Journal of High Energy Physics, Gravitation and Cosmology, 2025, 11(2), 331-355
https://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

Gravitoelectromagnetism and Electromagnetism Unified by the Theory of Informatons

Antoine Acke

Retired Professor Kaho Sint-Lieven, Now KU Leuven, Faculty of Engineering Technology, Ghent Campus, Gent, Belgium
Email: ant.acke@skynet.be

How to cite this paper: Acke, A. (2025) Gravitoelectromagnetism and Electromagnetism Unified by the Theory of Informatons. *Journal of High Energy Physics, Gravitation and Cosmology*, **11**, 331-355.
https://doi.org/10.4236/jhepgc.2025.112029

Received: February 10, 2025
Accepted: April 12, 2025
Published: April 15, 2025

Abstract

The theory of informatons starts from the idea that any material object at rest in an inertial reference frame is the source and the center of an expanding cloud of informatons: mass- and energy-less granular entities that are emitted by that object at a rate proportional to its rest mass and that rush away with the speed of light carrying information regarding its position ("*g*-information") and if this is the case, regarding its electric charge ("*e*-information"). Depending on the nature of the substance (*g*- or *e*-information) on which we focus, we identify that cloud as the "gravitational" or as the "electric field" of the object. In this article, we deduce from the kinematics of the informatons both the gravitoelectromagnetic description of the gravitational phenomena and laws and the classical description of electromagnetism.

Keywords

Gravity, Gravitoelectromagnetism (GEM), Electromagnetism (EM), Informatons

1. Introduction

The *classical field theory* considers the gravitational field as the entity that mediates in the gravitational interactions and the electromagnetic field as the entity that plays the same role in the electromagnetic ones.

In contemporary textbooks, the *gravitational field of a whether or not moving mass particle* is fully characterized by the vectoral quantity $\boldsymbol{E}_g$ and in the same context the *electric field of an electrically charged mass particle at rest* is fully characterized by the vectoral quantity $\boldsymbol{E}$. $\boldsymbol{E}_g$ and $\boldsymbol{E}$ have a value at every point of space and time and are thus relative to an inertial reference frame (IRF)

O, regarded as functions of space and time coordinates. But the *electromagnetic field* (*EM-field*) *of a moving electrically charged mass particle* is characterized as a dual entity always having a field- and an induction-component ($\boldsymbol{E}$ and $\boldsymbol{B}$) simultaneously created by their common source: the moving particle.

Oliver Heaviside [1], Henri Poincaré [2], Oleg Jefimenko [3] e.o. made fundamental contributions to the *gravitoelectromagnetic* description of the gravitational phenomena and laws. In that context ("gravitoelectromagnetism", GEM) the kinematics of the gravitating objects are taken into account what implies that the gravitational field of a moving mass particle, just like the electromagnetic field of a moving electrically charged particle, is a dual entity always having a field- and an induction-component ($\boldsymbol{E}_g$ and $\boldsymbol{B}_g$). Because the role of the kinematics of the gravitating objects is not relevant when the speed of the objects is small relative to the speed of light, this phenomenon is overlooked in the "classical" description of gravity. It should be noted that, *from the point of view of GRT*, the gravitoelectromagnetic description of the gravitational phenomena and laws is valid only in the weak field approximation.

The "theory of informatons" is starting from the idea that a mass particle at rest relative to an IRF ***O*** manifests its presence in space and time by the emission, at a rate proportional to its rest mass, of mass and energy less granular entities that are rushing away with the speed of light and that are carrying *information* regarding the position ("*g*-information") and if this is the case, regarding the electric charge of their emitter ("*e*-information"). Because they transport nothing else than information, we call these entities "*informatons*".

In the context of the mentioned theory, the gravitational as well as the electromagnetic field of a material object is understood as an expanding cloud of informatons that forms an indivisible whole with that object. The *g*-information stored in that cloud is the substance of the gravitational field and if this is the case, the *e*-information stored in it is the substance of the electromagnetic field. That means that "information" can be identified as the substance of gravitational and electromagnetic fields and "informatons" as the constituent elements of that substance.

2. Preliminary Definitions

We refer to §2 of reference [4] for the definitions of the concepts "*mass*", "*charge*", "*mass particle*", "*space*", "*time*" and "*inertial reference frame*" as they are understood in the context of the theory of informatons.

3. Preliminary Concepts

3.1. The Concept of Gravitational or *g*-Information

Newton's law of universal gravitation [5] may be expressed as follows:

The gravitational force $\boldsymbol{F}$ *between any two particles having masses* m_1 *and* m_2 *separated by a distance* r *is an attraction working along the line joining the particles and has a magnitude*

$$F = G \cdot \frac{m_1 \cdot m_2}{r^2}$$

where $G = 6.6732 \times 10^{-11}\ \mathrm{N \cdot m^2 \cdot kg^{-2}}$ *is a universal constant having the same value for all pairs of particles.*

This law expresses the basic fact of gravitation, namely that two masses are interacting "at-a-distance": they exert forces on one another even though they are not in contact.

According to Newton's law $\boldsymbol{F}_B$, the force exerted by a particle *A*, with mass m_1, on a particle *B*, with mass *m*, is pointing to the position of *A* and has a magnitude:

$$F_B = \left(G \cdot \frac{m_1}{r^2}\right) \cdot m$$

The orientation of this force and the fact that it is directly proportional to the mass of *A* and inversely proportional to the square of the distance from *A* to *B*, implies that particle *B* must receive *information* about the presence in space of particle *A*: particle *A* must send information to *B* about its position and about its mass. This conclusion is independent of the position and the mass of *B*. So we can generalize it and posit that:

A particle manifests itself in space by emitting information about its mass and about its position. We consider that type of information as a substantial element of nature and call it "*gravitational information*" or "*g*-information".

3.2. The Concept of Electrical or *e*-Information

Two-point charges at rest relative to an IRF in vacuum exert an electric force $\boldsymbol{F}$ on one another. Between charges of like sign, this force is repulsive and between charges of unlike sign it is attractive. The precise value of the electric force that one charged particle exerts on another is given by Coulomb's law [6]:

The magnitude of the electric force $\mathbf{F}$ *that a particle with charge* q_1 *exerts on another particle with charge* q_2 *is directly proportional to the product of their charges and inversely proportional to the square of the distance r between them. The direction of the force is along the line joining the particles.*

$$F = \frac{1}{4\pi\varepsilon_0} . \frac{|q_1| . |q_2|}{r^2}$$

where $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F/m}$ *is the permittivity constant.*

Coulomb's law expresses the basic fact of electrostatics, namely that two point charges are interacting "at-a-distance".

According to Coulomb's law $\boldsymbol{F}_B$, the electric force exerted by a point charge *A*, with charge q_1, on a point charge *B*, with charge *q*, is pointing to the position of *A* if the signs of the charges are unlike and in the opposite direction if they are like. The magnitude of that force is:

$$F_B = \left(\frac{1}{4\pi\varepsilon_0} \cdot \frac{|q_1|}{r^2}\right) \cdot |q|$$

The orientation of $\boldsymbol{F}_B$ and the fact that it is directly proportional to the charge of A and inversely proportional to the square of the distance from B to A, implies that particle B must receive *information* from particle A about its electric charge and about its position. In other words: point charge A must send information to B about its position and about the magnitude and the sign of its charge.

So, we can posit that: *a point charge manifests itself in space by emitting information about its charge and about its position*. We consider this type of information as a substantial element of nature and call it "*electrical information*" or "*e*-information".

4. The Postulate of the Emission of Informatons

We assume that a material object manifests its presence in space by continuously emitting granular carriers of *g*-information and, if it is electrically charged, of *e*-information. These information carriers are called "informatons". The emission of informatons by a material object anchored in an IRF $\boldsymbol{O}$, is governed by the "*postulate of the emission of informatons*".

1) *The emission* of informatons by a mass particle at rest is governed by the following rules:

a) *The emission is uniform in all directions of space, and the informatons diverge with the speed of light* ($c = 3.10^8$ m/s) *along radial trajectories relative to the position of the emitter.*

b) $\dot{N} = \frac{\mathrm{d}N}{\mathrm{d}t}$, *the rate at which a particle emits informatons*[1], *is time independent and proportional to the rest mass* m_0 *of that particle. So there is a constant K so that*:

$$\dot{N} = K \cdot m_0$$

c) *The constant K is equal to the ratio of the square of the speed of light* (c) *to the Planck constant* (h):

$$K = \frac{c^2}{h} = 1.36 \times 10^{50}\ \mathrm{kg}^{-1} \cdot \mathrm{s}^{-1}$$

2) We call the essential attribute of an informaton its *g-index*. The g-index of an informaton refers to information about the position of its emitter and equals the *elementary quantum of g*-information. It is represented by a vectoral quantity $\boldsymbol{s}_g$:

a) $\boldsymbol{s}_g$ *points to the position of the emitter.*

b) *The elementary quantum of g*-information *is*:

$$s_g = \frac{1}{K \cdot \eta_0} = \frac{h}{\eta_0 \cdot c^2} = 6.18 \times 10^{-60}\ \mathrm{m}^3 \cdot \mathrm{s}^{-1}$$

where $\eta_0 = \frac{1}{4 \cdot \pi \cdot G} = 1.19 \times 10^9\ \mathrm{kg} \cdot \mathrm{s}^2 \cdot \mathrm{m}^{-3}$, G being the gravitational constant.

3) Informatons emitted by an electrically charged particle at rest in an IRF,

[1]We neglect the possible stochastic nature of the emission, that is responsible for noise on the quantities that characterize the gravitational field. So, $\dot{N}$ is the average emission rate.

carry in addition an attribute that refers to the electric charge per unit mass of their emitter, namely the e-index. *e*-indices are represented as $\boldsymbol{s}_e$ and defined by:

a) *The e-indices are radial relative to the position of the emitter. They are centrifugal when the emitter carries a positive charge* ($q = +Q$) *and centripetal when the charge of the emitter is negative* ($q = -Q$).

b) s_e, *the magnitude of an e-index depends on* Q/m_0, *the charge per unit of rest mass of the emitter. It is defined by*:

$$s_e = \frac{1}{K \cdot \varepsilon_0} \cdot \frac{Q}{m_0} = 8.32 \times 10^{-40} \cdot \frac{Q}{m_0} \, \mathrm{kg} \cdot \mathrm{m}^3 \cdot \mathrm{s}^{-1} \cdot \mathrm{C}^{-1}$$

where $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F/m}$ *is the permittivity constant*.

Rule 1.a is the expression of the hypothesis that the space is a homogenous and isotropic continuum in which the gravitational and electromagnetic phenomena are travelling with the speed of light. Rule 1.b posits that the rate at which a particle emits informatons is a measure for its rest mass and rule 1.c implies the fact that, when a particle absorbs (emits) a photon $h \cdot \nu$, its rest mass is increasing (decreasing) with an amount $\frac{h \cdot \nu}{c^2}$ while its emission rate is increasing (decreasing) with an amount ν.

Rule 2.a and rule 2.b identify an informaton as the carrier of the constituent element of gravitational information.

Rule 3.a and rule 3.b identify an informaton emitted by an electrically charged mass particle as the carrier of the constituent element of electrical information linked to that particle.

To summarize, each material object manifests itself in space by the emission of informatons. Informatons are carriers of the elementary quantum of *g*-information and as such the constituent elements of gravitational fields. If their emitter is electrically charged, they are also carriers of the elementary quantity of *e*-information that depends on the charge/unit of mass of their emitter and they are as such the constituent elements of electric fields.

We will represent an informaton as a quasi-infinitely small sphere, moving with velocity $\boldsymbol{c}$ always carrying a vector $\boldsymbol{s}_g$ and if it is emitted by a charged particle in addition carrying a vector $\boldsymbol{s}_e$.

5. The Emission of Informatons by a Particle at Rest

In **Figure 1**, we consider a particle, with rest mass m_0 and (positive) charge q, that is anchored at the origin of an IRF $\boldsymbol{O}$.

From article 1 of the "postulate of the emission on informatons" it follows that that particle is the source and the center of a, with the speed of light, expanding spherical cloud of informatons. It is evident that the rate at which that particle emits informatons is also the rate at which it sends informatons through any closed surface surrounding it. So, the postulate of the emission of informatons implies that the *intensity of the flow of informatons* through any closed surface that encloses the particle is:

$$\dot{N} = \frac{\mathrm{d}N}{\mathrm{d}t} = K \cdot m_0$$

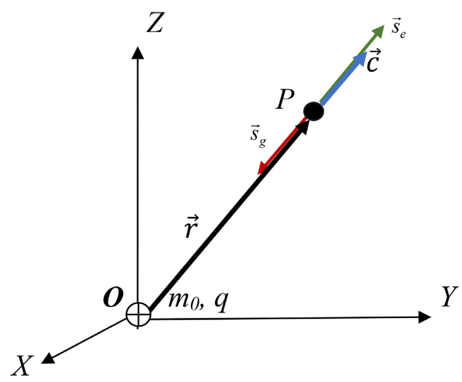

Figure 1. The emission of an informaton by an electrically charged particle.

If the closed surface is a sphere with radius *r*, the *intensity of the flow of informatons per unit area* is given by:

$$\frac{K \cdot m_0}{4 \cdot \pi \cdot r^2} \tag{1}$$

This is, at any point *P* at a distance *r* from their source the "*density of the flow of informatons*", *i.e. the rate per unit area at which these informatons cross an elementary surface perpendicular to the direction in which they move*.

Because for each spatial region, the inflow of informatons equals the outflow each spatial region contains an unchanging number of informatons and thus a constant quantity of *g*-information and a constant quantity of *e*-information. Moreover, the orientation of the *g*- and *e*-indices of the informatons passing near an arbitrary point is time-independent. And in addition, each spatial region contains a very large number of informatons, which makes that the cloud of informatons can be considered as a continuum. If we focus on the *g*-information as its substance that continuum is called the "*gravitational field*" of the particle and if we focus on the *e*-information it is referred to as its" *electric field*".

6. The *g*-Field and the *e*-Field of a Particle at Rest

According to articles 1 and 2 of the postulate of the emission of informatons, the informatons that in **Figure 1** with velocity

$$\boldsymbol{c} = c \cdot \frac{\boldsymbol{r}}{r} = c \cdot \boldsymbol{e}_r$$

pass near point *P*, defined by the position vector $\boldsymbol{r}$, have two attributes: their g-index $\boldsymbol{s}_g$ and their *e*-index $\boldsymbol{s}_e$:

$$\boldsymbol{s}_g = -\frac{1}{K \cdot \eta_0} \cdot \frac{\boldsymbol{r}}{r} = -\frac{1}{K \cdot \eta_0} \cdot \boldsymbol{e}_r \tag{2}$$

$$\boldsymbol{s}_e = \frac{q}{m_0} \cdot \frac{1}{K \cdot \varepsilon_0} \cdot \frac{\boldsymbol{r}}{r} = \frac{q}{m_0} \cdot \frac{1}{K \cdot \varepsilon_0} \cdot \boldsymbol{e}_r \tag{3}$$

The densities (*i.e.* the rates per unit area perpendicular to $\boldsymbol{c}$) of the flows of *g*- and *e*-information at *P* are respectively the product of the density of the flow of informatons with s_g, the elementary *g*-information quantum, and with s_e, the elementary *e*-information quantity.

So, combining (1) and (2) with (3) we become the following expressions for respectively the density of the flow of *g*-information and the flow of *e*-information at *P*:

$$\frac{K \cdot m_0}{4 \cdot \pi \cdot r^2} \cdot \frac{1}{K \cdot \eta_0} = \frac{m_0}{4 \cdot \pi \cdot \eta_0 \cdot r^2}$$

$$\frac{K \cdot m_0}{4 \cdot \pi \cdot r^2} \cdot \frac{q}{m_0} \cdot \frac{1}{K \cdot \varepsilon_0} = \frac{q}{4 \cdot \pi \cdot \varepsilon_0 \cdot r^2}$$

These quantities are, together with the orientation of the *g*- and *e*-indices of the informatons that are passing near *P*, characteristic for the gravitational field and for the electric field at that point. Thus, at a point *P*, the gravitational field of a particle with mass m_0 and electric charge q is unambiguously characterized by the vectoral quantity $\boldsymbol{E}_g$ defined as:

$$\boldsymbol{E}_g = \frac{\dot{N}}{4 \cdot \pi \cdot r^2} \cdot \boldsymbol{s}_g = -\frac{m_0}{4 \cdot \pi \cdot \eta_0 \cdot r^2} \cdot \boldsymbol{e}_r = -\frac{m_0}{4 \cdot \pi \cdot \eta_0 \cdot r^3} \cdot \boldsymbol{r}$$

And its electric field by the vectoral quantity $\boldsymbol{E}$ defined as:

$$\boldsymbol{E} = \frac{\dot{N}}{4 \cdot \pi \cdot r^2} \cdot \boldsymbol{s}_e = \frac{q}{4 \cdot \pi \cdot \varepsilon_0 \cdot r^2} \cdot \boldsymbol{e}_r = \frac{q}{4 \cdot \pi \cdot \varepsilon_0 \cdot r^3} \cdot \boldsymbol{r}$$

These quantities are the *gravitational field strength* or shortly the "*g-field*" and the *electric field strength* or shortly the "*e-field*".

We conclude:

1) $\boldsymbol{E}_g$, *the magnitude of* $\boldsymbol{E}_g$ *characterizes the density of the flow of g*-information *at an arbitrary point P* (*i.e. the rate per unit area at which g*-information *crosses an elementary surface perpendicular to the direction in which the informatons move at P*). *And E, the magnitude of* $\boldsymbol{E}$ *characterizes at P the density of the flow of e*-information (*i.e. the rate per unit area at which e*-information *crosses an elementary surface perpendicular to the direction in which the informatons move*).

2) *At any point of the gravitational field of a particle with rest mass* m_0 (*whether or not electrically charged*), *the orientation of* $\boldsymbol{E}_g$ *corresponds to the orientation of the g-indices of the informatons that are passing near that point. So* $\boldsymbol{E}_g$ *is pointing to the position of the source of the field. That applies also to* $\boldsymbol{E}$ *in the case of the electric field of a particle with negative charge, but in the case of a particle with a positive charge* $\boldsymbol{E}$ *is pointing in the opposite direction.*

Let us note that the role played by the factor $(-\frac{m_0}{\eta_0})$ in the definition of $\boldsymbol{E}_g$ is taken over by the factor $(\frac{q}{\varepsilon_0})$ in het definition of $\boldsymbol{E}$.

7. The Laws of Conservation of *g*- and *e*-Information

Let us consider a surface-element dS at P (Figure 2(a)). Its orientation and its magnitude are completely determined by the surface-vector $\mathrm{d}\boldsymbol{S}$ (Figure 2(b)). By $-\mathrm{d}\Phi_G$, we represent the rate at which *g*-information flows through dS in the sense of the positive normal $\boldsymbol{e}_n$ and we call the scalar quantity $\mathrm{d}\Phi_G$ defined as

$$\mathrm{d}\Phi_G = \boldsymbol{E}_g \cdot \mathrm{d}\boldsymbol{S} = E_g \cdot \mathrm{d}S \cdot \cos\alpha$$

the *elementary g-flux through dS*.

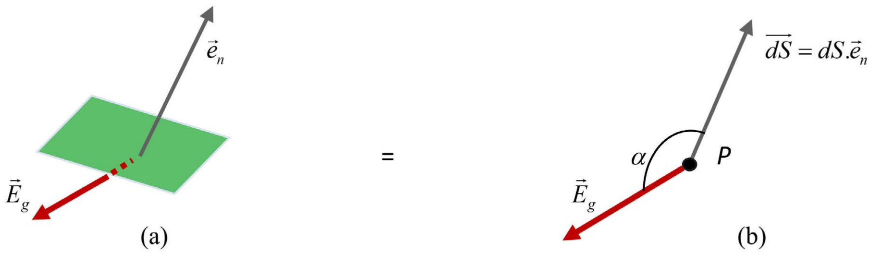

Figure 2. The flux through a surface element.

For an arbitrary closed surface S that surrounds a particle with rest mass m_0, the outward *g*-flux Φ_G (that we obtain by integrating the elementary contributions $\mathrm{d}\Phi_g$ over S) must be equal to the rate at which the particle emits *g*-information. Thus:

$$\Phi_G = \oiint \boldsymbol{E}_g \cdot \mathrm{d}\boldsymbol{S} = -\frac{m_0}{\eta_0} \tag{4}$$

In an analogous manner it can be shown that for an arbitrary closed surface that surrounds a particle with charge q, the outward e-flux Φ_E is equal to the rate at which the particle emits *e*-information. Thus:

$$\Phi_E = \oiint \boldsymbol{E} \cdot \mathrm{d}\boldsymbol{S} = \frac{q}{\varepsilon_0} \tag{5}$$

(4) and (5) (Gauss's laws) express *the laws of the conservation of g- and of e-*information.

8. The Gravitational Field and the Electric Field of a Set of Particles at Rest

We consider a set of particles with rest masses $m_1, \cdots, m_i, \cdots, m_n$ that are anchored in an IRF ***O***. At an arbitrary point P, the flows of *g*-information that are emitted by the distinct masses are defined by the gravitational fields $\boldsymbol{E}_{g1}, \cdots, \boldsymbol{E}_{gi}, \cdots, \boldsymbol{E}_{gn}$. $-d\Phi_g$, the rate at which *g*-information flows through a surface-element dS at P in the sense of the positive normal, is the sum of the contributions of the distinct masses:

$$-\mathrm{d}\Phi_G = \sum_{i=1}^{n} -\left(\boldsymbol{E}_{gi} \cdot \mathrm{d}\boldsymbol{S}\right) = -\left(\sum_{i=1}^{n} \boldsymbol{E}_{gi}\right) \cdot \mathrm{d}\boldsymbol{S} = -\boldsymbol{E}_g \cdot \mathrm{d}\boldsymbol{S}$$

So, the *effective density of the flow of g-*information *at P* (the effective g-field) is completely defined by:

$$\boldsymbol{E}_g = \sum_{i=1}^{n} \boldsymbol{E}_{gi}$$

If the particles are electrically charged with charges $q_1, \cdots, q_i, \cdots, q_n$ they will in addition create an e-field that at an arbitrary point is determined by:

$$\boldsymbol{E} = \sum_{i=1}^{n} \boldsymbol{E}_i$$

We conclude: *At a point in space, the g-field (e-field) of a set of (electrically charged) particles at rest is completely defined by the vectoral sum of the g-fields (e-fields) caused by the distinct particles.*

It's easy to show that the conservations laws (4) and (5) in the case of a set of particles take the following form:

$$\Phi_G = \oiint \boldsymbol{E}_g \cdot \mathrm{d}\boldsymbol{S} = -\frac{m_{in}}{\eta_0} \quad \text{and} \quad \Phi_E = \oiint \boldsymbol{E} \cdot \mathrm{d}\boldsymbol{S} = \frac{q_{in}}{\varepsilon_0}$$

where m_{in} and q_{in} are respectively the surrounded mass and the surrounded charge.

9. The *g*-Field and the *e*-Field of a Mass Continuum at Rest

We call an object in which the matter in a time independent manner is spread over the occupied volume, a *mass continuum*.

At each point Q in such a continuum, the accumulation of mass is characterized by the (*mass*) *density* ρ_G. To define this scalar quantity one considers the mass $\mathrm{d}m$ of a volume element $\mathrm{d}V$ that contains Q. The accumulation of mass in the vicinity of Q is defined by the mass density ρ_G:

$$\rho_G = \frac{\mathrm{d}m}{\mathrm{d}V}$$

If the mass continuum is electrically charged, in addition, it is characterized by the *charge density* ρ_E. This scalar quantity is defined by considering the charge $\mathrm{d}q$ in the volume element $\mathrm{d}V$:

$$\rho_E = \frac{\mathrm{d}q}{\mathrm{d}V}$$

A mass (charge) continuum, anchored in an IRF, is equivalent to a set of infinitely many infinitesimal small mass (charge) elements $\mathrm{d}m$ ($\mathrm{d}q$). The contribution of each of them to the *g*- (*e*-)field at an arbitrary point P is $\mathrm{d}\boldsymbol{E}_g$ ($\mathrm{d}\boldsymbol{E}$). $\boldsymbol{E}_g$ ($\boldsymbol{E}$), the effective *g*- (*e*-)field at P, is the result of the integration over the volume of the continuum of all these contributions.

It is evident that the outward *g*- (*e*-)flux through a closed surface S only depends on the mass (charge) enclosed by that surface (the enclosed volume is V):

$$\oiint_S \boldsymbol{E}_g \cdot \mathrm{d}\boldsymbol{S} = -\frac{1}{\eta_0} \cdot \iiint_V \rho_G \cdot \mathrm{d}V \quad \text{and} \quad \oiint_S \boldsymbol{E} \cdot \mathrm{d}\boldsymbol{S} = \frac{1}{\varepsilon_0} \cdot \iiint_V \rho_E \cdot \mathrm{d}V$$

This is Gauss's law in the case of a mass (electrically charged) continuum. *It is* *the expression of the conservation of g- (e-)information.*

These relations are equivalent with (theorem of Ostrogradsky [7]):

$$div\boldsymbol{E}_g = -\frac{\rho_G}{\eta_0} \quad \text{and} \quad div\boldsymbol{E} = \frac{\rho_E}{\varepsilon_0}$$

Furthermore, one can show that in any matter free point $rot\boldsymbol{E}_g = rot\boldsymbol{E} = 0$, what implies the existence of a gravitational (electric) potential function V_g (V) for which:

$$\boldsymbol{E}_g = -gradV_g \quad \text{and} \quad \boldsymbol{E} = -gradV$$

Let us note that the role played by the factor ($-\frac{\rho_G}{\eta_0}$) in the definition of $\boldsymbol{E}_g$ is taken over by the factor ($\frac{\rho_E}{\varepsilon_0}$) in the definition of $\boldsymbol{E}$.

10. The Emission of Informatons by a Particle Moving with Constant Velocity

We extend rule 1.b of the postulate of the emission of informatons with the following proposition: $\dot{N}$, *the rate at which a mass particle emits informatons is independent of its of motion.*

In **Figure 3** we consider a particle, with rest mass m_0 and (positive) charge q moving with constant velocity $\boldsymbol{v}$ along the Z-axis of an IRF $\boldsymbol{O}$. At the arbitrary moment t it passes at P_1. The position of P, an arbitrary fixed point in space, is defined by the vector $\boldsymbol{r} = \boldsymbol{P_1P}$. Because the position of P_1 is continuously changing, $\vec{r}$, just like the distance r and the angle θ, is time dependent.

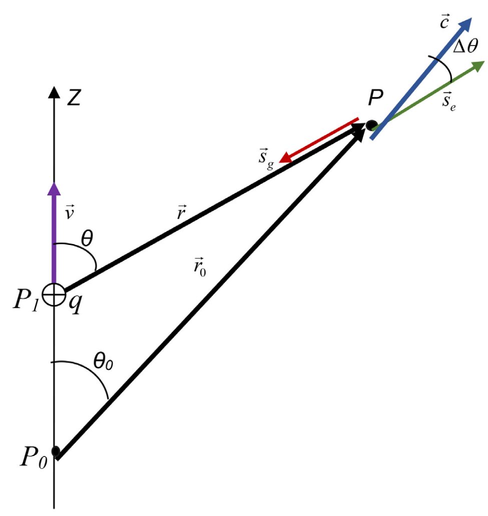

Figure 3. The emission of an informaton by an electrically charged particle.

The informatons that, with the speed of light, at the moment t are passing near P, are emitted when the particle was at P_0. Bridging the distance $P_0P = r_0$ took the time interval $\Delta t = \frac{r_0}{c}$. During their rush from P_0 to P their emitter, the particle, moved from P_0 to P_1: $P_0P_1 = v \cdot \Delta t$.

1) Rule 1.a of the postulate of the emission of informatons implies that $\boldsymbol{c}$ the velocity of these informatons, points in the direction of their movement, thus along the radius P_0P;

2) Rules 2.a and 3.a of that postulate imply that $\boldsymbol{s}_g$, their *g*-index, points to P_1, the position of the (positive) particle at the moment *t* and that $\boldsymbol{s}_e$, their *e*-index, points in the opposite direction.

The line carrying the indices $\boldsymbol{s}_g$ and $\boldsymbol{s}_e$ and those carrying $\boldsymbol{c}$ form an angle $\Delta\theta$. We call this angle, that is characteristic for the speed of the mass particle, the "*characteristic angle*" or the "*characteristic deviation*" of the informaton. The quantity $s_\beta = s_g \cdot \sin(\Delta\theta)$, referring to the speed of the emitter, is called the "*characteristic g*-information" or the "*β*-information" carried by the informaton and the quantity $s_b = s_e \cdot \sin(\Delta\theta)$ its "*characteristic e*-information" or "*b*-information".

We conclude that an informaton emitted by a moving particle, is a carrier of information referring to the velocity of that particle. This information may be represented by $\boldsymbol{s}_\beta$, its "*gravitational characteristic vector*" or "*β-index*" - and if the particle is electrically charged in addition by $\boldsymbol{s}_b$ its "*electrical characteristic vector*" or "*b-index*". These vectoral quantities are defined as:

$$\boldsymbol{s}_\beta = \frac{\boldsymbol{c} \times \boldsymbol{s}_g}{c} \quad \text{and} \quad \boldsymbol{s}_b = \frac{\boldsymbol{c} \times \boldsymbol{s}_e}{c}$$

1) The *β*- (b-)index is perpendicular to the plane formed by the path of the informaton and the straight line that carries the *g*- (*e*-)index, thus it is perpendicular to the plane formed by the point *P* and the path of the emitter.

2) Its orientation relative to that plane is defined by the "rule of the corkscrew".

3) The magnitude of the *β*-index is $s_\beta = s_g \cdot \sin(\Delta\theta)$ and the magnitude of the b-index is $s_b = s_e \cdot \sin(\Delta\theta)$.

In the case of **Figure 3** the *β*-index has the orientation of the positive *X*-axis and the b-index points in the opposite direction. In the case of a negatively charged particle both indices would have the same orientation.

11. Generalization: The Gravitational and the Magnetic Induction

If they are emitted by a *moving* electrically charged particle, all elements of the cloud of informatons in the volume element d*V* at *P* (**Figure 3**) carry, besides *g*- and *e*-information, also *β*- and b-information that depends on the state of movement of the emitting particle and is represented by the *β*-indices $\boldsymbol{s}_\beta$ and the b-indices $\boldsymbol{s}_b$ defined as:

$$\boldsymbol{s}_\beta = \frac{\boldsymbol{c} \times \boldsymbol{s}_g}{c} \quad \text{and} \quad \boldsymbol{s}_b = \frac{\boldsymbol{c} \times \boldsymbol{s}_e}{c}$$

If *n* is the density at *P* of the cloud of informatons (number of informatons per unit volume) at the moment *t*, the densities of the cloud of *β*/b-information (characteristic information per unit volume) at *P* is determined as:

$$n\cdot \boldsymbol{s}_\beta = n\cdot \frac{\boldsymbol{c}\times \boldsymbol{s}_g}{c} \quad \text{and} \quad n\cdot \boldsymbol{s}_b = \frac{\boldsymbol{c}\times \boldsymbol{s}_e}{c}$$

We call these (time dependent) vectoral quantities, that will be represented by $\boldsymbol{B}_g$ and $\boldsymbol{B}$, respectively the "*gravitomagnetic induction*" or "*β-induction*" and the "*magnetic induction*" or "*b-induction*" at *P*. The magnitude B_g/B characterizes the density of the *β*/b-information cloud at *P* and the orientation of $\boldsymbol{B}_g/\boldsymbol{B}$ refers to the orientation of the *β*/b-indices $\boldsymbol{s}_\beta/\boldsymbol{s}_b$ of the informatons passing near that point.

So, the *β*- and the *b*-induction caused at *P* by an electrically moving particle with rest mass m_0 and charge *q* are:

$$\boldsymbol{B}_g = n\cdot \frac{\boldsymbol{c}\times \boldsymbol{s}_g}{c} = \frac{\boldsymbol{c}}{c}\times\left(n\cdot \boldsymbol{s}_g\right) \quad \text{and} \quad \boldsymbol{B} = n\cdot \frac{\boldsymbol{c}\times \boldsymbol{s}_e}{c} = \frac{\boldsymbol{c}}{c}\times\left(n\cdot \boldsymbol{s}_e\right)$$

N, the density of the flow of informatons at *P* (the rate per unit area at which the informatons cross an elementary surface perpendicular to the direction of their movement), and *n*, the density of the cloud of informatons at that point (number of informatons per unit volume), are connected by the relation: $n = \frac{N}{c}$.

With $\boldsymbol{E}_g = N\cdot \boldsymbol{s}_g$ and $\boldsymbol{E} = N\cdot \boldsymbol{s}_e$ we can express the *β*- and the b-induction at *P* as:

$$\boldsymbol{B}_g = \frac{\boldsymbol{c}}{c^2}\times\left(N\cdot \boldsymbol{s}_g\right) = \frac{\boldsymbol{c}\times \boldsymbol{E}_g}{c^2} \quad \text{and} \quad \boldsymbol{B} = \frac{\boldsymbol{c}}{c^2}\times\left(\boldsymbol{N}\cdot \boldsymbol{s}_e\right) = \frac{\boldsymbol{c}\times \boldsymbol{E}}{c^2}$$

We conclude: *A moving mass particle manifests itself in space by its "gravitoelectromagnetic (GEM) field": a dual entity always having a field- and an induction-component (* $\boldsymbol{E}_g$ *and* $\boldsymbol{B}_g$ *). If the particle is electrically charged it is, in addition, the source of an "electromagnetic (EM) field": also a dual entity with a field- and an induction-component (* $\boldsymbol{E}$ *and* $\boldsymbol{B}$ *). The source of the GEM field is the rest mass* m_0 *of the particle, its electric charge q is the source of the EM field.*

12. The Field- and Induction Component of the Gravitational and of the Electromagnetic Field of a Mass Particle Moving with Constant Velocity

12.1. The *g*-Field and *e*-Field of a Mass Particle Moving with Constant Velocity

In Figure 4(a), we consider a particle with rest mass m_0 and (positive) charge *q* that is moving with constant velocity $\boldsymbol{v} = v\cdot \boldsymbol{e}_z$ along the *Z*-axis of an IRF ***O***. At the moment $t = 0$, it passes through the origin *O* and at the moment $t = t$ through the point P_1. It is evident that:

$$OP_1 = z_{P_1} = v\cdot t$$

P is an arbitrary fixed point in ***O***. Its position relative to the moving particle is determined by the time dependent position vector $\boldsymbol{r} = \boldsymbol{P_1P}$.

We introduce $\boldsymbol{O}'$, the proper IRF of the particle (**Figure 4(b)**), *i.e.* the IRF whose origin is anchored to the particle and we assume that $t = t' = 0$ when its origin O' passes through O. Relative to $\boldsymbol{O}'$, the position of P is determined by the time dependent position vector $\boldsymbol{r}' = \boldsymbol{O'P}$.

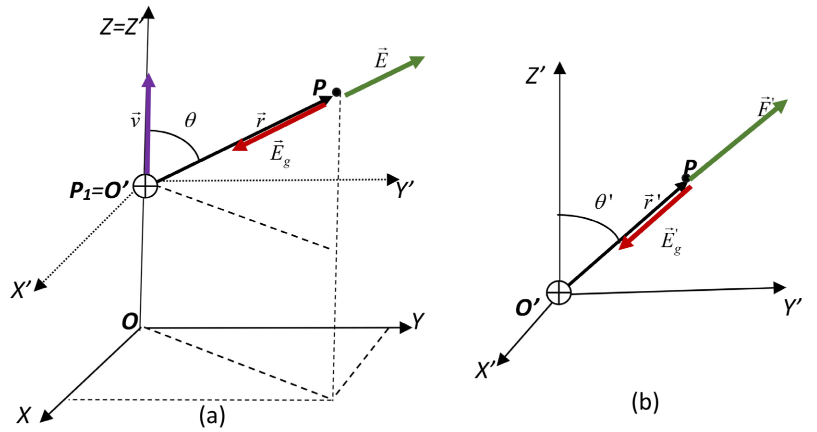

Figure 4. The *g*-field of an electrically charged mass particle moving with constant velocity.

The particle is at rest in $\boldsymbol{O}'$. So according to §.6, $\boldsymbol{E}'_g$, its *g*-field relative to $\boldsymbol{O}'$, is completely defined by the vectoral quantity:

$$\boldsymbol{E}'_g = -\frac{\frac{\mathrm{d}N}{\mathrm{d}t'} \cdot s_g}{4 \cdot \pi \cdot r'^2} \cdot \boldsymbol{e}_{r'}$$

$\mathrm{d}N$ is the number of informatons that during the time interval $\mathrm{d}t'$ pass through an elementary surface $\mathrm{d}S'$ that in $\boldsymbol{O}'$ is perpendicular to $\boldsymbol{c}$, the velocity of these informatons.

By definition, $\boldsymbol{E}'_g$ is, relative to $\boldsymbol{O}'$, the density of the *g*-information flow at P and the magnitude of $\boldsymbol{E}'_g$ is the rate per unit area at which, relative to $\boldsymbol{O}'$, *g*-information flows through an elementary surface $\mathrm{d}S'$ that at P is perpendicular to the velocity $\boldsymbol{c}$ of the informatons that carry that information.

The Lorentz transformation equations [8] provide the key for the mathematical deduction of $\boldsymbol{E}_g$, the *g*-field at P relative to $\boldsymbol{O}$, from $\boldsymbol{E}'_g$, the *g*-field relative to $\boldsymbol{O}'$. In §3 of [9] one can find the detailed calculations. They lead to the following result:

$$\boldsymbol{E}_g = -\frac{m_0}{4\pi\eta_0 r^3} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot \boldsymbol{r} = -\frac{m_0}{4\pi\eta_0 r^2} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot \boldsymbol{e}_r \tag{6}$$

It is evident that one, in an analogous manner, can deduce $\boldsymbol{E}$, the electric field at P relative to $\boldsymbol{O}$, from $\boldsymbol{E}'$, the electric field at that point relative to $\boldsymbol{O}'$.

As earlier mentioned this implies the substitution of the factor $(-\frac{m_0}{\eta_0})$ in formula (6) by the factor $(\frac{q}{\varepsilon_0})$. Thus:

$$\boldsymbol{E} = \frac{q}{4\pi\varepsilon_0 r^3} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot \boldsymbol{r} = \frac{q}{4\pi\varepsilon_0 r^2} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot \boldsymbol{e}_r \tag{7}$$

We conclude: *An* (*electrically charged*) *mass particle describing a uniform rectilinear movement relative to an inertial reference frame* ***O****, creates in the space linked to that frame a time dependent gravitational* (*electric*) *field.*

1) $\boldsymbol{E}_g$, *the g-field at an arbitrary point P, points at any moment to the actual position of the particle*[2] *and its magnitude is*:

$$E_g = \frac{m_0}{4\pi\eta_0 r^2} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}}$$

2) *If the charge of the particle is negative,* $\mathbf{E}$, *the e-field at P, also points at any moment to the actual position of the particle. If it is positive,* $\mathbf{E}$ *points in the opposite direction. The magnitude of* $\mathbf{E}$ *is*:

$$E = \frac{|q|}{4\pi\varepsilon_0 r^2} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}}$$

If the speed of the particle is much smaller than the speed of light, the expressions (6) and (7) reduce to that valid in the case of a particle at rest. This non-relativistic result could directly be obtained if one assumes that the displacement of the mass particle during the time interval that the informatons need to move from the emitter to *P* can be neglected compared to the distance they travel during that period.

Finally let us note that the fact that the rate at which *g*- (*e*-information) that escapes from an enclosed space is completely determined by the rate at which it is generated inside that space (*conservation of g*/*e*-information) can be expressed as:

$$\oiint \boldsymbol{E}_g \cdot \mathrm{d}\boldsymbol{S} = -\frac{m_0}{\eta_0} \quad \text{and} \quad \oiint \boldsymbol{E} \cdot \mathrm{d}\boldsymbol{S} = \frac{q}{\varepsilon_0}$$

12.2. The β-Induction and the b-Induction of a Mass Particle Moving with Constant Velocity

We refer to the situation of §10 (Figure 3). Applying the sine-rule to the triangle P_0P_1P, we obtain:

$$\frac{\sin(\Delta\theta)}{v \cdot \Delta t} = \frac{\sin\theta}{c \cdot \Delta t}$$

From which it follows:

$$s_\beta = s_g \cdot \frac{v}{c} \cdot \sin\theta \quad \text{and} \quad s_b = s_e \cdot \frac{v}{c} \cdot \sin\theta$$

Thus, taking into account the orientation of the different vectors, the β/b-index of an informaton emitted by an electrically charged point mass moving with con-

[2]The orientation of the g-field implies that the g-indices of the informatons that at a certain moment pass near *P*, point, in accordance with the "postulate of the emission of informatons", to the actual position of the emitting mass and not to its light delayed position.

stant velocity, can also be expressed as:

$$\boldsymbol{s}_\beta = \frac{\boldsymbol{v} \times \boldsymbol{s}_g}{c} \quad \text{and} \quad \boldsymbol{s}_b = \frac{\boldsymbol{v} \times \boldsymbol{s}_e}{c}$$

From the general definitions in §11 of $\boldsymbol{B}_g$ and $\boldsymbol{B}$ it follows that in the particular case of an electrically charged particle moving with constant velocity $\boldsymbol{v}$:

$$\boldsymbol{B}_g = \frac{\boldsymbol{v}}{c^2} \times \left(N \cdot \boldsymbol{s}_g \right) = \frac{\boldsymbol{v} \times \boldsymbol{E}_g}{c^2} \quad \text{and} \quad \boldsymbol{B} = \frac{\boldsymbol{v}}{c^2} \times \left(N \cdot \boldsymbol{s}_e \right) = \frac{\boldsymbol{v} \times \boldsymbol{E}}{c^2}$$

Taking (6) and (7) into account, we become the *β*- and the *b*-induction at *P*:

$$\boldsymbol{B}_g = \frac{\nu_0 \cdot m_0}{4\pi r^3} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot (\boldsymbol{r} \times \boldsymbol{v}) \tag{8}$$

$$\boldsymbol{B} = \frac{\mu_0 \cdot q}{4\pi r^3} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot (\boldsymbol{v} \times \boldsymbol{r}) \tag{9}$$

With: $\nu_0 = \frac{1}{c^2 \cdot \eta_0} = 9.34 \times 10^{-27}\ \mathrm{m \cdot kg^{-1}}$ and $\mu_0 = \frac{1}{c^2 \cdot \varepsilon_0} = 1.26 \times 10^{-6}\ \mathrm{H/m}$

We conclude: *An* (*electrically charged*) *mass particle describing a uniform rectilinear movement relative to an IRF* ***O****, creates in the space linked to that frame a time dependent gravitomagnetic* (*magnetic*) *induction field characterized by* (8) [(9)], *the β-induction* (*the b-induction*).

1) *The orientation of* $\boldsymbol{B}_g$, *the β- or gravitomagnetic induction at an arbitrary point P, is determined by the orientation of the vectoral product* $(\boldsymbol{r} \times \boldsymbol{v})$ *and the magnitude is*:

$$B_g = \frac{\nu_0 \cdot m_0}{4\pi r^2} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot v \cdot \sin\theta$$

2) *If the charge of the particle is negative, the orientation of* $\boldsymbol{B}$, *the b- or magnetic induction at P, is also at any moment determined by the orientation of the vectoral product* $(\boldsymbol{r} \times \boldsymbol{v})$. *If it is positive,* $\boldsymbol{B}$ *points in the opposite direction. The magnitude of* $\boldsymbol{B}$ *is*:

$$B = \frac{\mu_0 \cdot |q|}{4\pi r^2} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot v \cdot \sin\theta$$

If the speed of the mass is much smaller than the speed of light, the expressions for the gravitomagnetic and magnetic induction reduce to:

$$\boldsymbol{B}_g = \frac{\nu_0 \cdot m_0}{4\pi r^3} \cdot (\boldsymbol{r} \times \boldsymbol{v}) \quad \text{and} \quad \boldsymbol{B} = \frac{\mu_0 \cdot q}{4\pi r^3} \cdot (\boldsymbol{v} \times \boldsymbol{r})$$

This non-relativistic results (Biot-Savart law) could directly be obtained if one assumes that the displacement of the point mass during the time interval that the informatons need to move from the emitter to *P* can be neglected compared to the distance they travel during that period.

Finally from the fact that $\boldsymbol{s}_\beta$ ($\boldsymbol{s}_b$) is always perpendicular to both $\boldsymbol{c}$ and $\boldsymbol{s}_g$

($\boldsymbol{s}_e$) it follows that:

$$\oiint \boldsymbol{B}_g \cdot \mathrm{d}\boldsymbol{S} = 0 \quad \text{and} \quad \oiint \boldsymbol{B} \cdot \mathrm{d}\boldsymbol{S} = 0$$

13. Summary and Generalization

13.1. The Gravitoelectromagnetic and the Electromagnetic Field of a Mass Particle Moving with Constant Velocity

An electrically charged particle with rest mass m_0 and charge q, moving with constant velocity $\boldsymbol{v} = v \cdot \boldsymbol{e}_z$ along the Z-axis of an IRF, creates and maintains an expanding cloud of informatons that are carriers of g-/β- and e-/b-information.

1) Focusing on the g-/β-information, that cloud manifests itself as a time dependent continuum: the *gravitoelectromagnetic field* (*GEM-field*) of the particle. It is characterized by two time dependent vectoral quantities: the "gravitational field" (short: *g-field*) $\boldsymbol{E}_g$ and the "gravitomagnetic induction" (short: *β-induction*) $\boldsymbol{B}_g$. With N and n respectively the density of the flow and the density of the cloud of informatons at an arbitrary point P:

$$\boldsymbol{E}_g = N \cdot \boldsymbol{s}_g = -\frac{m_0}{4\pi\eta_0 r^3} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot \boldsymbol{r}$$

$$\boldsymbol{B}_g = n \cdot \boldsymbol{s}_\beta = \frac{\nu_0 \cdot m_0}{4\pi r^3} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot (\boldsymbol{r} \times \boldsymbol{v})$$

If $v \ll c$, these expressions reduce to:

$$\boldsymbol{E}_g = -\frac{m_0}{4\pi\eta_0 r^3} \cdot \boldsymbol{r} \quad \text{and} \quad \boldsymbol{B}_g = \frac{\nu_0 \cdot m_0}{4\pi r^3} \cdot (\boldsymbol{r} \times \boldsymbol{v})$$

2) Focusing on the e-/b-information, that cloud manifests itself as a another time dependent continuum: the *electromagnetic field* (*EM-field*) of the particle. It is, just like the GEM-field characterized by two time dependent vectoral quantities: the "electric field" (short: *e-field*) $\boldsymbol{E}$ and the "magnetic induction" (short: *b-induction*) $\boldsymbol{B}_g$:

$$\boldsymbol{E} = N \cdot \boldsymbol{s}_e = \frac{q}{4\pi\varepsilon_0 r^3} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot \boldsymbol{r}$$

$$\boldsymbol{B} = n \cdot \boldsymbol{s}_b = \frac{\mu_0 \cdot q}{4\pi r^3} \cdot \frac{1-\beta^2}{\left(1-\beta^2 \cdot \sin^2\theta\right)^{\frac{3}{2}}} \cdot (\boldsymbol{v} \times \boldsymbol{r})$$

If $v \ll c$, these expressions reduce to:

$$\boldsymbol{E} = \frac{q}{4\pi\varepsilon_0 r^3} \cdot \boldsymbol{r} \quad \text{and} \quad \boldsymbol{B} = \frac{\mu_0 \cdot q}{4\pi r^3} \cdot (\boldsymbol{v} \times \boldsymbol{r})$$

Let us notice that the role played by the factor ($-\nu_0 \cdot m_0$) in the definition of $\boldsymbol{B}_g$ is taken over by the factor ($\mu_0 \cdot q$) in the definition of $\boldsymbol{B}$.

One can verify that:

1) $divE_{(g)} = 0$

2) $divB_{(g)} = 0$

3) $rotE_{(g)} = -\frac{\partial B_{(g)}}{\partial t}$

4) $rotB_{(g)} = \frac{1}{c^2} \cdot \frac{\partial E_{(g)}}{\partial t}$

These relations are the *laws of Maxwell-Heaviside*.

13.2. The GEM and the EM Field of a Set of Electrically Charged Particles Moving with Constant Velocities

We consider a set of particles with rest masses $m_1, \cdots, m_i, \cdots, m_n$ and electric charges $q_1, \cdots, q_i, \cdots, q_n$ that move with constant velocities $\boldsymbol{v}_1, \cdots, \boldsymbol{v}_i, \cdots, \boldsymbol{v}_n$ relative to an IRF $\boldsymbol{O}$. It creates and maintains a GEM and an EM field that in $\boldsymbol{O}$ at each point is characterized by the vector pair ($\boldsymbol{E}_g, \boldsymbol{B}_g$), respectively ($\boldsymbol{E}, \boldsymbol{B}$).

1) Each particle continuously emits *g*- (*e*-)information and contributes with an amount $\boldsymbol{E}_{gi}$ ($\boldsymbol{E}_i$) to the *g*- (*e*)-field at an arbitrary point *P*. As in §8 we conclude that the effective *g*- (*e*-)field $\boldsymbol{E}_g$ ($\boldsymbol{E}$) at *P* is:

$$\boldsymbol{E}_g = \sum \boldsymbol{E}_{gi} \quad \text{and} \quad \boldsymbol{E} = \sum \boldsymbol{E}_i$$

2) Because it is moving, each particle emits also *β*- (b-)information, contributing to the *β*- (b-)induction at *P* with an amount $\boldsymbol{B}_{gi}$ ($\boldsymbol{B}_i$). It is evident that the *β*–information in the volume element d*V* at *P* at each moment *t* is:

$$\sum \left(\boldsymbol{B}_{(g)i} \cdot \mathrm{d}V \right) = \left(\sum \boldsymbol{B}_{(g)i} \right) \cdot \mathrm{d}V$$

Thus, the effective *β*- (b-)induction $\boldsymbol{B}_{(g)}$ at *P* is:

$$\boldsymbol{B}_g = \sum \boldsymbol{B}_{gi} \quad \text{and} \quad \boldsymbol{B} = \sum \boldsymbol{B}_i$$

On the basis of the superposition principle we can conclude that the laws of Maxwell-Heaviside mentioned in §13, a remain valid in the case of the gravitational field of a set of particles describing uniform rectilinear motions.

13.3. The Gravitational and the Electromagnetic Field of Stationary Flows of Mass and Charge

The term "stationary flow" refers to the movement of an, either or not electrically charged, homogeneous and incompressible fluid that, in an invariable way, flows relative to an IRF. The intensity of a mass flow (charge flow) at an arbitrary point *P* is characterized by the flow density $\boldsymbol{J}_G$ ($\boldsymbol{J}_E$). The magnitude of this vectoral quantity at *P* equals the rate per unit area at which the mass (charge) flows through a surface element that is perpendicular to the flow at *P*. The orientation of $\boldsymbol{J}_G$ ($\boldsymbol{J}_E$) corresponds to the direction of that flow. So, the rate at which the flow transports, in the positive sense (defined by the orientation of the surface vectors $\mathrm{d}\boldsymbol{S}$), mass (charge) through an arbitrary surface ΔS, is:

$$i_G = \iint_{\Delta S} \boldsymbol{J}_G \cdot \mathrm{d}\boldsymbol{S} \quad \text{and} \quad i_E = \iint_{\Delta S} \boldsymbol{J}_E \cdot \mathrm{d}\boldsymbol{S}$$

$i_{G/E}$ is the *intensity of the mass/charge flow through* ΔS.

Since a stationary mass (charge) flow is the macroscopic manifestation of moving mass (charge) elements $\rho_G \cdot dV$ ($\rho_E \cdot dV$), it creates and maintains a GEM- (EM-) field. And since the velocity $\boldsymbol{v}$ of the mass (charge) element at a certain point is time independent, *the GEM- (EM-) field of a stationary mass flow will be time independent*. It is evident that the rules for a static *g*-(*e*-)-field (§9) also apply for this time independent *g*-(*e*-)field:

1) $div\boldsymbol{E}_g = -\dfrac{\rho_G}{\eta_0}$ and $div\boldsymbol{E} = \dfrac{\rho_E}{\varepsilon_0}$.

2) $rot\boldsymbol{E}_g = rot\boldsymbol{E} = 0$ what implies: $\boldsymbol{E}_{(g)} = -gradV_{(g)}$.

It can be proven that the rules for the time independent *g*- (*e*-)induction are:

1) $div\boldsymbol{B}_g = 0$ what implies the existence of a gravitational vector potential function $\boldsymbol{A}_g$ for which $\boldsymbol{B}_g = rot\boldsymbol{A}_g$.

2) $rot\boldsymbol{B}_g = -\nu_0 \cdot \boldsymbol{J}_G$ and $rot\boldsymbol{B} = \nu_0 \cdot \boldsymbol{J}_E$.

In this context let us also note that *an electric current-carrying conductor is the source of an EM-field that only consists of the magnetic field that is generated by the flow of the conduction electrons*. Because a current-carrying conductor is an electrically neutral structure, at an arbitrary point in its vicinity the e-field generated by the negative conduction electrons is equal and opposite to the e-field generated by the positive lattice of the conductor.

14. Forces between Objects at Rest

14.1. The Interactions between Mass Particles at Rest

We consider a set of mass particles anchored in an IRF $\boldsymbol{O}$. They create and maintain a gravitational field that at each point of the space linked to $\boldsymbol{O}$ is completely determined by the vector $\boldsymbol{E}_g$. Each particle is "immersed" in a cloud of *g*-information. At every point, except at its own position, each particle contributes to the construction of that cloud.

Let us consider the particle with rest mass m_0 anchored at *P*. If the other particles were not there, then m_0 would be at the center of a perfectly spherical cloud of *g*-information. In reality this is not the case: the emission of *g*-information by the other particles is responsible for the disturbance of that "characteristic symmetry" of the proper *g*-field of m_0. Because $\boldsymbol{E}_g$ at *P* is the density of the flow of *g*-information send to *P* by the other particles, it is a measure for the extent to which the characteristic symmetry of the proper *g*-field of m_0 at *P* is disturbed.

If it was free to move, the particle could restore the characteristic symmetry of the *g*-information cloud in its immediate vicinity by accelerating with an amount $\boldsymbol{a} = \boldsymbol{E}_g$. Indeed, accelerating this way has the effect that the extern field disappears in the origin of the reference frame anchored to m_0. In other words, if it accelerates with an amount $\boldsymbol{a} = \boldsymbol{E}_g$, m_0 would become "blind" for the *g*-information send to its immediate vicinity by the other particles, it would only "see" its proper spherical *g*-information cloud.

So, from the point of view of a particle at rest at a point *P* in a gravitational field $\boldsymbol{E}_g$, the characteristic symmetry of the *g*-information cloud in its immediate vicinity is conserved if it accelerates with an amount $\boldsymbol{a}=\boldsymbol{E}_g$. A particle that is anchored in a gravitational field cannot accelerate. In that case, it *tends* to move.

The insight is expressed in the following postulate:

A particle anchored at a point in a gravitational field is subjected to a tendency to move in the direction defined by $\boldsymbol{E}_g$, *the g-field at that point. Once the anchorage is broken, the particle acquires an acceleration* $\boldsymbol{a}$ *that equals* $\boldsymbol{E}_g$.

If the particles under consideration are electrically charged, they create in addition an electric field $\boldsymbol{E}$ in the space linked to $\boldsymbol{O}$. The particle with charge q anchored at P reacts on the disturbance by $\boldsymbol{E}$ of the characteristic symmetry of its proper *e*-field in the same way as it reacts on the disturbance by $\boldsymbol{E}_g$ of the symmetry of its proper *g*-field: it tends to accelerate with the aim to become blind for the *e*-field created by the other particles. This insight is expressed in the following postulate:

A particle with rest mass m_0 *and electrical charge* q *anchored at a point in an electric field is subjected to a tendency to move in the direction defined by* $\boldsymbol{E}$, *the e-field at that point. Once the anchorage is broken, the particle acquires a vectoral acceleration* $\boldsymbol{a}$ *that equals* $\dfrac{q}{m_0}\boldsymbol{E}$.

14.2. The Force Concept, The Gravitational and the Electric Force

A particle with rest mass m_0, anchored at a point P in a gravitational field, experiences an action because of that field, an action that is compensated by the anchorage.

1) That action is proportional to the extent to which the characteristic symmetry of the proper gravitational field of m_0 in the immediate vicinity of P is disturbed by the extern *g*-field, thus to $\boldsymbol{E}_g$ at P.

2) It depends also on the magnitude of m_0. Indeed, the *g*-information cloud created and maintained by m_0 is more compact as m_0 is greater. That implies that the disturbing effect on the characteristic symmetry around m_0 by the extern g-field $\boldsymbol{E}_g$ is smaller when m_0 is greater. Thus, to impose the acceleration $\boldsymbol{a}=\boldsymbol{E}_g$, the action of the gravitational field on m_0 must be greater as m_0 is greater.

We can conclude that the action that tends to accelerate a particle anchored in a gravitational field must be proportional to $\boldsymbol{E}_g$, the *g*-field to which the particle is exposed, and to m_0, the rest mass of the particle. We represent that action by $\boldsymbol{F}_G$ and we call this vectoral quantity "*the force developed by the g-field on the particle*" or the *gravitational force*. We define it as follows:

$$\boldsymbol{F}_G=m_0\cdot\boldsymbol{E}_g \tag{10}$$

If an electrically charged particle is anchored in an electric field $\boldsymbol{E}$, it is, for similar reasons as in the case of gravitation, subject to an additional action that proportional is to the *e*-field $\boldsymbol{E}$ and to q, the charge of the particle. That action is represented by $\boldsymbol{F}_E$. It is "*the force developed by the e-field on the particle*" or the *electric force*. It is defined as:

$$\boldsymbol{F}_E=q\cdot\boldsymbol{E} \tag{11}$$

From (10) and (11) it follows:

$$\boldsymbol{E}_g = \frac{\boldsymbol{F}_G}{m_0} \quad \text{and} \quad \boldsymbol{E} = \frac{\boldsymbol{F}_E}{q}$$

So, according to the conclusions of §14.a, the acceleration $\boldsymbol{a}$ imposed to a mass particle by a gravitational or an electric force $\boldsymbol{F}$ is:

$$\boldsymbol{a} = \frac{\boldsymbol{F}}{m_0}$$

As shown in [9] Newton's law of universal gravitation can be easily derived from what precedes and the same applies to the law of Coulomb.

Finally, let us compare the magnitude F_E of the electric force and the magnitude of the gravitational force F_G between two identical mass particles with rest mass m_0 and charge q:

$$\frac{F_E}{F_G} = \frac{\eta_0}{\varepsilon_0} \cdot \left(\frac{q}{m_0}\right)^2 = 1.34 \times 10^{20} \cdot \left(\frac{q}{m_0}\right)^2$$

In the concrete case of two spheres with a mass of *1 kg* and charged with *1 μC* this means that the electric force is 1.34×10^8 times bigger than the gravitational force, what implies *that F_G is masked by F_E*.

15. Forces between Moving Objects

15.1. The Interactions between Moving Mass Particles

We consider a number of mass particles moving relative to an IRF ***O***. They create and maintain a GEM field that at each point of the space linked to ***O*** is defined by the vectors $\boldsymbol{E}_g$ and $\boldsymbol{B}_g$. Each particle is "immersed" in a cloud of informatons carrying both g- and *β*-information. At each point, except at its own position, each particle contributes to the construction of that cloud.

Let us consider the particle with rest mass m_0 that, at the moment *t*, goes with velocity $\boldsymbol{v}$ through the point *P*.

1) If the other particles were not there $\boldsymbol{E}'_g$, the *g*-field in the immediate vicinity of m_0, would, according to §12.a, be symmetric relative to the carrier line of the velocity $\boldsymbol{v}$ of m_0. In reality that symmetry is disturbed by the *g*-information that the other particles send to *P*. $\boldsymbol{E}_g$, the instantaneous value of the g-field at *P*, is a measure for the extent to which this occurs.

2) If the other particles were not there $\boldsymbol{B}'_g$, the *β*-induction in the immediate vicinity of m_0, would, according to §12.b, "rotate" around the carrier line of the vector $\boldsymbol{v}$. This implies that the pseudo-gravitational-field $\boldsymbol{E}''_g = \boldsymbol{v} \times \boldsymbol{B}'_g$ defined by the vector product of $\boldsymbol{v}$ with the *β*-induction that characterizes the proper *β*-field of m_0, would also be symmetric relative to that carrier line. In reality, this symmetry is disturbed by the *β*-information send to *P* by the other particles. The vector product $\left(\boldsymbol{v} \times \boldsymbol{B}_g\right)$ is a measure for the extent to which this occurs.

So, the *characteristic symmetry* of the cloud of *g*-/*β*-information around a moving particle (the proper GEM field) is in the immediate vicinity of that particle disturbed by $\boldsymbol{E}_g$ regarding the proper g-field and by ($\boldsymbol{v} \times \boldsymbol{B}_g$) regarding the proper *β*-induction.

If it is free to move, the particle m_0 could restore the characteristic symmetry in its immediate vicinity by accelerating, relative to its proper IRF $\boldsymbol{O}'$, with an amount $\boldsymbol{a}' = \boldsymbol{E}_g + (\boldsymbol{v} \times \boldsymbol{B}_g)$. In that manner, it would become "blind" for the disturbance of the symmetry of its proper GEM field in its direct vicinity.

These insights form the basis of the following postulate.

A particle with rest mass m_0, moving with velocity $\boldsymbol{v}$ in a GEM-field ($\boldsymbol{E}_g, \boldsymbol{B}_g$), tends to become blind for the influence of that field on the symmetry of its proper GEM-field. If it is free to move, it will acquire an acceleration $\boldsymbol{a}'$ relative to its proper IRF that equals $\boldsymbol{E}_g + (\boldsymbol{v} \times \boldsymbol{B}_g)$.

If the particles under consideration are electrically charged, they create in addition an EM field in the space linked to $\boldsymbol{O}$. The particle with charge q that, at the moment t, goes through P with velocity $\boldsymbol{v}$, reacts on the disturbance of the characteristic symmetry of its proper EM-field in the same way as it reacts on the disturbance of the symmetry of its proper GEM-field: it accelerates with the aim to become blind for the EM-field created by the other particles. This insight is expressed in the following postulate:

A particle with charge q, moving with velocity $\boldsymbol{v}$ in an EM-field ($\boldsymbol{E}, \boldsymbol{B}$) tends to become blind for the influence of that field on the symmetry of its proper EM field. If it is free to move, it will acquire an acceleration $\boldsymbol{a}'$ relative to its proper IRF that equals $\frac{q}{m_0} \cdot \left[\boldsymbol{E} + (\boldsymbol{v} \times \boldsymbol{B})\right]$.

15.2. Lorentz Force Law

The action of the GEM field ($\boldsymbol{E}_g, \boldsymbol{B}_g$) [the EM field ($\boldsymbol{E}, \boldsymbol{B}$)] on a particle with rest mass m_0 and charge q that is moving with velocity $\boldsymbol{v}$ relative to the IRF $\boldsymbol{O}$ is called the *gravitational force* $\boldsymbol{F}_G$ [*the electromagnetic force or Lorentzforce* $\boldsymbol{F}_{EM}$] on that particle. In extension of §14.b we define $\boldsymbol{F}_G$ and $\boldsymbol{F}_{EM}$ as:

$$\boldsymbol{F}_G = m_0 \cdot \left[\boldsymbol{E}_g + (\boldsymbol{v} \times \boldsymbol{B}_g)\right] \quad \text{and} \quad \boldsymbol{F}_{EM} = q \cdot \left[\boldsymbol{E} + (\boldsymbol{v} \times \boldsymbol{B})\right]$$

According §15.a, if it is free to move the effect of $\boldsymbol{F}_G$ ($\boldsymbol{F}_{EM}$) on that particle is that it will be accelerated relative to its proper IRF $\boldsymbol{O}'$ with an amount $\boldsymbol{a}'$:

$$\boldsymbol{a}' = \boldsymbol{E}_g + (\boldsymbol{v} \times \boldsymbol{B}_g) \quad \text{and} \quad \boldsymbol{a}' = \frac{q}{m_0} \cdot \left[\boldsymbol{E} + (\boldsymbol{v} \times \boldsymbol{B})\right]$$

Using the appropriate transformation formulas [8], $\boldsymbol{a}'$, the acceleration relative to its proper IRF $\boldsymbol{O}'$, can be expressed in function of the characteristics of the motion of the particle relative to IRF $\boldsymbol{O}$. In §10 of [9] it is shown that:

$$\boldsymbol{a}' = \frac{\mathrm{d}}{\mathrm{d}t}\left[\frac{\boldsymbol{v}}{\sqrt{1-\beta^2}}\right] \quad \text{with} \quad \beta = \frac{v}{c}$$

We can conclude that the effect on the movement of the particle on as well $\boldsymbol{F}_G$ as $\boldsymbol{F}_{EM}$ is described by:

$$\boldsymbol{F} = \frac{\mathrm{d}\boldsymbol{p}}{\mathrm{d}t} \quad \text{with} \quad \boldsymbol{p} = m \cdot \boldsymbol{v}$$

$\boldsymbol{p}$ is the *linear momentum of the particle* relative to the IRF $\boldsymbol{O}$. It depends on its *relativistic mass m*:

$$m = \frac{m_0}{\sqrt{1-\beta^2}}$$

In §2 of [9] it is shown that m determines the rate at which the particle emits informatons when the time is read on the clock of its proper IRF. The relativistic mass m of a particle is a measure for its inertia *i.e.* its resistance to changes in its state of motion, while its rest mass m_0 is a measure for its power to gravitate.

15.3. The Interaction between Two Moving Particles

Two particles with rest masses m_1 and m_2 (**Figure 5**) are anchored in the IRF $\boldsymbol{O'}$ that is moving relative to IRF $\boldsymbol{O}$ with constant velocity $\boldsymbol{v} = v \cdot \overline{e}_z$.

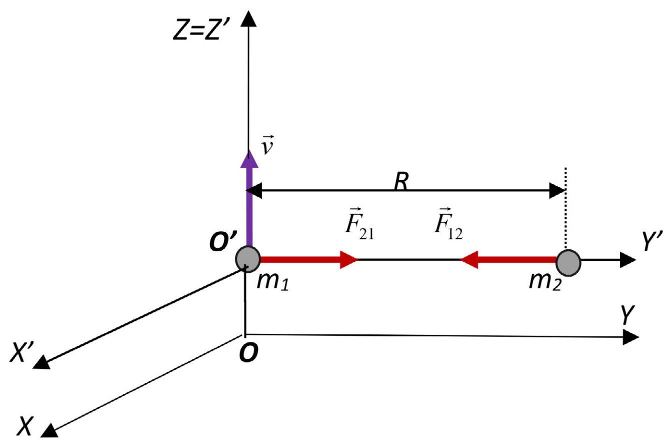

Figure 5. The gravitational interaction between two moving particles.

According to §13.a, the components of the gravitational field created and maintained by m_1 at the position of m_2 are, in magnitude, determined by:

$$E_{g2} = \frac{m_1}{4\pi\eta_0 R^2} \cdot \frac{1}{\sqrt{1-\beta^2}}$$

$$B_{g2} = \frac{m_1}{4\pi\eta_0 R^2} \cdot \frac{1}{\sqrt{1-\beta^2}} \cdot \frac{v}{c^2}$$

$\boldsymbol{E}_{g2}$ points to the position of m_1 and $\boldsymbol{B}_{g2}$ points in the direction of the X-axis.

And according to the force law F_{12}, the magnitude of the force exerted by the gravitational field ($\boldsymbol{E}_{g2}, \boldsymbol{B}_{g2}$) on m_2, this is the attraction force of m_1 on m_2 is:

$$F_{12} = m_2 \cdot \left(E_{g2} - v \cdot B_{g2}\right)$$

After substitution:

$$F_{12} = \frac{1}{4\pi\eta_0} \cdot \frac{m_1 m_2}{R^2} \cdot \sqrt{1-\beta^2} = F'_{12} \cdot \sqrt{1-\beta^2}$$

with

$$F_{12}' = \frac{1}{4\pi\eta_0} \cdot \frac{m_1 m_2}{R^2}$$

the magnitude of the force that m_1, according Newtons universal law of gravitation, in the IRF $\boldsymbol{O}'$, where both particles are at rest, exerts on m_2.

In the same way, we find:

$$F_{21} = \frac{1}{4\pi\eta_0} \cdot \frac{m_1 m_2}{R^2} \cdot \sqrt{1-\beta^2} = F_{12}' \cdot \sqrt{1-\beta^2}$$

We conclude that the moving masses attract each other with a force:

$$F = F_{12} = F_{21} = F' \cdot \sqrt{1-\beta^2}$$

This result perfectly agrees with that based on S.R.T. Indeed, relative to $\boldsymbol{O}'$ the particles are at rest. According to Newton's law of universal gravitation, they exert on each other equal but opposite forces:

$$F' = F_{12}' = F_{21}' = \frac{1}{4 \cdot \pi \cdot \eta_0} \cdot \frac{m_1 \cdot m_2}{R^2}$$

Relative to $\boldsymbol{O}$ both masses are moving with constant speed v in the direction of the Z-axis. From the transformation equations between an inertial frame $\boldsymbol{O}$ and another inertial frame $\boldsymbol{O}'$, in which a point mass experiencing a force F' is instantaneously at rest, we can immediately deduce the force F that the point masses exert on each other in $\boldsymbol{O}$ [8]:

$$F = F_{12} = F_{21} = F' \cdot \sqrt{1-\left(\frac{v}{c}\right)^2} = F' \cdot \sqrt{1-\beta^2}$$

If the particles under consideration are electrically charged, there is in addition an EM force. A reasoning analogous to the preceding shows the magnitude of the force that two mass particles with charges q_1 and q_2 exert on one another is:

$$F_{12} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{|q_1| \cdot |q_2|}{R^2} \cdot \sqrt{1-\beta^2} = F_{12}' \cdot \sqrt{1-\beta^2}$$

with $F_{12}' = \frac{1}{4\pi\varepsilon_0} \cdot \frac{|q_1| \cdot |q_2|}{R^2}$ the "Coulomb force". Between charges of like sign these force is repulsive and between charges of unlike sign it is attractive.

From the above we can conclude *that the component of the gravitational* (*electromagnetic*) *force due to the β-* (*b*-) *induction is β-times smaller than that due to the g-* (*e*-) *field*. This implies that, for speeds much smaller than the speed of light, the effects of the β/b-information are masked. This is not the case for EM fields generated by an electric current-carrying conductor where the source of the field is the flow of (negative) conduction electrons that are moving in a fixed positive lattice. Because the conductor as such is an electrically neutral structure, at an arbitrary point in its vicinity the *e*-field generated by the negative conduction electrons is equal and opposite to the *e*-field generated by the positive lattice what implies that there is only a magnetic induction field.

Finally, we mention that it can be shown that the β-information emitted by moving gravitating objects is responsible for deviations (as the advance of Mercury Perihelion) of the real orbits of planets with respect to these predicted by the classical theory of gravitation [10].

16. Epilogue

From what precedes, we conclude that a moving electrically charged particle is the source and the center of an expanding cloud of informatons that on the macroscopic level manifests itself, depending on the viewpoint, as its gravitoelectromagnetic (GEM) or as its electromagnetic (EM) field.

In [11] the Maxwell-Heaviside equations for the GEM field are deduced from the kinematics of the informatons and in [12] the GEM field of an accelerated mass particle is studied. In the light of the foregoing, it is evident that the mentioned equations and the conclusions regarding gravitational waves and gravitons also apply for EM-fields. It is sufficient to substitute, m_0 by q, the factor $-\frac{\rho_G}{\eta_0}$ by $\frac{\rho_E}{\varepsilon_0}$ and the factor $-\nu_0 \cdot \boldsymbol{J}_G$ by $\mu_0 \cdot \boldsymbol{J}_E$.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Heaviside, O. (1893) A Gravitational and Electromagnetic Analogy, Part I. *The Electrician*, **1**, 455-466.

[2] Poincaré, H. (1905) Sur la dynamique de l'électron. Les Comptes rendus de l'Académie des sciences de la séance du 5 juin 1905.

[3] Jefimenko, O. (1992) Causality, Electromagnetic Induction, and Gravitation. Electret Scientific.

[4] Acke, A. (2024) Newton's Law of Universal Gravitation Explained by the Theory of Informatons. *Journal of High Energy Physics, Gravitation and Cosmology*, **10**, 918-929. https://doi.org/10.4236/jhepgc.2024.103056

[5] Resnick, D. and Halliday, R. (1970) Fundamentals of Physics. John Wiley & Sons.

[6] Ohanian, H.C. (1985) Physics. W. W. Norton & Company, Inc.

[7] Angot, A. (1957) Compléments de Mathematiques. Editions de la Revue d'Optique.

[8] Resnick, R. (1968) Introduction to Special Relativity. John Wiley & Sons, Inc.

[9] Acke, A. (2024) The Gravitational Interaction between Moving Mass Particles Explained by the Theory of Informatons. *Journal of High Energy Physics, Gravitation and Cosmology*, **10**, 986-1002. https://doi.org/10.4236/jhepgc.2024.103060

[10] Tajmar, M and de Matos, C.J. (2003) Advance of Mercury Perihelion Explained by Cogravity. arXiv: gr-qc/0304104 https://arxiv.org/abs/gr-qc/0304104

[11] Acke, A. (2024) The Maxwell-Heaviside Equations Explained by the Theory of Informatons. *Journal of High Energy Physics*, *Gravitation and Cosmology*, **10**, 1003-1016. https://doi.org/10.4236/jhepgc.2024.103061

[12] Acke, A. (2024) Gravitomagnetic Waves Predicted by the Theory of Informatons. *Journal of High Energy Physics*, *Gravitation and Cosmology*, **10**, 1564-1577. https://doi.org/10.4236/jhepgc.2024.104088