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Gravitational Poynting theorem: interaction of gravitation and electromagnetism

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The geometrical basis of ECE theory is used to deduce the existence of a gravitational equivalent of the Poynting Theorem and four gravitational fields: $\boldsymbol{g}$, $\boldsymbol{d}$, $\boldsymbol{h}$ and $\boldsymbol{b}$. These are the equivalents of $\boldsymbol{E}$, $\boldsymbol{D}$, $\boldsymbol{H}$ and $\boldsymbol{B}$ in electromagnetism, the field equations of gravitation having the same structure as those of electromagnetism, two homogeneous and two inhomogeneous. The interaction of gravitation and electromagnetism is developed on the principle that all forms of energy are interconvertible, so the mechanism of conversion of electromagnetic to gravitational energy is elucidated via the respective Poynting Theorems.

Keywords: ECE theory, gravitational Poynting Theorem, gravitational fields, interconversion of electromagnetic and gravitational energy.

1. Introduction.

The geometrical structure of Einstein–Cartan–Evans (ECE) theory [1–10] shows that the field equations of gravitation have a richer structure than thought hitherto, and that that structure is the same as for electromagnetism. In this paper the gravitational field equations are developed further and in parallel with electromagnetism. There are two homogeneous equations of electromagnetism, with the fields $\boldsymbol{E}$ and $\boldsymbol{B}$, respectively the electric field strength and magnetic flux density. So it is shown in Section 2 that there are two homogeneous field equations of gravitation with the same structure and describing the interaction of the acceleration due to gravity $\boldsymbol{g}$ and the gravitomagnetic flux density $\boldsymbol{b}$. There are two inhomogeneous field equations of electromagnetism, with the electric displacement $\boldsymbol{D}$ and magnetic field strength $\boldsymbol{H}$, and in Section 2 it is shown that there are two inhomogeneous field equations of gravitation, involving the gravitational displacement $\boldsymbol{d}$, and the field strength of magnetogravitation $\boldsymbol{h}$. In Section 2 the units of these fields are defined and also the way in which they interact with the mass density ρ_m and current of mass density $\boldsymbol{J}_m$. The tensor structure of the equations is defined by the Cartan geometry [11] of ECE theory.

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In Section 3 the gravitational Poynting Theorem is developed in parallel with the well known Poynting Theorem of electromagnetism, the law of conservation of energy. In ECE theory both laws of conservation of energy are derived from geometry within the context of general relativity and again, both have the same structure, defined in this Section. Since all forms of energy are interconvertible, the structure of the gravitational Poynting theorem may be used to investigate the way in which electromagnetism affects gravitation. This investigation may lead towards a practical counter gravitational device in which the electromagnetic field decreases ***g***, the acceleration due to gravity.

2. The field equations of gravitation and magnetogravitation

As shown in the preceding paper, UFT 167 of this series [1–10] the geometrical structure of the homogeneous field equation is:

$$\partial_\mu \tilde{T}^{a\mu\nu} = j_H^{a\nu}. \tag{1}$$

Here $\tilde{T}^{a\mu\nu}$ is the Hodge dual of the torsion tensor, $\tilde{R}_\mu^{a\mu\nu}$ the Hodge dual of the curvature tensor, and $\Omega^a_{\mu b}$ the relevant spin connection. In general the homogeneous four current

$$j_H^{a\nu} = \tilde{R}_\mu^{\ a\mu\nu} - \Omega^a_{\mu b}\tilde{T}^{a\mu\nu} = 0, \tag{2}$$

is non-zero, but from experimental results in electromagnetism, it is assumed to be zero. The basic geometrical structure of the inhomogeneous field equation is:

$$\partial_\mu T^{a\mu\nu} = j_I^{a\nu} = R_\mu^{\ a\mu\nu} - \omega^a_{\mu b} T^{b\mu\nu} \tag{3}$$

in which the current $j_I^{a\nu}$ originates in mass density and the current of mass density. In ECE theory the basic geometrical structures (1) and (2) are the same for gravitation and electromagnetism.

The geometrical structure (3) gives the inhomogeneous field equation of gravitation in tensor format. For each sense of polarization a the field equation is:

$$\partial_\mu K^{\mu\nu} = J_M^\nu. \tag{4}$$

The field tensor is defined as:

$$K^{\mu\nu} = \frac{1}{k} g^{\mu\rho} g^{\nu\sigma} T_{\rho\sigma} \tag{5}$$

where k is the Einstein constant:

$$k = \frac{8\pi G}{c^2} = 1.86595\times10^{-26}\ \text{m kg}^{-1} \tag{6}$$

where G is the Newton constant, and where the inverse metrics have been used to raise indices as usual. Note that these are the inverse metrics of a four dimensional spacetime with both torsion and curvature [1-11]. The field tensor is a 4 × 4 matrix defined as follows:

$$K^{\mu\nu} = \begin{pmatrix} 0 & -\mathrm{d_X} & -\mathrm{d_Y} & -\mathrm{d_Z} \\ \mathrm{d_X} & 0 & -\mathrm{h_Z/c} & -\mathrm{h_Y/c} \\ \mathrm{d_Y} & \mathrm{h_Z/c} & 0 & -\mathrm{h_X/c} \\ \mathrm{d_Z} & \mathrm{h_Y/c} & \mathrm{h_X/c} & 0 \end{pmatrix} \tag{7}$$

so the tensor equation (4) becomes two vector equations:

$$\nabla\cdot\boldsymbol{d} = \rho_m, \tag{8}$$

$$\nabla\times\boldsymbol{h} - \frac{\partial\boldsymbol{d}}{\partial t} = \mathbf{J}_m. \tag{9}$$

Equation (8) is the direct analogy of the Coulomb law in electromagnetism, and Eq. (9) the direct analogy of the Ampere–Maxwell law. In direct analogy with electromagnetism the gravitational displacement is defined by:

$$\boldsymbol{d} = \frac{1}{8\pi G} g \tag{10}$$

where $\boldsymbol{g}$ is the acceleration due to gravity. The units of $\boldsymbol{d}$ are kg m^2 in direct analogy with the units of electric displacement $\boldsymbol{D}$ in electromagnetism (C m^2). The analogue of Eq. (10) in electromagnetism is:

$$\boldsymbol{D} = \epsilon_0\boldsymbol{E}, \tag{11}$$

where $\boldsymbol{E}$ is the electric field strength (V m^{-1}), the analogue of $\boldsymbol{g}$ in gravitation, and where ϵ_0 is the vacuum permittivity. Here ρ_m is the mass density in units of kg m^{-3} , in direct analogy with the charge density in units of C m^{-3}. The current of mass density $\mathbf{J}_m$ has units of C ρ_m or kg s^{-1} m^{-2} in analogy with the electric current density $\boldsymbol{J}$ with units of C s^{-1} m^{-2}. The gravitomagnetic field strength $\boldsymbol{h}$ has units of kg m^{-1} s^1 in analogy with magnetic field strength $\boldsymbol{H}$ in units of C $s^{-1}m^{-1}$ or A m^{-1}.

The homogeneous field tensor is defined within the factor c as the torsion of spacetime:

$$g_{\mu\nu} = cT_{\mu\nu} = \begin{pmatrix} 0 & g_X/c & g_Y/c & g_Z/c \\ -g_X/c & 0 & -b_Z & b_Y \\ -g_Y/c & b_Z & 0 & -b_X \\ -g_Z/c & -b_Y & b_X & 0 \end{pmatrix} \tag{12}$$

The metric of the homogeneous field equation is defined as:

$$g_{\mu\nu}(\text{metric}) = \text{diag}(1,-1,-1,-1) \tag{13}$$

so that the homogeneous field equation is:

$$\partial_\mu \tilde{g}^{\mu\nu} = 0 \tag{14}$$

where:

$$\tilde{g}_{\mu\nu} = \begin{pmatrix} 0 & -b_X & -b_Y & -b_Z \\ b_X & 0 & g_Z/c & -g_Y/c \\ b_Y & -g_Z/c & 0 & g_X/c \\ b_Z & g_Y/c & -g_X/c & 0 \end{pmatrix} \tag{15}$$

Equation (14) may be developed in terms of two vector equations:

$$\nabla \cdot \boldsymbol{b} = 0, \tag{16}$$

and

$$\nabla \times g - \frac{\partial \boldsymbol{b}}{\partial t} = \mathbf{0}. \tag{17}$$

in which the units of the gravitomagnetic flux density $\boldsymbol{b}$ are s^{-1} and in which $\boldsymbol{g}$ is the acceleration due to gravity in m s^{-2}. Equation (16) is the direct analogue of the Gauss law of magnetism:

$$\nabla \cdot \boldsymbol{B} = 0 \tag{18}$$

and Eq. (17) is the direct analogue of the Faraday law of induction:

$$\nabla \times \boldsymbol{E} + \frac{\partial \boldsymbol{B}}{\partial t} = \mathbf{0}. \tag{19}$$

The metric (13) is defined in terms of the conjugate product of tetrads [1–10]:

$$g_{\mu\nu}(\text{metric}) = q_\mu^a \, q_\nu^b + \eta_{ab} \tag{20}$$

and should not be confused with the Minkowski metric of flat spacetime in which there is no torsion. It is based on experimental data. The two equations (18) and (19) of electromagnetism are thought to be well verified experimentally, i.e. there is no magnetic monopole or magnetic current. In analogy it is assumed that there is no magneto-gravitational monopole or current. Note carefully that in general the metrics of the homogeneous and inhomogeneous structures are different. As shown in UFT 167 the inhomogeneous metric elements in electromagnetism define the permittivity and permeability of a given material. The analogous concept is present in the inhomogeneous structure of gravitation.

In summary of this section, the ECE field equations of gravitation are, for each index of polarization:

$$\left.\begin{aligned} &\nabla \cdot \boldsymbol{b} = 0, \\ &\nabla + \boldsymbol{g} - \frac{\partial \boldsymbol{b}}{\partial t} = \mathbf{0}, \\ &\nabla \cdot \boldsymbol{d} = \rho_m, \\ &\nabla \times \boldsymbol{h} - \frac{\partial \boldsymbol{d}}{\partial t} = \mathbf{J}_m. \end{aligned}\right\} \tag{21}$$

The ECE field equations of electromagnetism, in direct analogy, are, for each index :

$$\left.\begin{aligned} &\nabla \cdot \boldsymbol{B} = 0, \\ &\nabla + \boldsymbol{E} - \frac{\partial \boldsymbol{B}}{\partial t} = \mathbf{0}, \\ &\nabla \cdot \boldsymbol{D} = \rho, \\ &\nabla \times \boldsymbol{H} - \frac{\partial \boldsymbol{D}}{\partial t} = \mathbf{J}. \end{aligned}\right\} \tag{22}$$

3. Gravitational and electromagnetic Poynting theorems

The gravitational Poynting Theorem is deduced in direct analogy with the well known electromagnetic Poynting Theorem [12] - the law of conservation of energy. Therefore the usual Poynting Theorem is reviewed first as follows.

The theory of this section is developed with the understanding that it is valid for each polarization index ***a***, both for electromagnetism and gravitation. The electromagnetic energy density in units of joules per cubic metre is:

$$\mathrm{U}=\frac{1}{2}\left(\boldsymbol{E}\cdot\boldsymbol{D}+\boldsymbol{B}\cdot\boldsymbol{H}\right) \tag{23}$$

and the total rate of doing work by the electromagnetic field in a volume V is:

$$P = \int_V \boldsymbol{J}\cdot\boldsymbol{E}\; d^3x \tag{24}$$

in joules per second, the units of power. This power is the conversion of electromagnetic energy to other forms of energy, notably gravitational energy. The Poynting theorem is

$$\boldsymbol{J}\cdot\boldsymbol{E} = \left(\nabla\times\boldsymbol{H}-\frac{\partial\boldsymbol{D}}{\partial t}\right)\cdot\boldsymbol{E} \tag{25}$$

where Eq. (22.d) has been used to eliminate ***J.*** Using Eq. (19) the theorem can be expressed as:

$$\frac{\partial U}{\partial t}+\nabla\cdot\boldsymbol{S}=-\boldsymbol{J}\cdot\boldsymbol{E} \tag{26}$$

where the Poynting vector is defined as:

$$\boldsymbol{S}:=\boldsymbol{E}\times\boldsymbol{H}. \tag{27}$$

Similarly, the total rate of doing work by the gravitational field in a volume V is:

$$P_{\mathrm{grav}} = \int_V \boldsymbol{J}_m\cdot\boldsymbol{g}\; d^3x \tag{28}$$

where $\boldsymbol{J}_m$ is the mass current density. The gravitational energy density is:

$$U_{\mathrm{grav}}=\frac{1}{2}\left(\boldsymbol{g}\cdot\boldsymbol{d}+\boldsymbol{b}\cdot\boldsymbol{h}\right) \tag{29}$$

which has the correct units of kg $m^{-1}s^{-2}$, or kg $m^2s^{-2}m^{-3}$, or Jm^{-3}. The gravitational Poynting theorem is therefore:

$$\frac{\partial U_{grav}}{\partial t} + \nabla \cdot \boldsymbol{S}_{grav} = -\boldsymbol{J}_m \cdot \boldsymbol{g} \tag{30}$$

where the gravitational Poynting vector is:

$$\boldsymbol{S}_{grav} = \boldsymbol{g} \times \boldsymbol{h}. \tag{31}$$

When considering the interaction of electromagnetism and gravitation ***J. E*** is the work done per unit time per unit volume by the electromagnetic field on the gravitational field, and $\boldsymbol{j}_m$ **.** ***g*** **i**s the work done per unit time per unit volume by the gravitational field on the electromagnetic field.

For practical applications we wish to consider the effect of an electromagnetic device on gravitation, notably on ***g*.** The overall aim is to make ***g*** smaller in magnitude and to counter gravitation. In the presence of electromagnetism the gravitational Poynting theorem becomes:

$$\boldsymbol{g} \cdot \left(\nabla \times \boldsymbol{h} - \frac{\partial \boldsymbol{d}}{\partial t} \right) = \boldsymbol{g} \cdot \boldsymbol{J}_m + \boldsymbol{E} \cdot \boldsymbol{J}. \tag{32}$$

For simplicity, consider situations where:

$$\nabla \times \boldsymbol{h} = \boldsymbol{0} \tag{33}$$

then:

$$-\boldsymbol{g} \cdot \frac{\partial \boldsymbol{d}}{\partial t} = \boldsymbol{g} \cdot \boldsymbol{J}_m + \boldsymbol{E} \cdot \boldsymbol{J} \tag{34}$$

where:

$$\boldsymbol{d} = \frac{1}{c^2 k} \boldsymbol{g} \tag{35}$$

$$\boldsymbol{g} \cdot \frac{\partial \boldsymbol{g}}{\partial t} = -c^2 k \left(\boldsymbol{g} \cdot \boldsymbol{J}_m + \boldsymbol{E} \cdot \boldsymbol{J} \right) \tag{36}$$

If the mass is a fixed mass such as that of the Earth (the object responsible for **g**), then:

$$\boldsymbol{J}_m = \boldsymbol{0} \tag{37}$$

so:

$$\boldsymbol{g} \cdot \frac{\partial \boldsymbol{g}}{\partial t} = -c^2 \, k \, \boldsymbol{E} \cdot \boldsymbol{J} \tag{38}$$

where the Einstein constant is:

$$k = \frac{8\pi G}{c^2}. \tag{39}$$

In the Z axis:

$$\frac{\partial g_Z}{\partial t} = -\left(\frac{c^2 \, k}{g_Z}\right) E_Z \, J_Z = -1.71 \times 10^{-10} \, E_Z \, J_Z \tag{40}$$

so g_z changes with time in the opposite direction to E_z and J_z. The effect is very small, but could be amplified by a resonance mechanism, which could be found within the structure of the Poynting theorem itself.

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