l\nu}F_{\mu}^{l}, \tag{12}$$

A different result could be obtained, if inner product of field strength tensor is leaving as $F_{ab}F^{ab}$. In this way result is:

$$2\frac{\delta F_{ab}F^{ab}}{\delta g^{\mu\nu}}=0. \tag{13}$$

Let's decide, that Equation (13) is true (discussion in Appendix), so the calculations of energy-stress tensor term of electromagnetic field give result:

$$T_{\mu\nu}^{(em)}=-2\frac{\delta\mathcal{L}_{em}}{\delta g^{\mu\nu}}+g_{\mu\nu}\mathcal{L}_{em} = -g_{\mu\nu}\frac{\alpha_g c^2}{2\mu_0}\left(B^2-\frac{E^2}{c^2}\right), \tag{14}$$

which is symmetric and satisfy rotation conservation low.

4. Einstein's Field Equation for Gravity Mass in Electromagnetic Field

According to Equation (6) energy-stress tensor of gravity mass in electromagnetic field could be found with adding Lagrangian of gravitational and electromagnetic parts of Lagrangian

$$\begin{aligned} \mathcal{L}_{\mathrm{M}} &= \mathcal{L}_{\rho} + \mathcal{L}_{em} = -\rho c^2 - \frac{\alpha_g c^2}{4\mu_0} F_{\mu\nu} F^{\mu\nu}, \\ T_{\mu\nu} &= g_{\mu\nu} \mathcal{L}_{\mathrm{M}}, \\ T_{\mu\nu} &= -g_{\mu\nu}\rho c^2 - g_{\mu\nu}\frac{\alpha_g c^2}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right). \end{aligned} \tag{15}$$

After inserting of energy-stress tensor of Equation (15) into Equation (4) Einstein-Hilbert field equation looks like this

$$\begin{aligned} & R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R \\ &= -g_{\mu\nu}\frac{8\pi G}{c^4}\left(\rho \mathrm{c}^2 + \frac{\alpha_g c^2}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right)\right). \end{aligned} \tag{16}$$

Taking the trace of Equation (16) (contracting with $g_{\mu\nu}$) and using the fact that $g^{\mu\nu} g_{\mu\nu} = 4$, we get for space curvature:

$$R = \frac{32\pi G}{c^4}\left(\rho c^2 + \frac{\alpha_g c^2}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right)\right), \tag{17}$$

yielding the equivalent form of Equation (16)

$$R_{\mu\nu} = g_{\mu\nu}\frac{8\pi G}{c^4}\left(\rho c^2 + \frac{\alpha_g c^2}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right)\right), \tag{18}$$

Space curvature Equation (17) of spheric gravity mass with radius r in electromagnetic field could be rewritten as

$$R = \frac{24G}{c^2 r^3}\left(M - M_{eg}\right), \tag{19}$$

$$M_{eg} = \frac{\alpha_g V}{2}\left(\varepsilon_0 E^2 - \frac{B^2}{\mu_0}\right), \tag{20}$$

$$V = \frac{4\pi r^3}{3}, \tag{21}$$

where M_{eg} is electromagnetic mass and V is volume of electromagnetic field and is equal to volume of devices, which is inside this electromagnetic field.

From Equation (19) assumption could be made, that summary curvature of the space generated by gravity mass should decrease in electric field and increase in magnetic field. If the mass of device M equals to absolute value of electromagnetic mass $|M_{eg}|$, zero curvature of such device could be obtained, so gravity mass of this device stop interacting with the other gravity mass. Let's prove it analytically.

The solution of Equation (19) in spheric coordinates (see for example [19]) is:

$$g_{\mu\nu} = \begin{pmatrix} 1 - \frac{\Lambda r^2}{3} & 0 & 0 & 0 \\ 0 & -\frac{1}{1 - \frac{\Lambda r^2}{3}} & 0 & 0 \\ 0 & 0 & -r^2 & 0 \\ 0 & 0 & 0 & -r^2 \sin\theta \end{pmatrix}, \tag{22}$$

where Λ equals to

$$\Lambda = \frac{8\pi G}{c^4}\left(\rho c^2 + \frac{\alpha_g c^2}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right)\right). \tag{23}$$

Thus, the gravitational potential of a point mass is

$$\Phi = -\frac{\Lambda r^2 c^2}{6} \tag{24}$$

$$= -\frac{4\pi G r^2}{3}\left(\rho + \frac{\alpha_g}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right)\right) \tag{25}$$

$$= -\frac{G\left(M - M_{eg}\right)}{r}. \tag{26}$$

Equation (26) prove proposition, if the mass M equals to absolute value of $|M_{eg}|$, we have zero gravitational gravity potential for gravity mass M and so such mass does not interact with external gravity field.

5. Biefeld-Brown Effect in Vacuum

Replacing of magnetic field B with $B = 0$ and replacing of electric field density with capacitor energy density multiplied by volume of electric field of capacitor in Equation (20) gives for electro gravity mass of capacitor

$$M_{eg} = \frac{CU^2}{2}\alpha_g. \tag{27}$$

The simple capacitor of two parallel conductive plates describes as

$$C = \frac{\varepsilon\varepsilon_0 S}{d}, \tag{28}$$

so Equation (27) could be rewritten as:

$$M_{eg} = \frac{\varepsilon\varepsilon_0 S U^2}{2d}\alpha_g, \tag{29}$$

where ε is relative permittivity of material, ε_0 is absolute permittivity of vacuum, S is the area of the capacitor and d is separation of the planes of the capacitor. Equation (29) explains all experimental data observed Biefeld-Brown effect. The effect depends on the separation of the plates of the capacitor, the closer the plates, the greater the effect. The effect depends on the dielectric strength of the material between the electrodes, the higher the strength, the greater the effect. The effect depends on the area of the conductor, the greater the area, the greater the effect. The effect depends on the voltage difference between the plates, the greater the voltage, the greater effect. The effect depends on the volume of the dielectric material, the greater the volume, the greater part of electromagnetic energy concentrates in dielectric material, the greater the effect.

Electro-gravity constant α_g could be found from Buehler [20] experiments. Author founds in their experiments with capacitor isolated from electronic wind, that lifting force of charged capacitor depends on energy of this capacitor is

$$\Delta F = \frac{\left(m - m_{eg}\right)MG}{R^2} - \frac{mMG}{R^2} = k\frac{CU^2}{2}, \quad (30)$$

where ΔF is lifting force, m is device mass, M mass of earth, R earth radius and constant k equals to 0.47. The inserting of numeric values of given constants into Equation (30) results for numeric value of electro-gravity constant $\alpha_g = 0.0479$.

6. Biefeld-Brown Effect in Air

Lagrangian Equation (11) isn't Gauge invariant and after adding of $J^\mu A_\mu$ term new lagrangian

$$\mathcal{L}_{em} = -\alpha_g c^2 \left(\frac{1}{4\mu_0} F_{ab}F^{ab} + J^\mu A_\mu\right). \quad (31)$$

satisfy electromagnetic field's equations of motion

$$\delta_\nu F^{\nu\mu} = \mu_0 J^\mu \quad (32)$$

where J^μ is the four-current is the contravariant four-vector which combines electric current and electric charge density as follows

$$J^\alpha = \left(c\rho, \boldsymbol{J}\right) \quad (33)$$

and A_μ is the electromagnetic four-potential is a covariant four-vector containing the electric potential and magnetic vector potential, as follows

$$A_\alpha = \left(\phi/c, -\boldsymbol{A}\right) \quad (34)$$

So Equation (15) must be rewritten as follow

$$T_{\mu\nu} = -g_{\mu\nu}\rho c^2 - g_{\mu\nu}\frac{\alpha_g c^2}{2\mu_0}\left(B^2 - \frac{E^2}{c^2}\right) - g_{\mu\nu}\alpha_g c^2\left(\phi\rho - \boldsymbol{A}\cdot\boldsymbol{J}\right) \quad (35)$$

and Equation (20) transforms into

$$M_{eg} = \frac{\alpha_g V}{2}\left(\varepsilon_0 E^2 - \frac{B^2}{\mu_0} - \phi\rho + \boldsymbol{A}\cdot\boldsymbol{J}\right) \quad (36)$$

Equation (36) shows, that electromagnetic propulsion lifter acquire antigravity property through gravity shielding of $\boldsymbol{A}\cdot\boldsymbol{J}$ member, which describe ionic wind.

7. Mass Increasing Effect of Inductance Coil

If do not zero space curvature of electric field explains Biefeld-Brown effect excellently, the same effect, but with increasing of device mass, must be observed in a magnetic field. Analogically to Equation (29) electro-gravity mass equation for inductance coil looks like this

$$M_{eg} = -\frac{LI^2}{2}\alpha_g, \quad (37)$$

where L is the inductance, which depends on area and amount of windings and coil length, and I is the current. Equation (37) predict similar effects, observed in Biefeld-Brown experiments with a capacitor, but in opposite direction of changing of coil mass: for the fixed inductance L increasing of current in coil must increase mass of the coil.

8. Conclusions

On the basis of the results obtained in this work the following conclusions have been made:

1) Electro gravity mass equation is in good agreement with Biefeld-Brown effect and fully explains all qualitative data observed in this effect;

2) Electromagnetic gravity model predicts decreasing of gravity mass effect in electric field and increasing of gravity mass in magnetic field;

3) Electromagnetic field gravity constant equals to $\alpha_g = 0.0479$ [s^2/m^2] and is the basic constant of proposed electromagnetic gravity model;

4) The total curvature of electromagnetic wave is zero, but separate curvatures of electric and magnetic components of the wave haven't zero values.

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Appendix: Discussion on Classic Derivation of Electromagnetic Energy-Stress Tensor

According to [21] energy-stress tensor T^{ik} of electromagnetic field could be derived from action principle

$$\delta S = \delta \int \Lambda \left(q, \frac{\partial q}{\partial x^i} \right) \mathrm{d}V \mathrm{d}t = 0. \quad (38)$$

Variation of given action and determination it to zero leads to equation

$$\frac{\partial T_i^k}{x^k} = 0, \quad (39)$$

where

$$T_i^k = q_{,i} \frac{\partial \Lambda}{\partial q_{,k}} - \delta_i^k \Lambda. \quad (40)$$

Equation (39) is equivalent to proposition, that it is obtained conservation low of 4-momentum vector P^i

$$P^i = \frac{1}{c} \int T^{ik} \mathrm{d}S_k, \quad (41)$$

where integration is making in all hyperplane. Description of T^{ik}, grounded on Equation (41) is ambiguous, because every tensor described as

$$T^{ik} + \frac{\partial}{\partial x^i} \psi^{ikl}, \quad \psi^{ikl} = -\psi^{ilk} \quad (42)$$

meets conservation low Equation (39). Trace of given energy-stress tensor with additional term

$$T + \frac{\partial}{\partial x^i} \psi^{iil} \quad (43)$$

generally isn't zero and must be calibrated with experiment.

The other rotational momentum conservation low specify energy-stress tensor to be symmetric

$$T^{ik} = T^{ki} \quad (44)$$

and it could be reached with choosing of Ψ^{ikl}.

Now all this could be used to get T^{ik} for Lagrangian of electromagnetic field

$$\Lambda = -\frac{1}{4\mu_0} F_{kl} F^{kl}, \quad (45)$$

which gives

$$T_i^k = -\frac{1}{\mu_0} \frac{\partial A^l}{\partial x_i} F^{kl} + \frac{1}{4\mu_0} \delta_i^k F_{lm} F^{lm}, \quad (46)$$

where F_{kl} is described as

$$F_{kl} = \frac{\partial A_l}{\partial x^k} - \frac{\partial A_k}{\partial x^l}. \quad (47)$$

Tensor in Equation (46) isn't symmetric. The trace calculation of energy-stress tensors Equation (46) gives

$$T_i^i = -\frac{1}{\mu_0} \frac{\partial \left(A^l F^{il} \right)}{\partial x_i} + \frac{1}{\mu_0} F_{lm} F^{lm}, \quad (48)$$

which is true in electromagnetic field without charge, because $\delta F^{il}/\delta x_i$. Equation (48) satisfy Equation (43) transformation and finally the last equation could be rewritten as

$$T_i^i = \frac{1}{\mu_0} F_{lm} F^{lm} \neq 0. \quad (49)$$

On the other hand symmetrization of T_k^i for indexes $i \neq k$ could be reached, if the term would be added

$$\frac{1}{\mu_0} \frac{\partial A^i}{\partial x_l} F_l^k = \frac{1}{\mu_0} \frac{\partial \left(A^i F_l^k \right)}{\partial x_l} \quad (50)$$

It could be made too, because it is Equation (42) transformation. The result of following transformations is new symmetric tensor

$$\begin{aligned} T_{(i=k)}^{ik} &= -\frac{1}{\mu_0} \frac{\partial A^l}{\partial x^i} F^{kl} + \frac{1}{4\mu_0} \frac{\partial \left(A^l F^{il} \right)}{\partial x^i} + \frac{1}{4} g^{ik} T \\ T_{(i \neq k)}^{ik} &= \frac{1}{\mu_0} \left(-F^{il} F_l^k + \frac{1}{4} g^{ik} F_{lm} F^{lm} \right) \end{aligned} \quad (51)$$

Transformations Equation (50) applied to whole T_k^i tensor change both not diagonal elements and diagonal elements of energy-stress tensor, which trace after transformation become zero

$$T_i^i = 0. \quad (52)$$

The answer to this question, which Equation (49) or Equation (52) is true, could be given just by experiments in a pure electric and magnetic fields. If gravity mass do not interact in both pure electric and magnetic fields, we must leave energy-stress tensor trace zero equality axiom. If interaction of gravity mass and pure electric and magnetic fields exist, there is sample explanation of this interaction within assumption of not zero trace of energy-stress tensor.

