Article

Theoretical Foundation of Gravito-Electromagnetism

Antoine Acke*

Abstract

Under the heading "gravito-electromagnetism"(G.E.M.), the analogy between gravitational and electrical phenomena that is expressed by Newton's law of universal gravitation and Coulomb's law of electrical interaction, is extended to a formal analogy between the gravitational and the electromagnetic fields. In this paper we present an introduction to G.E.M. and we propose a theoretical foundation of this topic.

Key Words: gravito-electromagnetism, gravitation, electromagnetism.

I. Gravito-Electromagnetism

Gravitoelectromagnetism (G.E.M.) assumes an isomorphism between Maxwell's field equations and the equations that describe the gravitational field. G.E.M. has been established by Oliver Heaviside (1) and Oleg Jefimenko (2). Within the framework of general relativity, it has been discussed by a number of authors (3). G.E.M. is able to explain a number of phenomena that cannot be explained by Newtonian physics, for instance the advance of Mercury Perihelion (4).

1.1. The Gravitational Field

The amount of matter within the contours of a physical body is called its *mass.* The mass of an object manifests itself when it interacts with other objects. A fundamental form of interaction is "*gravitation*": material objects (masses) attract each other.

According to G.E.M., the gravitational field is the entity that mediates in the interaction between material bodies: a mass creates and maintains a gravitational field and it experiences a force because of the gravitational field of another mass.

In each point *P* of the space linked to the inertial reference frame ***O***, the gravitational field is completely determined by two vectorial quantities: the gravitational field strength or the *g-field* $\vec{E}_g$ and the gravitational induction or the *g-induction* $\vec{B}_g$ †. Each mass contributes to $\vec{E}_g$, only masses that are moving relative to ***O*** contribute to $\vec{B}_g$.

* ***Correspondence***: Antoine Acke, ir, retired professor, Ghent-Belgium; E-mail: ant.acke@skynet.be.

† This quantity is also called the "*cogravitational field*", represented as $\vec{K}$; or the "*gyrotation*", represented as $\vec{\Omega}$. It is the gravitational analog of the magnetic induction $\vec{B}$.

A point mass *m*, that moves through *P* with velocity $\vec{v}$, experiences a *gravitational force* $\vec{F}_G$:

$$\vec{F}_G = m.\left[\vec{E}_g + (\vec{v} \times \vec{B}_g)\right]$$

$\vec{E}_g$ and $\vec{B}_g$ are implicitly defined by this equation. In non-relativistic circumstances, the term ($\vec{v} \times \vec{B}_g$) is very small compared to the term $\vec{E}_g$: its effect is masked.

1.2. The laws of G.E.M.

In a point *P* of a gravitational field where the instantaneous value of the mass-density (*mass per m*^{3}) and the instantaneous value of the density of the mass-flow (*rate per m*^{2} *at which the mass crosses an elementary surface perpendicular to the direction of movement*) are respectively ρ_G and $\vec{J}_G$, the following laws apply:

1. *The spatial variation of* $\vec{E}_g$ *obeys the law*: $div\vec{E}_g = -\dfrac{\rho_G}{\eta_0}$

($\eta_0 = \dfrac{1}{4.\pi.G} = 1{,}19.10^9 \, kg.s^2.m^{-3}$ with *G* the gravitational constant)

2. *The spatial variation of* $\vec{B}_g$ *obeys the law*: $div\vec{B}_g = 0$

3. The spatial variation of $\vec{E}_g$ and the rate at which $\vec{B}_g$ is changing, are connected by:

$$rot\vec{E}_g = -\frac{\partial \vec{B}_g}{\partial t}$$

4. *The spatial variation of* $\vec{B}_g$ *and the rate at which* $\vec{E}_g$ *is changing, are connected by*:

$$rot\vec{B}_g = \frac{1}{c^2}\frac{\partial \vec{E}_g}{\partial t} - \nu_0.\vec{J}_G$$

($\nu_0 = \dfrac{1}{c^2.\eta_0} = \dfrac{4.\pi.G}{c^2} = 9{,}34.10^{-27} m.kg^{-1}$)

Using the theorems [5] of Ostrogradsky (1, 2) and Stokes (3, 4), these laws can be transformed into:

1. $\oiint_S \vec{E}_g.\overrightarrow{dS} = -\dfrac{1}{\eta_0}.\iiint_G \rho_G.dV$ (*G* is the space contained by the closed surface *S*)

2. $\oiint_S \vec{B}_g.\overrightarrow{dS} = 0$ (*S* is a closed surface)

3. $\oint_L \vec{E}_g.\overrightarrow{dl} = -\iint_S \frac{\partial \vec{B}_g}{\partial t}.\overrightarrow{dS} = -\frac{\partial}{\partial t}\iint_S \vec{B}_g.\overrightarrow{dS}$ (*L* is a closed line encircling the surface *S*)

4. $\oint_L \vec{B}_g.\overrightarrow{dl} = \frac{1}{c^2}\iint_S \frac{\partial \vec{E}_g}{\partial t}.\overrightarrow{dS} - \nu_0.\iint_S \vec{J}_g.\overrightarrow{dS} = \frac{1}{c^2}.\frac{\partial}{\partial t}\iint_S \vec{E}_g.\overrightarrow{dS} - \nu_0.\iint_S \vec{J}_G.\overrightarrow{dS}$

1.3. Justification of G.E.M.

The analogy between gravitational and electrical phenomena that is expressed by Newton's law of universal gravitation and Coulomb's law of electrical interaction, is extended to a formal analogy between the gravitational and the electromagnetic fields.

Starting from the observation that the electromagnetic field is characterised by two vectorial quantities - the electric field $\vec{E}$ and the magnetic induction $\vec{B}$ - one assumes that there must be a gravitational analogue for each of these quantities, and that the equations governing these gravitational analogues must be isomorphic with Maxwell's laws for the electromagnetic field. These considerations lead to the equations formulated under 1.2.

The analogy gravitation-electromagnetism suggests that the mechanism behind the gravitational interactions must be of the same nature as that behind the electromagnetic interactions. In this paper - that focuses on the gravitational phenomena - we propose a new theory that can explain both gravitation and electromagnetism.

We start from the idea that, if masses can influence each other at a distance, they must in one way or another exchange data. We assume that each mass emits *information* relative to its magnitude ("*emission-rate*"), its position ("*g-information*") and its velocity ("β -*information*"); and that it must be able to "interpret" the information emitted by its neighbours. We posit that such information is carried by dot-shaped mass- and energy-less entities that rush through space at the speed of light. Because they transport nothing else but information, we call these entities "*informatons*". In the "*postulate of the emission of informatons*", we define an informaton by its attributes and we determine the rules that govern the emission by a point mass that is anchored in an inertial reference frame.

We leave open the question whether informatons really exist. In any case, their introduction as the fundamental building blocks of the gravitational field leads to a non-conventional, but consistent, description of the gravitational phenomena and laws. They offer a convenient framework on which we can build a new formalism for gravity that also supports electromagnetism.

II. The Postulate of the Emission of Informatons

The emission of informatons by a point mass (m) anchored in an inertial reference frame ***O***, is governed by the *postulate of the emission of informatons*:

A. *The emission* is governed by the following rules:

1. *The emission is uniform in all directions of space, and the informatons fly away at the speed of light (c = 3.10^8* m/s) *along trajectories that are radial relative to the location of the emitter.*

2. $\dot{N} = \frac{dN}{dt}$*, the rate at which a point-mass emits informatons***, is time- independent and proportional to its mass m. So, there is a constant K so that:*

$$\dot{N} = K.m$$

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

$$K = \frac{c^2}{h} = 1{,}36.10^{50}\,kg^{-1}.s^{-1}$$

B. We call the essential attribute of an informaton its *g-spin vector*. g-spin vectors are represented as $\vec{s}_g$ and defined by:

1. *The g-spin vectors are directed toward the position of the emitter.*

2. *All g-spin vectors have the same magnitude, namely:*

$$s_g = \frac{1}{K.\eta_0} = 6{,}18.10^{-60}\,m^3.s^{-1}$$

($\eta_0 = \frac{1}{4.\pi.G} = 1{,}19.10^9\,kg.s^2.m^{-3}$ with *G* the gravitational constant)

s_g, the magnitude of the g-spin-vector, is the *elementary g-information quantity.*

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

III. The Gravitational Field of Masses at Rest

3.1. The gravitational field of a point mass at rest

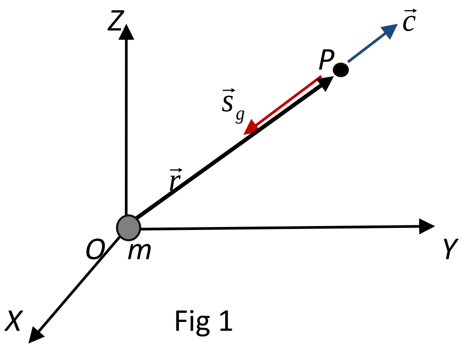

Fig 1

In fig 1 we consider a point mass that is anchored in the origin of an inertial reference frame ***O***. It continuously emits informatons in all directions of space.

The informatons that go through a fixed point *P* - defined by the position vector $\vec{r}$ - have two attributes: their velocity $\vec{c}$ and their g-spin vector $\vec{s}_g$:

$$\vec{c} = c.\frac{\vec{r}}{r} = c.\vec{e}_r \qquad \text{and} \qquad \vec{s}_g = -\frac{1}{K.\eta_0}.\frac{\vec{r}}{r} = -\frac{1}{K.\eta_0}.\vec{e}_r$$

The rate at which the point mass emits g-information - that is also the rate at which it sends g-information through any closed surface that spans *m* - is

$$\dot{N}.s_g = \frac{m}{\eta_0}$$

The emission of informatons fills the space around *m* with a cloud of g-information. This cloud has the shape of a sphere whose surface goes away - at the speed of light - from the centre *O*, the position of the point mass.

- Within the cloud there is a *stationary state*: each spatial region contains a constant number of informatons and thus a constant quantity of g-information. Moreover, the orientation of the g-spin vectors of the informatons passing through a fixed point is always the same.

- The cloud can be identified with a *continuum*: each spatial region contains a very large number of informatons: the g-information is present everywhere in the region.

The cloud of g-information surrounding *O* constitutes the *gravitational field* * - or the g-field - of the point mass *m.*

Without interruption "countless" informatons are rushing through any - even very small - surface in the gravitational field: we can identify the stream of g-information through a surface with a *continuous flow*.

We know already that the intensity of the flow of g-information through a closed surface that spans *O* is expressed as:

$$\dot{N}.s_g = \frac{m}{\eta_0}$$

If the closed surface is a sphere with radius *r*, the *intensity of the flow per* m^2 is given by:

$$\frac{m}{4.\pi.r^2.\eta_0}$$

This is the *density* of the flow of g-information in each point *P* at a distance *r* from *m* (fig 1). Together with the orientation of the g-spin vectors of the informatons passing in the vicinity of *P,* this quantity is characteristic for the gravitational field in that point.
Thus, in a point *P*, the gravitational field of the point mass *m* is defined by the vectorial quantity $\vec{E}_g$:

$$\vec{E}_g = \frac{\dot{N}}{4.\pi.r^2}.\vec{s}_g = -\frac{m}{4.\pi.\eta_0.r^2}.\vec{e}_r = -\frac{m}{4.\pi.\eta_0.r^3}.\vec{r}$$

$\vec{E}_g$ is the *gravitational field strength* or the *g-field*. In any point of the gravitational field of the point mass *m*, the orientation of $\vec{E}_g$ corresponds to the orientation of the g-spin-vectors of the informatons who are passing near that point. And the magnitude of $\vec{E}_g$ is the *density of the g-information flow* in that point.

Let us consider a surface-element *dS* in *P* (fig 2,a). Its orientation and magnitude are completely determined by the surface-vector $\overrightarrow{dS}$ (fig 2,b)

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* The time *T* elapsed since the emergence of a point-mass (this is the time elapsed since the emergence of the universe) and the radius *R* of its field of gravitation are linked by the relation *R = c.T.* Assuming that the universe - since its beginning ($1{,}8.10^{10}$ years ago) - uniformly expands, a point at a distance *r* from *m* runs away with speed *v*: $v = \frac{r}{R}.c = \frac{1}{T}.r = H_0.r$. H_0 is the Hubble constant:

$$H_0 = \frac{1}{T} = 1{,}7.10^4 \, \frac{m/s}{million\,light - years}$$

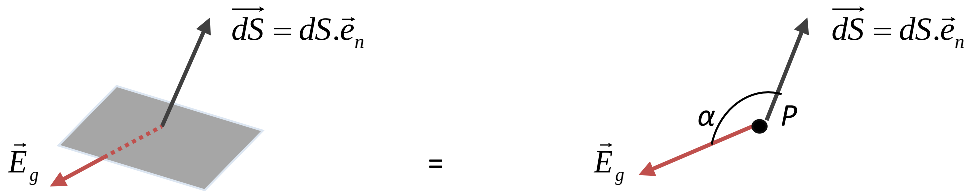

Fig 2,a

Fig 2,b

By $d\Phi_g$, we represent the rate at which g-information flows through *dS* in the sense of the positive normal and we call this scalar quantity the *elementary g-flux through dS*:

$$d\Phi_g = -\vec{E}_g.\overrightarrow{dS} = -E_g.dS.\cos\alpha$$

For an arbitrary closed surface *S* that spans *m*, the outward flux (which we obtain by integrating the elementary contributions $d\Phi_g$ over *S*) must be equal to the rate at which the mass emits g-information. Indeed, the rate at which g-information flows out must be equal to the rate at which the mass produces g-information. Thus:

$$\Phi_g = -\oiint \vec{E}_g.\overrightarrow{dS} = \frac{m}{\eta_0}$$

This relation expresses *the conservation of g-information* in the case of a point mass at rest.

3.2. The gravitational field of a set of point-masses at rest

We consider a set of point-masses $m_1,\ldots,m_i,\ldots m_n$ which are anchored in an inertial frame ***O***. In an arbitrary point *P*, the flows of g-information which are emitted by the distinct masses are defined by the gravitational fields $\vec{E}_{g1},\ldots,\vec{E}_{gi},\ldots,\vec{E}_{gn}$.

$d\Phi_g$, the rate at which g-information flows through a surface-element *dS* in *P* in the sense of the positive normal, is the sum of the contributions of the distinct masses:

$$d\Phi_g = \sum_{i=1}^{n} -(\vec{E}_{gi}.\overrightarrow{dS}) = -(\sum_{i=1}^{n}\vec{E}_{gi}).\overrightarrow{dS} = -\vec{E}_g.\overrightarrow{dS}$$

Thus $\vec{E}_g$, the *effective density of the flow of g-information in P* (the effective g-field) is completely defined by: $\vec{E}_g = \sum_{i=1}^{n}\vec{E}_{gi}$

One shows easily that the outward g-flux through a closed surface in the g-field of a set of anchored point masses only depends on the spanned masses m_{in}:

$$\Phi_g = -\oiint \vec{E}_g.\overrightarrow{dS} = \frac{m_{in}}{\eta_0}$$

In this case, this relation expresses *the conservation of g-information*.

3.3. The gravitational field of a mass continuum at rest

In each point *Q* of a mass continuum, the accumulation of mass is defined by the (*mass*-) *density* ρ_G. A mass continuum - anchored in an inertial frame - is equivalent to a set of infinitely many infinitesimal mass elements *dm.* The contribution of each of them to the g-field in an arbitrary point *P* is $d\vec{E}_g$. $\vec{E}_g$, the effective g-field in *P*, is the result of the integration over the volume of the continuum of all these contributions.

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

$$-\oiint_S \vec{E}_g.\overrightarrow{dS} = \frac{1}{\eta_0}.\iiint_V \rho_G.dV$$

According to the theorem of Ostrogradsky [5], that is equivalent with: $div\vec{E}_g = -\dfrac{\rho_G}{\eta_0}$

This relation expresses *the conservation of g-information* in the case of a mass contiuum at rest.
Furthermore, one can show that: $rot\vec{E}_g = 0$ what implies the existence of *a gravitational potential function V_g* for which: $\vec{E}_g = -gradV_g$.

IV. The gravitational Field of moving Masses

4.1. The emission-rate of a moving mass

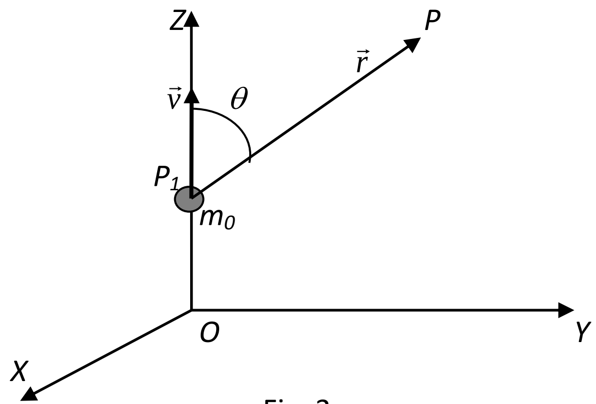

Fig. 3

In fig 3, we consider a point mass that moves with constant velocity $\vec{v} = v.\vec{e}_z$ along the *Z*-axis of an inertial reference frame ***O*** . At the moment *t = 0*, it passes through the origin *O* and at the moment *t = t* through the point P_1.

*We assume that $\dot{N}$ - the rate at which a point mass emits informatons in the space connected to **O** - is independent of its motion and determined by its rest mass m_0:*

$$\dot{N} = \frac{dN}{dt} = K.m_0$$

That implies that, if the time (*t'*) is read on a standard clock that is anchored to that mass, in ***O*** the rate of emission is expressed by (6) (7):

$$\frac{dN}{dt'} = K.\frac{m_0}{\sqrt{1-\beta^2}} = K.m \qquad \text{with} \qquad m = \frac{m_0}{\sqrt{1-\beta^2}}$$, the "relativistic mass"

4.2. The field caused by a uniform rectilinear moving point mass

In fig 3, we consider a point mass with rest mass m_0 that, with constant velocity $\vec{v} = v.\vec{e}_z$, moves along the *Z*-axis of an inertial reference frame ***O***. At the moment *t = 0*, it passes through the origin *O* and at the moment *t = t* through the point P_1.

m_0 continuously emits informatons that, with the speed of light, rush away with respect to the point where the mass is at the moment of emission. We determine the density of the flow of g-information - this is the g-field - in a fixed point *P*. The position of *P* relative to the reference frame ***O*** is determined by the time-dependent position-vector $\vec{r} = \overrightarrow{P_1P}$. θ is the angle between $\vec{r}$ and the *Z*-axis.

One can show that (6) (7) - relative to ***O*** - the instantaneous value of the g-field in *P* is:

$$\vec{E}_g = -\frac{m_0}{4\pi\eta_0 r^3}.\frac{1-\beta^2}{(1-\beta^2.\sin^2\theta)^{\frac{3}{2}}}.\vec{r} = -\frac{m_0}{4\pi\eta_0 r^2}.\frac{1-\beta^2}{(1-\beta^2.\sin^2\theta)^{\frac{3}{2}}}.\vec{e}_r$$

We conclude: *A point mass describing - relative to an inertial reference frame **O** - a uniform rectilinear movement, creates in the space linked to that frame a time-dependent gravitational field. $\vec{E}_g$, the g-field in an arbitrary point P, points at any time to the position of the mass at that moment* and its magnitude is:*

* From this conclusion on the direction of the g-field, one can deduce that the movement of an object in a gravitational field is determined by the present position of the source of the field and not by its light-speed delayed position.

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

If the speed of the mass is much smaller than the speed of light, this expression reduces itself to this valid in the case of a mass at rest. This non-relativistic result could also been 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.

The orientation of the field strength implies that the spin vectors of the informatons that at a certain moment pass through P, point to the position of the emitting mass at that moment.

4.3. The emission of informatons by a point mass that describes a uniform rectilinear motion

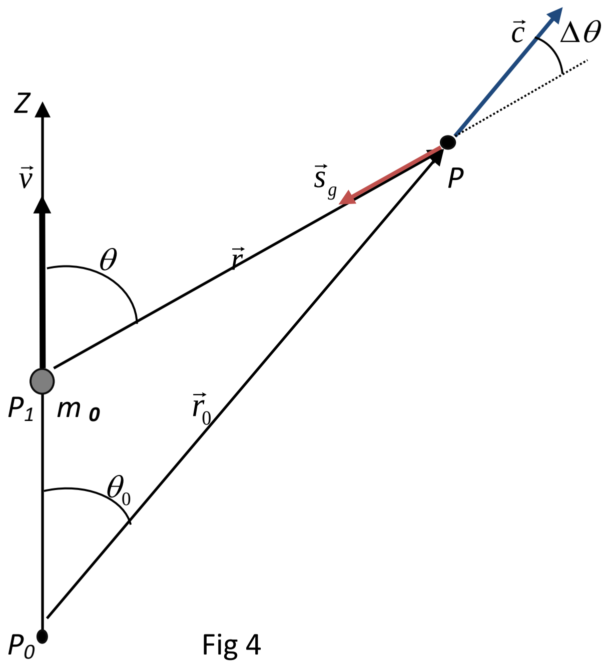

Fig 4

In fig 4 we consider a point mass m_0 that moves with a constant velocity $\vec{v}$ along the *Z*-axis of an inertial reference frame. Its instantaneous position (at the arbitrary moment *t*) is P_1.
The position of *P*, an arbitrary fixed point in space, is defined by the vector $\vec{r} = \overrightarrow{P_1P}$. This position- vector $\vec{r}$ - just like the distance *r* and the angle θ - is time-dependent because the position of P_1 is constantly changing.

The informatons that - with the speed of light - at the moment *t* are passing through *P*, are emitted when m_0 was at P_0. Bridging the distance $P_0P = r_0$ took the time-interval Δt:

$$\Delta t = \frac{r_0}{c}$$

During their rush from P_0 to *P*, the mass moved from P_0 to P_1: $P_0P_1 = v.\Delta t$

- The velocity of the informatons $\vec{c}$ is oriented along the path they follow, thus along the radius *P_0P.*

- Their g-spin vector $\vec{s}_g$ points to P_1, the position of m_0 at the moment *t*.

The lines that carry $\vec{s}_g$ and $\vec{c}$ form an angle $\Delta\theta$. We call this angle - that is characteristic for the speed of the point mass - the "*characteristic angle*". The quantity $s_\beta = s_g.\sin(\Delta\theta)$ is called the "*characteristic g-information*" or the "β*-information"* of an informaton.

We note *that an informaton emitted by a moving point mass, transports information about the velocity of that mass.* This information is represented by its "*gravitational characteristic vector*" or "β*-vector*" $\vec{s}_\beta$ *which is defined by:*

$$\vec{s}_\beta = \frac{\vec{c} \times \vec{s}_g}{c}$$

- The β-vector is perpendicular to the plane formed by the path of the informaton and the straight line that carries the g-spin vector, thus perpendicular to the plane formed by the point *P* and the path of the informaton.

- Its orientation relative tot that plane is defined by the "rule of the corkscrew": in the case of fig 4, the β-vectors have the orientation of the positive *X*-axis.

- Its magnitude is: $s_\beta = s_g.\sin(\Delta\theta)$, the β*-information* of the informaton.

From the sine rule applied to the triangle *P_0P_1P,* it follows: $s_\beta = s_g.\frac{v}{c}.\sin\theta = s_g.\beta.\sin\theta$

Taking into account the orientation of the different vectors, the β-vector of an informaton emitted by a point mass with constant velocity can also be expressed as:

$$\vec{s}_\beta = \frac{\vec{v} \times \vec{s}_g}{c}$$

4.4. The gravitational induction of a point mass describing a uniform rectilinear motion

We consider again the situation of fig 4. All informatons in *dV* - the volume element in *P* - carry both g-information and β-information. The β-information is related to the velocity of the emitting mass and represented by the characteristic vectors $\vec{s}_\beta$:

$$\vec{s}_{\beta} = \frac{\vec{c} \times \vec{s}_g}{c} = \frac{\vec{v} \times \vec{s}_g}{c}$$

If - at the moment *t* - *n* is the density in *P* of the cloud of informatons (number of informatons per m^3), the amount of β-information in *dV* is determined by the magnitude of the vector:

$$n.\vec{s}_{\beta}.dV = n.\frac{\vec{c} \times \vec{s}_g}{c}.dV = n.\frac{\vec{v} \times \vec{s}_g}{c}.dV$$

And the density of the β-information (characteristic information per m^3) in *P* is characterized by:

$$n.\vec{s}_{\beta} = n.\frac{\vec{c} \times \vec{s}_g}{c} = n.\frac{\vec{v} \times \vec{s}_g}{c}$$

We call this (time-dependent) vectorial quantity - that will be represented by $\vec{B}_g$ - the "*gravitational induction*" or the "*g-induction*"* in *P.*

So, the g-induction caused in *P* by the moving mass m_0 (fig 4), is:

$$\vec{B}_g = n.\frac{\vec{v} \times \vec{s}_g}{c} = \frac{\vec{v}}{c} \times (n.\vec{s}_g)$$

N - the density of the flow of informatons in *P* (the rate per m^2 at which the informatons cross an elementary surface perpendicular to the direction of movement) - and *n* - the density of the cloud of informatons in *P* (number of informatons per m^3) - are connected by the relation: $n = \frac{N}{c}$

Taking into account that (4.2) : $N.\vec{s}_g = \vec{E}_g = -\frac{m_0}{4\pi\eta_0 r^3}.\frac{1-\beta^2}{(1-\beta^2.\sin^2\theta)^{\frac{3}{2}}}.\vec{r}$

We find:

$$\vec{B}_g = -\frac{m_0}{4\pi\eta_0 c^2.r^3}.\frac{1-\beta^2}{(1-\beta^2.\sin^2\theta)^{\frac{3}{2}}}.(\vec{v} \times \vec{r})$$

We define the constant ν_0 as: $\nu_0 = \frac{1}{c^2.\eta_0} = 9{,}34.10^{-27} m.kg^{-1}$

And finally, we obtain:

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* This quantity is also called the "cogravitational field, represented as $\vec{K}$, or the "gyrotation", represented as $\vec{\Omega}$

$$\vec{B}_g = \frac{\nu_0 . m_0}{4\pi r^3} . \frac{1-\beta^2}{(1-\beta^2 . \sin^2\theta)^{\frac{3}{2}}} . (\vec{r} \times \vec{v})$$

$\vec{B}_g$ in *P* is perpendicular to the plane formed by *P* and the path of the point mass; its orientation is defined by the rule of the corkscrew; and its magnitude is:

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

If the speed of the mass is much smaller than the speed of light, this expression reduces itself to:

$$\vec{B}_g = \frac{\nu_0 . m}{4\pi r^3} . (\vec{r} \times \vec{v})$$

This non-relativistic result could also been 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.

4.5. The gravitational field of a point mass describing a uniform rectilinear motion

A point mass m_0, moving with constant velocity $\vec{v} = v.\vec{e}_z$ along the *Z*-axis of an inertial frame, creates and maintains a cloud of informatons that are carrying both g- and β-information. That cloud can be identified with a time-dependent continuum. That continuum is called the *gravitational field of* the point mass. It is characterized by two time-dependent vectorial quantities: the gravitational field (short: *g-field*) $\vec{E}_g$ and the gravitational induction (short*: g-induction*) $\vec{B}_g$.

- With *N* the density of the flow of informatons in *P*, the g-field in that point is:

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

- With *n,* the density of the cloud of informatons in *P*, the g-induction in that point is:

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

It is easy to verify the following equations:

$$div\vec{E}_g = 0\,; \qquad div\vec{B}_g = 0\,; \qquad rot\vec{E}_g = -\frac{\partial \vec{B}_g}{\partial t}\,; \qquad rot\vec{B}_g = \frac{1}{c^2}.\frac{\partial \vec{E}_g}{\partial t}$$

These relations are the laws of G.E.M. in the case of the gravitational field of a point mass describing a uniform rectilinear motion.

Note that, if $v << c$, the expressions for the g-field and the g-induction reduce to:

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

4.6. The gravitational field of a set of point masses describing uniform rectilinear motions

We consider a set of point masses $m_1,\ldots,m_i,\ldots m_n$ which move with constant velocities $\vec{v}_1,\ldots,\vec{v}_i,\ldots,\vec{v}_n$ in an inertial reference frame ***O***. This set creates and maintains a gravitational field that in each point of the space linked to ***O***, is characterised by the vector pair ($\vec{E}_g$, $\vec{B}_g$) .

- Each mass m_i emits continuously g-information and contributes with an amount $\vec{E}_{gi}$ to the g-field at an arbitrary point *P*. As in 3.2 we conclude that the effective g-field $\vec{E}_g$ in *P* is defined as:

$$\vec{E}_g = \sum \vec{E}_{gi}$$

- If it is moving, each mass m_i emits also β-information, thereby contributing to the g-induction in *P* with an amount $\vec{B}_{gi}$. It is evident that the β-information in the volume element *dV* in *P* at each moment *t* is expressed by:

$$\sum(\vec{B}_{gi}.dV) = (\sum \vec{B}_{gi}).dV$$

Thus, the effective g-induction $\vec{B}_g$ in *P* is:

$$\vec{B}_g = \sum \vec{B}_{gi}$$

The laws of G.E.M. mentioned in the previous section remain valid for the effective g-field and g-induction in the case of the gravitational field of a set of point masses describing a uniform rectilinear motion.

4.7. The gravitational field of a stationary mass flow

In each point *Q* of a stationary mass flow, the intensity of the flow is defined by the flow density $\vec{J}_G$. The magnitude of this vectorial quantity equals the rate per m^2 at which the mass flows through a surface element that is perpendicular to the flow in *Q.* The orientation of $\vec{J}_G$ corresponds to the direction of that flow.

Since a stationary mass flow is the macroscopic manifestation of moving mass elements $\rho_G.dV$, it creates and maintains a gravitational field. And since the velocity $\vec{v}$ of the mass element in each point is time independent, *the gravitational field of a stationary mass flow will be time independent*. It is evident that the rules of 3.3 also apply for this time independent g-field:

$$div\vec{E}_g = -\frac{\rho_G}{\eta_0} \qquad \text{and} \qquad rot\vec{E}_g = 0 \quad \text{what implies } \vec{E}_g = -gradV_g$$

One can prove [(6) (7)] that the rules for the time independent g-induction are:

$$div\vec{B}_g = 0 \text{ what implies } \vec{B}_g = rot\vec{A}_g \qquad \text{and} \qquad rot\vec{B}_g = -\nu_0.\vec{J}_G$$

These are the laws of G.E.M. in the case of the gravitational field of a stationary mass flow.

4.8. The Laws of the gravitational Field - The Laws of G.E.M.

One can mathematically deduce [(6) (8)] the laws of G.E.M. (§1.2) from the definitions of $\vec{E}_g$ and $\vec{B}_g$.

1. *The first law is the expression of the law of conservation of g-information.*

2. *The second law is the expression of the fact that the* β *-vector of an informaton is always perpendicular to its g-spin vector* $\vec{s}_g$ *and to its velocity* $\vec{c}$ *.*

3. *The third law is the expression of the fact that any change of the product* $n.\vec{s}_g$ *in a point of a gravitational field is related to a spatial variation of the product* $N.\vec{s}_g$ *in the vicinity of that point*.

4. *The fourth law* is *the expression of the fact that any change of the product* $N.\vec{s}_g$ *in a point of a gravitational field is related to a spatial variation of the product* $n.\vec{s}_g$ *in the vicinity of that point, and that a flow of mass creates* β *-information.*

V. The interaction between masses

5.1. The postulate of the gravitational interaction between masses at rest

We consider a set of point masses anchored in an inertial reference frame ***O***. They create and maintain a gravitational field that, in each point of the space linked to ***O***, is completely determined by the vector $\vec{E}_g$. Each mass is "immersed" in a cloud of g-information. In every point, except its own anchorage, each mass contributes to the construction of that cloud.
Let us consider the mass *m* anchored in *P*. If the other masses were not there, then *m* would be at the centre of a perfectly spherical cloud of g-information. In reality this is not the case: the emission of g-information by the other masses is responsible for the disturbance of that "*characteristic symmetry*". Because $\vec{E}_g$ in *P* represents the intensity of the flow of g-information send to *P* by the other masses, the extent of disturbance of that characteristic symmetry in the direct vicinity of *m* is determined by $\vec{E}_g$ in *P*.

If it was free to move, the point mass *m* could restore the characteristic symmetry of the g-information cloud in his direct vicinity: it would suffice to accelerate with an amount $\vec{a} = \vec{E}_g$. Accelerating in this way has the effect that the extern field disappears in the origin of the reference frame anchored to *m*. If it accelerates that way, the mass becomes "blind" for the g-information send to *P* by the other masses, it "sees" only its own spherical g-information cloud.

These insights are expressed by the following postulate.

A point mass anchored in a point of a stationary gravitational field is subjected to a tendency to move in the direction defined by $\vec{E}_g$, the g-field in that point. Once the anchorage is broken, the mass acquires a vectorial acceleration $\vec{a}$ that equals $\vec{E}_g$.

5.2. The gravitational force - Newton's second law

Any disturbance of the characteristic symmetry of the cloud of g-information around a point mass, gives rise to an action aimed to the destruction of that disturbance.

A point mass *m*, anchored in a point *P* of a gravitational field, experiences an action because of that field; an action that is compensated by the anchorage. That action - that tend to accelerate the point mass - is proportional to $\vec{E}_g$ (the g-field to which the mass is exposed) and to *m* (the magnitude of the mass) (6) (7). We represent that action by $\vec{F}_g$ and we call this vectorial quantity "the force developed by the g-field on the mass" or the *gravitational force* on *m*. We define it by the relation:

$$\vec{F}_g = m.\vec{E}_g$$

A mass anchored in a point *P* cannot accelerate, what implies that the effect of the anchorage must compensate the gravitational force. That means that the disturbance of the characteristic symmetry around *P* by $\vec{E}_g$ must be cancelled by the g-information flow created and maintained by the anchorage. The density of this flow in *P* must be equal and opposite to $\vec{E}_g$. It cannot but the anchorage exerts an action on *m* that is exactly equal and opposite to the gravitational force. That action is called a *reaction force*.

This discussion leads to the following insight: *Each phenomenon that disturbs the characteristic symmetry of the cloud of g-information around a point mass, exerts a force on that mass.*

By combination of the postulate with the definition of gravitational force on *m*, it follows:

$$\vec{a} = \frac{\vec{F}_g}{m}$$

Considering that the effect of the gravitational force is actually the same as that of each other force we can conclude that the relation between a force $\vec{F}$ and the acceleration $\vec{a}$ that it imposes to a free mass m is $\vec{F} = m.\vec{a}$. *This is Newton's second law*.

5.3. Newtons universal law of gravitation

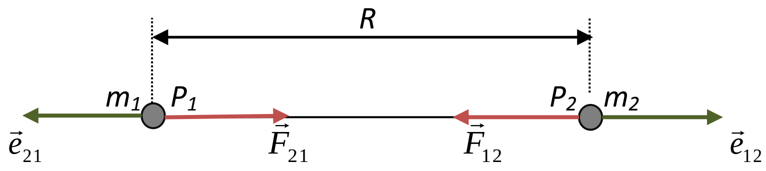

Fig 5

In fig 5 we consider two point masses m_1 and m_2 anchored in the points P_1 and P_2 of an inertial frame.

m_1 creates and maintains a gravitational field that in P_2 is defined by the g-field strength:

$$\vec{E}_{g2} = -\frac{m_1}{4.\pi.\eta_0}.\vec{e}_{12}$$

This field exerts a gravitational force on m_2:

$$\vec{F}_{12} = m_2.\vec{E}_{g2} = -\frac{m_1.m_2}{4.\pi.\eta_0}.\vec{e}_{12}$$

In a similar manner we find= $\vec{F}_{21} = -\frac{m_1.m_2}{4.\pi.\eta_0}.\vec{e}_{21} = -\vec{F}_{12}$

This is the mathematical formulation of *Newtons universal law of gravitation.*

5.4. The interaction between moving masses

One can show (6) (7) that the characteristic symmetry of the "eigen-field" created by a mass *m* that moves with velocity $\vec{v}$ through a point *P* of a gravitational field ($\vec{E}_g, \vec{B}_g$) is disturbed not only by $\vec{E}_g$, but equally by ($\vec{v} \times \vec{B}_g$). So, the postulate between masses should be extended:

A point mass m, moving with velocity $\vec{v}$ in a gravitational field ($\vec{E}_g, \vec{B}_g$), tends to become blind for the influence of that field on the symmetry of its eigen field. If it is free to move, it will accelerate relative to its eigen inertial reference frame with an amount $\vec{a}'$:*

$$\vec{a}' = \vec{E}_g + (\vec{v} \times \vec{B}_g)$$

The action of the gravitational field ($\vec{E}_g, \vec{B}_g$) on a point mass that is moving with velocity $\vec{v}$ relative to the inertial reference frame ***O***, is called the *gravitational force* $\vec{F}_G$ on that mass.

In extension of 5.1.2 we define $\vec{F}_G$ as: $\vec{F}_G = m_0.\left[\vec{E}_g + (\vec{v} \times \vec{B}_g)\right]$

m_0 is the rest mass of the point mass: it is the mass that determines the rate at which it emits informatons in the space linked to ***O***.

It follows (6) (7): $\vec{F}_G = \dfrac{d\vec{p}}{dt}$; $\vec{p} = \dfrac{m_0}{\sqrt{1-\beta^2}}.\vec{v}$ is the linear momentum of the point mass relative to the inertial reference frame ***O***.

In fig 6 two point-masses m_1 and m_2 are anchored in the inertial frame ***O'*** that is moving relative to the inertial frame ***O*** with constant velocity $\vec{v} = v.\vec{e}_z$. The distance between the masses is *R.*

In ***O'*** the masses don't move. They attract - according Newton's law of gravitation - one another with an equal force:

$$F' = F'_{12} = F'_{21} = m_2.E'_{g2} = m_1.E'_{g1} = \frac{1}{4.\pi.\eta_0}.\frac{m_1.m_2}{R^2}$$

* The eigen inertial reference frame (at a moment *t*) of a moving mass *m* is the reference frame that has the same velocity as the mass.

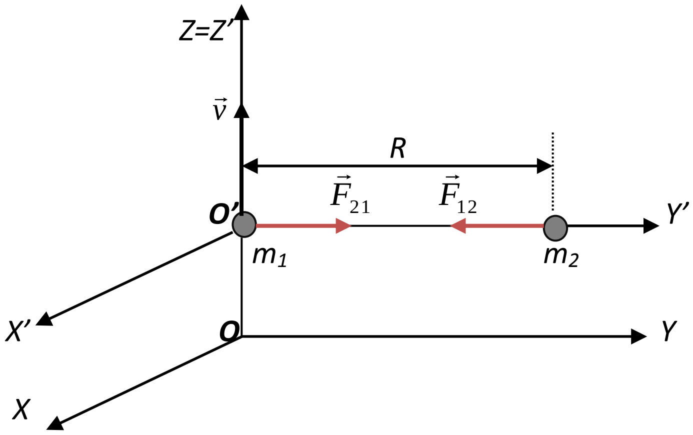

Fig 6

In the frame ***O*** both masses are moving in the direction of the *Z*-axis with the speed *v*. The gravitational field of a moving mass is characterized by the vector pair ($\vec{E}_g, \vec{B}_g$) and the mutual attraction is:

$$F = F_{12} = F_{21} = m_2.(E_{g2} - v.B_{g2}) = m_1.(E_{g1} - v.B_{g1})$$

Taking into account, the results from §4.5, we find:

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

We can conclude that the component of the gravitational force due to the g-induction is β^2 times smaller than that due to the g-field. *This implies that, for speeds much smaller than the speed of light, the effects of the β-information are masked.*

The β-information emitted by the rotating sun is not taken into account when the classical theory of gravitation describes the planetary orbits. It can be shown that this neglect is responsible for deviations (as the advance of Mercury Perihelion) of the real orbits with respect to these predicted by that theory [4].

Epilogue

1. The *theory of informatons* is also able to explain the phenomena and the laws of electromagnetism [6] [9] .

2. Certain properties of photons can be explained by the assumption that this "particle" is nothing else than an informaton transporting an energy package [6] [9] .

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