# Physical Foundation of Gravito-Electromagnetism
## The Theory of Informatons

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## ABSTRACT

The *"theory of informatons"* explains the gravitational interactions by the hypothesis that "*information*" is the substance of gravitational (and of E.M.) fields. The constituent element of that substance is called an "*informaton*". Every material object manifests itself in space by the emission of informatons. These are dot shaped mass and energy less entities that rush away with the speed of light, carrying information about the position ("*g-information*") and about the velocity ("*β-information*") of the emitter. The laws of gravito-electromagnetism are mathematically deduced from the dynamics of the informatons, and the gravitational interactions are explained as the effect of the trend of a material object to become blind for flows of information generated by other masses.

**Key words:** gravitation, gravito-electromagnetism, informatons.

## INTRODUCTION

Daily contact with the things on hand confronts us with their *substantiality*. An object is not just form, it is also matter. It takes space, it eliminates emptiness. 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) action at a distance on each other: they attract each other and if they are free, they move to each other along the straight line that connects them.

According to the classical theory of fields, the gravitational interactions can be described by introducing the "*gravitational field*": each material object manifests its substantiality in space by creating and maintaining a vector field and each object in that field experiences a tendency to change its state of motion. The "*field theory*" considers the gravitational field as the mathematical entity that mediates in the gravitational interaction.

This is further developed by Oliver Heaviside (1) and Oleg Jefimenko (2). In "the *theory of gravitoelectromagnetism*" *(G.E.M.)* they describe the gravitational field starting from the idea that it must be isomorphic with the electromagnetic field. This implies that it should be characterized by two vectorial quantities that are analogue to respectively the electric field $\vec{E}$ and the magnetic induction $\vec{B}$, and that the relations governing these quantities should

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be analogue to Maxwell's laws. Within the framework of general relativity, G.E.M. has been discussed by a number of authors [3]. It is shown that the gravitational analogues to Maxwell's equations (the G.E.M. equations) can be derived from the Einstein field equation.

Although G.E.M. describes the gravitational phenomena in a correct and coherent manner, it doesn't create clarity about the true nature of the action at a distance. In the context of G.E.M., the gravitational field is a purely mathematical construction that doesn't provide insight in the mechanisms that are at the base of the physical laws.

In this article we develop 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 and its position, and is able to "interpret" the information emitted by its neighbours. In this way we propose a physical foundation of G.E.M. by introducing "*information*" as the substance of the gravitational field.

Explicitly, we start from the idea that the gravitational field of a material object can be explained as the macroscopic manifestation of the emission by that object of mass-, energy- and dot shaped entities that rush away with the speed of light, carrying information about the position ("*g-information*") and the velocity ("*β-information*") of the emitter. Because they transport nothing else than information, we call these entities "*informatons*". In the "*postulate of the emission of informatons*", we define an informaton by its attributes and determine the rules that govern the emission of informatons by a point mass that is anchored in an inertial reference frame.

The first consequence of this postulate is that a point mass at rest - and by extension any material object at rest - can be considered as the source of an expanding spherical cloud of informatons, that - in an arbitrary point *P* - is characterised by the vectorial quantity $\vec{E}_g$. $\vec{E}_g$ is *the density of the flow of g-information* in that point. That cloud of informatons can be identified with the gravitational field and the quantity $\vec{E}_g$ with the gravitational field strength in *P*. A second consequence is that the informatons emitted by a moving point mass, constitute a gravitational field that is characterised by two vectorial quantities: $\vec{E}_g$, the density of the g-information flow, and $\vec{B}_g$, *the density of the β-information cloud*. We show that the relations - arising from the dynamics of the informatons - between these two quantities are the laws of G.E.M.: the gravitational analogues of the laws of Maxwell-Heaviside.

Finally, we explain the gravitational interaction between masses as the reaction of a point mass on the disturbance of the symmetry of its "own" gravitational field by the field that, in its direct vicinity, is created and maintained by other masses.

## I. The Postulate of the Emission of Informatons

With the aim to understand and to describe the mechanism of the gravitational interaction, we introduce a new quantity in the arsenal of physical concepts: *information.* We suppose that information is transported by mass and energy less dot shaped entities that rush through space with the speed of light ($c$). We call these information carriers *informatons*.

Each material object continuously emits informatons. An informaton always carries *g-information*, which is at the root of gravitation.

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 diverge at the speed of light (c = 3.10*$^8$ m/s) *along radial trajectories 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 his *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, that is responsible for noise on the quantities that characterize the gravitational field. So, $\dot{N}$ is the average emission rate.

# II. The gravitational Field of Masses at Rest

## 2.1. The gravitational field of a point mass at rest

In fig1 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 $\vec{s}_g$ :

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

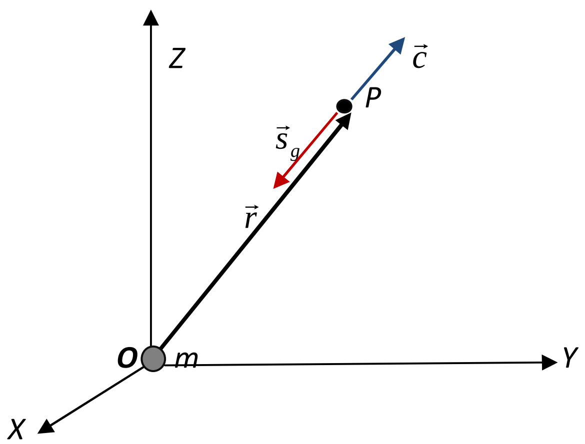


Fig 1

The rate at which the point mass emits g-information is the product of the rate at which it emits informatons with the elementary g-information quantity:

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

Of course, this is also the rate at which it sends g-information through any closed surface that spans *m.*

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 is a stationary state: because the inflow equals the outflow, each spatial region contains an unchanging 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 like continuously spread over the volume of the region.

That 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 describe the motion of g-information through a surface as a *continuous flow* of g-information.

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 unit area* 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). This quantity is, together with the orientation of the g-spin vectors of the informatons that are passing in the vicinity of *P,* characteristic for het gravitational field in that point.

Thus, in a point *P*, the gravitational field of the point mass *m* is defined by the vectorial quantity $\vec{E}_g$ :

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

This quantity is the *gravitational field strength* or the *g-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 note that $\vec{E}_g$ is opposite to the sense of movement of the informatons.

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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 de Hubble constant:

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

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)

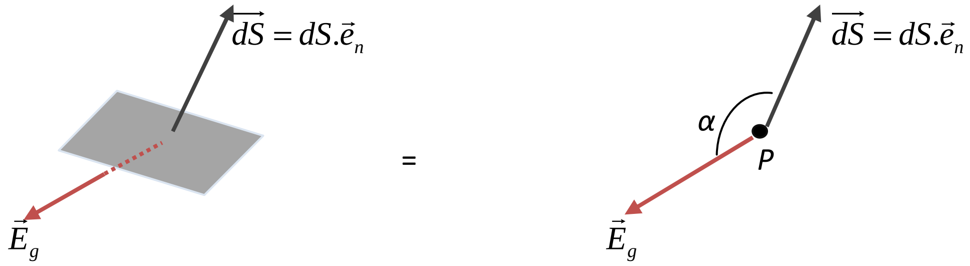


Fig 2,a                Fig 2,b

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. The rate at which g-information flows out must indeed 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.

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

We consider a set of point-masses $m_1,\dots,m_i,\dots m_n$ that are anchored in an inertial frame ***O***.

In an arbitrary point *P*, the flows of g-information who are emitted by the distinct masses are defined by the gravitational fields $\vec{E}_{g1},\dots,\vec{E}_{gi},\dots,\vec{E}_{gn}$ .

$d\Phi_g$, 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, the *effective density of the flow of g-information in P* (the effective g-field ) is completely defined by:

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

We conclude: *The g-field of a set of point masses at rest is in any point of space completely defined by the vectorial sum of the g-fields caused by the distinct masses.*

Let us note that the orientation of the effective g-field has no longer a relation with the direction in which the passing informatons are moving.

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

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

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

## 2.3. The gravitational 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*.

In each point *Q* of such a continuum, the accumulation of mass is defined by the (*mass*) *density* $\rho_G$. To define this scalar quantity one considers a volume element *dV* that contains *Q*, and one determines the enclosed mass *dm*. The accumulation of mass in the vicinity of *Q* is defined by:

$$\rho_G = \frac{dm}{dV}$$

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 field strength in an arbitrary point *P* is $d\vec{E}_g$. $\vec{E}_g$, the effective field strength 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 the surface (the enclosed volume is *V*).

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

That is equivalent with (theorem of Ostrogradsky [(4)]:

$$div\vec{E}_g = -\frac{\rho_G}{\eta_0}$$

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: $\vec{E}_g = -gradV_g$

## III. The gravitational Field of moving Masses

### 3.1. Rest mass and relativistic mass

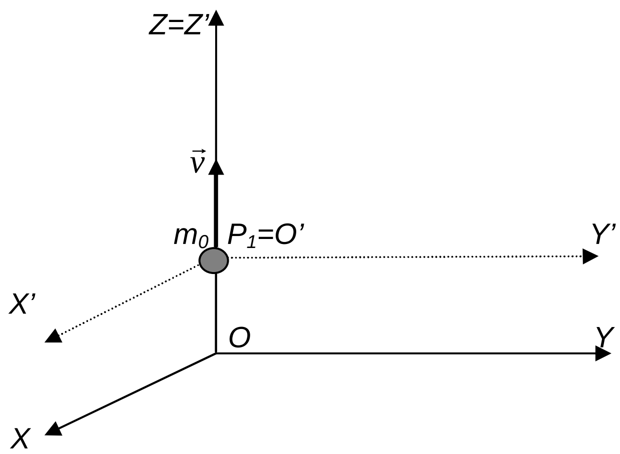


Fig 3

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

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

That implies that, if the time is read on a standard clock anchored in ***O***, *dN* - the number of informatons that during the interval *dt* - by a, whether or not moving, point mass is emitted in the space connected to ***O***, is:

$$dN = K.m_0.dt$$

We can the space-time also connect to an inertial reference frame ***O'*** (fig 3) whose origin is anchored to the point mass and that is running away relative to ***O*** with the velocity $\vec{v} = v.\vec{e}_z$ .
We assume that *t = t' = 0* when the mass passes through ***O*** (*t* is the time read on a standard clock in ***O*** and *t'* the time read on a standard clock in ***O'***).

We determine the time that expires while the moving point mass emits *dN* informatons.

1. An observer in ***O*** uses therefore a standard clock that is linked to that reference frame. The emission of *dN* informatons takes *dt* seconds. The relationship between *dN* and *dt* is:

$$dN = K.m_0.dt$$

2. To determine the duration of the same phenomenon, the observer in ***O*** can also read the time on the moving clock, that is the standard clock linked to the inertial reference frame ***O'***. According to that clock, the emission of *dN* informatons takes *dt'* seconds.

(*x, y, z; t*) - the coordinates of an event connected to ***O*** - and (*x', y', z'; t'*) - the coordinates of the same event connected to ***O'*** - are related by the Lorentz-transformation [(5)]:

| | |
|---|---|
| $x' = x$ | $x = x'$ |
| $y' = y$ | $y = y'$ |
| $z' = \dfrac{z - vt}{\sqrt{1-\beta^2}}$ | $z = \dfrac{z' + vt'}{\sqrt{1-\beta^2}}$ |
| $t' = \dfrac{t - \frac{v}{c^2} z}{\sqrt{1-\beta^2}}$ | $t = \dfrac{t' + \frac{v}{c^2} z'}{\sqrt{1-\beta^2}}$ |

The relationship between *dt* and *dt'* is:

$$dt = \frac{dt'}{\sqrt{1-\beta^2}} \quad \text{with} \quad \beta = \frac{v}{c}$$

So:

$$dN = K.m_0.dt = K.m_0.\frac{dt'}{\sqrt{1-\beta^2}} = K.\frac{m_0}{\sqrt{1-\beta^2}}.dt' = \frac{\dot{N}}{\sqrt{1-\beta^2}}.dt'$$

and:

$$\frac{dN}{dt'} = \frac{\dot{N}}{\sqrt{1-\beta^2}} = K.\frac{m_0}{\sqrt{1-\beta^2}} = K.m \quad \text{with} \quad m = \frac{m_0}{\sqrt{1-\beta^2}}$$ , the “relativistic mass”

Conclusion: *The rate at which a point mass, moving with constant velocity relative to an inertial reference frame **O**, emits informatons in the space linked to **O**, is determined by its relativistic mass if the time is read on a standard clock that is anchored to that mass.*

## 3.2. The field caused by a uniform rectilinear moving point mass

In fig 4,a, we consider again 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 $P_1$. It is evident that:

$$OP_1 = z_{P_1} = v.t$$

$m_0$ 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 wish to 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 independent Cartesian coordinates (*x, y, z*), or by the time dependent position vector $\vec{r} = \overrightarrow{P_1P}$. $\theta$ is the angle between $\vec{r}$ and the *Z*-axis.

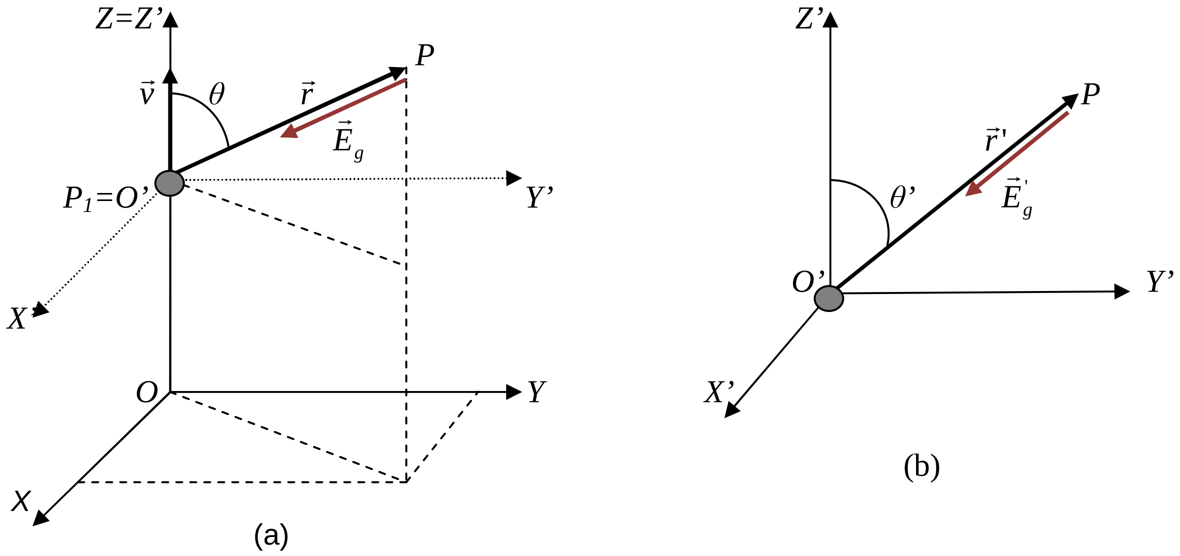


Fig. 4

Relative to the inertial reference frame ***O'***, that is anchored to the moving mass and that at the moment $t = t' = 0$, coincides with ***O*** (fig 4,b), the instantaneous value of the density of the flow of g-information in *P* is determined by:

$$\vec{E}_g^{'} = -\frac{m_0}{4\pi\eta_0 r'^3}.\vec{r}'$$

Indeed relative to ***O'*** the point mass is at rest and he position of *P* is determined by the time dependant position vector $\vec{r}'$ or by the Cartesian coordinates (*x', y', z'*). So, the g-field generated by the mass is determined by 2.1.

The components of $\vec{E}_g^{'}$ in *O'X'Y'Z'*, namely:

$$E_{gx'}^{'} = -\frac{m_0}{4\pi\eta_0 r'^3}.x' \qquad E_{gy'}^{'} = -\frac{m_0}{4\pi\eta_0 r'^3}.y' \qquad E_{gz'}^{'} = -\frac{m_0}{4\pi\eta_0 r'^3}.z'$$

determine in *P* the densities of the flows of g-information respectively through a surface element *dy'.dz'* perpendicular to the *X'*-axis, through a surface element *dz'.dx'* perpendicular to the *Y'*-axis and through a surface element *dx'.dy'* perpendicular to the *Z'*-axis.

The g-fluxes through these different surface elements in *P*, or the rates at which g-information flows through it are:

$$E_{gx'}^{'}.dy'.dz' = -\frac{m_0.x'}{4\pi\eta_0 r'^3}.dy'.dz'$$

$$E_{gy'}^{'}.dz'.dx' = -\frac{m_0.y'}{4\pi\eta_0 r'^3}.dz'.dx'$$

$$E_{gz'}^{'}.dx'.dy' = -\frac{m_0.z'}{4\pi\eta_0 r'^3}.dx'.dy'$$

The Cartesian coordinates of *P* in the frames ***O*** and ***O'*** are connected by [(5)]:

$$x' = x \qquad y' = y \qquad z' = \frac{z - v.t}{\sqrt{1-\beta^2}} = \frac{z - z_{P_1}}{\sqrt{1-\beta^2}}$$

And the line elements by:

$$dx' = dx \qquad dy' = dy \qquad dz' = \frac{dz}{\sqrt{1-\beta^2}}$$

Further•: $r' = r.\dfrac{\sqrt{1-\beta^2.\sin^2\theta}}{\sqrt{1-\beta^2}}$

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• In ***O***: $r = \sqrt{x^2 + y^2 + (z - z_{P_1})^2}$ , $\sin\theta = \dfrac{\sqrt{x^2+y^2}}{r}$ and $\cos\theta = \dfrac{z - z_{P_1}}{r}$ .

And in ***O'***: $r' = \sqrt{x'^2 + y'^2 + z'^2}$ and $\sin\theta' = \dfrac{\sqrt{x'^2+y'^2}}{r'}$ .

We express *r'* in function of *x, y* and *z*:

$$r' = \sqrt{x^2 + y^2 + \frac{(z - z_{P1})^2}{(1-\beta^2)}} = \sqrt{r^2.\sin^2\theta + \frac{(z - z_{P1})^2}{1-\beta^2}} = \frac{\sqrt{r^2.\sin^2\theta.(1-\beta^2) + r^2.\cos^2\theta}}{\sqrt{1-\beta^2}} = r\frac{\sqrt{1-\beta^2.\sin^2\theta}}{\sqrt{1-\beta^2}}$$

So relative to ***O***, the g-information fluxes that the moving mass sends - in the positive direction - through the surface elements *dy.dz*, *dz.dx* and *dx.dy* in *P* are:

$$-\frac{m_0}{4\pi\eta_0 r^3}.\frac{1-\beta^2}{(1-\beta^2.\sin^2\theta)^{\frac{3}{2}}}.x.dy.dz$$

$$-\frac{m_0}{4\pi\eta_0 r^3}.\frac{1-\beta^2}{(1-\beta^2.\sin^2\theta)^{\frac{3}{2}}}.y.dz.dx$$

$$-\frac{m_0}{4\pi\eta_0 r^3}.\frac{1-\beta^2}{(1-\beta^2.\sin^2\theta)^{\frac{3}{2}}}.(z-z_{P_1}).dx.dy$$

Since the densities in *P* of the flows of g-information in the direction of the *X*-, the *Y*- and the *Z*-axis are the components of the g-field caused by the moving point mass $m_0$ in *P*, we find:

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

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

$$E_{gz}=-\frac{m_0}{4\pi\eta_0 r^3}.\frac{1-\beta^2}{(1-\beta^2.\sin^2\theta)^{\frac{3}{2}}}.(z-z_{P_1})$$

So, the g-field caused by the moving point mass in the fixed point *P* is:

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

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 that 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.*

The points where $E_g$ - at the moment $t$ - has a certain magnitude satisfy the relation:

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

If the mass is at rest, this equation defines a sphere: the gravitational field of a point mass at rest shows spherical symmetry relative to the position of the mass.

If the mass moves with constant velocity, this equation defines a surface of revolution with the $Z$-axis (this is the path of the mass) as symmetry-axis. The faster the mass moves, the more the surface differs from a sphere. The dimension in the direction of the movement is reduced by a factor ($1 - \beta^2$), and that perpendicular on the movement is increased by a factor $\frac{1}{\sqrt{1-\beta^2}}$.

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

In fig 5 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 $\vec{r} = \overrightarrow{P_1P}$. The position vector $\vec{r}$ - just like the distance $r$ and the angle $\theta$ - 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 $\Delta t$:

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

During their rush from $P_0$ to $P$, the mass moved from $P_0$ to $P_1$:

$$P_0P_1 = v.\Delta t$$

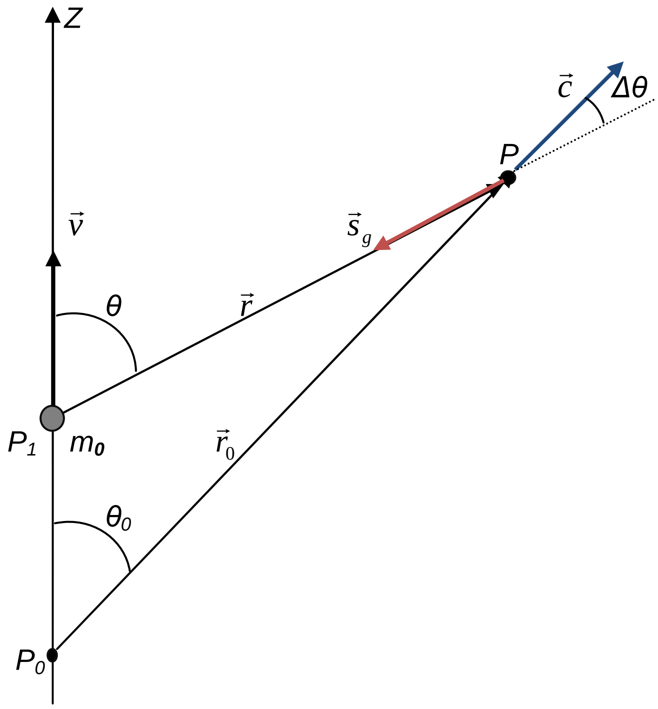


Fig 5

- 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 $t$. This is an implication of rule B.1 of the postulate of the emission of informatons.

The lines who 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-index*" $\vec{s}_\beta$ that is defined by:

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

- The β-index 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 to that plane is defined by the “rule of the corkscrew”: in the case of fig 5, the β-indices have the orientation of the positive *X*-axis.

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

We apply the sine rule to the triangle $P_0P_1P$:

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

It follows:

$$s_\beta = s_g.\frac{v}{c}.\sin\theta = s_g.\beta.\sin\theta = s_g.\beta_\perp$$

$\beta_\perp$ is the component of the dimensionless velocity $\vec{\beta} = \frac{\vec{v}}{c}$ perpendicular to $\vec{s}_g$ .

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

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

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

We consider again the situation of fig 5. 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 β-indices $\vec{s}_\beta$:

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

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

- Its magnitude $B_g$ determines the density of the β-information in *P.*

- Its orientation determines the orientation of the β-vectors $\vec{s}_\beta$ in the direct vicinity of that point.

So, the g-induction caused in *P* by the moving mass $m_0$ (fig 5) 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 unit area 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 unit volume) - are connected by the relation:

$$n = \frac{N}{c}$$

With:

$$\vec{E}_g = N.\vec{s}_g$$

we can express the gravitational induction in *P* as:

$$\vec{B}_g = \frac{\vec{v}}{c^2}\times(N.\vec{s}_g) = \frac{\vec{v}\times\vec{E}_g}{c^2}$$

Taking into account (3.2):

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

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 $\nu_0$ = *9,34.10*$^{-27}$ *m.kg*$^{-1}$ as:

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

$$\nu_0 = \frac{1}{c^2.\eta_0}$$

And finally, we obtain:

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

$\vec{B}_g$ 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 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.

## 3.5. 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 rate per unit area at which the informatons cross an elementary surface perpendicular to the direction of movement), the g-field in that point is:

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

The orientation of $\vec{E}_g$ learns that the direction of the flow of g-information in *P* is not the same as the direction of the flow of informatons.

- With *n,* the density of the cloud of informatons in *P* (number of informatons per unit volume), the g-induction in that point is:

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

One verifies that:

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

*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.*

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

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

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

We consider a set of point masses $m_1,\dots,m_i,\dots m_n$ that move with constant velocities $\vec{v}_1,\dots,\vec{v}_i,\dots,\vec{v}_n$ 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 $m_i$ continuously emits g-information and contributes with an amount $\vec{E}_{gi}$ to the g-field at an arbitrary point *P*. As in 2.2 we conclude that the effective g-field $\vec{E}_g$ in *P* is defined as:

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

- If it is moving, each mass $m_i$ emits also β-information, 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:

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

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 op point masses describing a uniform rectilinear motion.

## 3.7. The gravitational field of a stationary mass flow

The term "stationary mass flow" indicates the movement of an homogeneous and incompressible fluid that, in an invariable way, flows relative to an inertial reference frame.

The intensity of the flow in an arbitrary point *P* is characterised by the flow density $\vec{J}_G$. The magnitude of this vectorial quantity equals the rate per unit area at which the mass flows through a surface element that is perpendicular to the flow in *P.* The orientation of $\vec{J}_G$ corresponds to the direction of that flow. If $\vec{v}$ is the velocity of the mass element $\rho_G.dV$ that at the moment *t* flows through *P*, then:

$$\vec{J}_G = \rho_G.\vec{v}$$

The rate at which mass flows through a surface element $\overrightarrow{dS}$ in *P* in the sense of the positive normal, is given by:

$$di_G = \vec{J}_G.\overrightarrow{dS}$$

And the rate at which the flow transports - in the positive sense (defined by the orientation of the surface vectors $\overrightarrow{dS}$ ) - mass through an arbitrary surface *ΔS*, is:

$$i_G = \iint_{\Delta S} \vec{J}_G.\overrightarrow{dS}$$

We call $i_G$ the *intensity of the mass flow through ΔS.*

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 2.3 also apply for this time independent g-field:

- $div\vec{E}_g = -\frac{\rho_G}{\eta_0}$

- $rot\vec{E}_g = 0$ what implies: $\vec{E}_g = -gradV_g$

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

- $div\vec{B}_g = 0$ what implies $\vec{B}_g = rot\vec{A}_g$

- $rot\vec{B}_g = -\nu_0.\vec{J}_G$

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

## IV. The Laws of the gravitational Field - The Laws of G.E.M.

In the space linked to an inertial reference frame ***O***, the gravitational field is characterised by two time dependent vectors: the (effective) g-field $\vec{E}_g$ and the (effective) g-induction $\vec{B}_g$. In an arbitrary point *P*, these vectors are the results of the superposition of the contributions of the various sources of informatons (the masses) to respectively the density of the flow of g-information and to the cloud of β-information in *P*:

$$\vec{E}_g = \sum N.\vec{s}_g \qquad \text{and} \qquad \vec{B}_g = \sum n.\vec{s}_\beta$$

The informatons that - at the moment *t* - pass in the direct vicinity of *P* with velocity $\vec{c}$ contribute with an amount ($N.\vec{s}_g$) to the instantaneous value of the g-field and with an amount ($n.\vec{s}_\beta$) to the instantaneous value of the g-induction in that point.

- $\vec{s}_g$ and $\vec{s}_\beta$ respectively are their g-spin and their β-index. They are linked by the relationship:

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

- *N* is the instantaneous value of the density of the flow of informatons with velocity $\vec{c}$ at *P* and *n* is the instantaneous value of the density of the cloud of those informatons in that point. *N and* *n* are linked by the relationschip:

$$n = \frac{N}{c}$$

## 4.1. Relations between $\vec{E}_g$ and $\vec{B}_g$ in a matter free point of a gravitational field

In each point where no matter is located - where $\rho_G(x, y,z;t) = \vec{J}_G(x,y,z;t) = 0$ - the following statements are valid.

**1. In a matter free point *P* of a gravitational field, the spatial variation of $\vec{E}_g$ obeys the law:**

$$div\vec{E}_g = 0$$

*This statement is the expression of the law of conservation of g-information.* The fact that the rate at which g-information flows inside a closed empty space must be equal to the rate at which it flows out, can be expressed as:

$$\oiint_S \vec{E}_g.\overrightarrow{dS} = 0$$

So (theorem of Ostrogradsky) [(4)]:

$$div\vec{E}_g = 0$$

**2. In a matter free point *P* of a gravitational field, the spatial variation of $\vec{B}_g$ obeys the law:**

$$div\vec{B}_g = 0$$

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

In fig 6, we consider the flow of informatons which - at the moment *t* - pass with velocity $\bar{c}$ in the vicinity of the point *P*. An informaton that at the moment *t* passes in *P* is at the moment (*t + dt*) in *Q*:

$$PQ = c.dt$$

In *P*, the instantaneous value of the density of the considered flow of informatons is represented by *N*, the instantaneous value of the density of the cloud that they constitute by *n*, and the instantaneous value of their characteristic angle by $\Delta\theta$.

We introduce the coordinate system *PXYZ*:

$$\vec{s}_g = -s_g.\vec{e}_x \quad \text{and} \quad \vec{s}_\beta = \frac{\vec{c}\times\vec{s}_g}{c} = s_g.\sin(\Delta\theta).\vec{e}_z$$

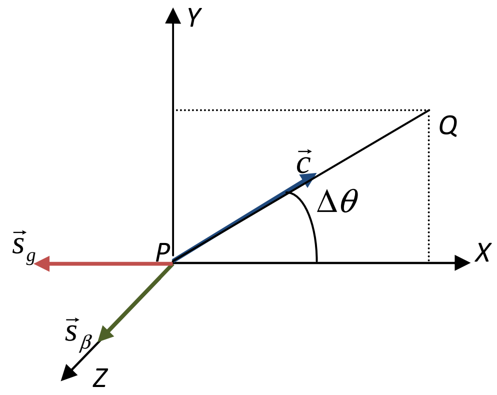


Fig 6

The contribution of the considered informatons to the g-induction in *P* is: $\vec{B}_g = n.\vec{s}_\beta$

From mathematics [4] we know:

$$div\vec{B}_g = div(n.\vec{s}_\beta) = grad(n).\vec{s}_\beta + n.div(\vec{s}_\beta)$$

- $grad(n).\vec{s}_\beta = 0$ because *grad(n)* is perpendicular to $\vec{s}_\beta$. Indeed *n* changes only in the direction of the flow of informatons, so *grad(n)* has the same orientation as $\vec{c}$:

$$grad(n) = \frac{n_Q - n_P}{PQ}.\frac{\vec{c}}{c}$$

- $n.div(\vec{s}_\beta) = 0$. According to the definition: $div(\vec{s}_\beta) = \dfrac{\oiint \vec{s}_\beta.\overrightarrow{dS}}{dV}$. We calculate the double integral over the closed surface *S* formed by the infinitesimal surfaces *dS = dz.dy* which are in *P* and in *Q* perpendicular to the *X*-axis and by the tube which connects the edges of these surfaces. *dV* is the infinitesimal volume enclosed by *S*. It is obvious that:

$$div(\vec{s}_\beta) = \frac{\oiint \vec{s}_\beta.\overrightarrow{dS}}{dV} = 0$$

Both terms of the expression of $div\vec{B}_g$ are zero, so $div\vec{B}_g = 0$, what implies (theorem of Ostrogradsky) that for every closed surface *S* in a gravitational field:

$$\boxed{\oiint_S \vec{B}_g.\overrightarrow{dS} = 0}$$

**3. In a matter free point *P* of a gravitational field, the spatial variation of $\vec{E}_g$ and the rate at which $\vec{B}_g$ is changing are connected by the relation:**

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

*This statement is the expression of the fact that any change of the product $n.\vec{s}_\beta$ in a point of a gravitational field is related to a variation of the product $N.\vec{s}_g$ in the vicinity of that point.*

We consider again $\vec{E}_g$ and $\vec{B}_g$, the contributions to the g-field and to the g-induction in the point *P* of the informatons which - at the moment t - pass in the vicinity of that point with velocity $\vec{c}$ (fig 6).

$$\vec{E}_g = N.\vec{s}_g = -N.s_g.\vec{e}_x \qquad \text{and} \qquad \vec{B}_g = n.\vec{s}_\beta = n.\frac{\vec{c}\times\vec{s}_g}{c} = n.s_g.\sin(\Delta\theta).\vec{e}_z$$

We investigate the relationship between

$$rot\vec{E}_g = \{grad(N)\times\vec{s}_g\} + N.rot(\vec{s}_g) \qquad \text{and} \qquad \frac{\partial \vec{B}_g}{\partial t} = \frac{\partial n}{\partial t}.\vec{s}_\beta + n.\frac{\partial \vec{s}_\beta}{\partial t}$$

- The term $\{grad(N)\times\vec{s}_g\}$ describes the component of $rot\vec{E}_g$ caused by the spatial variation of *N* in the vicinity of *P* when $\Delta\theta$ remains constant.

  *N* has the same value in all points of the infinitesimal surface that, in *P*, is perpendicular to the flow of informatons. So *grad(N)* is parallel to $\vec{c}$ and its magnitude is the increase of the magnitude of *N* per unit length.
  With $N_P = N$, $N_Q = N + dN$ and $PQ = c.dt$, *grad(N)* is determined by:

  $$grad(N) = \frac{N_Q - N_P}{PQ}\frac{\vec{c}}{c} = \frac{dN}{c.dt}.\frac{\vec{c}}{c}$$

  It follows:

  $$grad(N)\times\vec{s}_g = \frac{dN}{c.dt}.\frac{\vec{c}}{c}\times\vec{s}_g = \frac{dN}{c.dt}.\vec{s}_\beta$$

  From the fact that the density of the flow of informatons in *Q* at the moment *t* is equal to the density of that flow in *P* at the moment (*t* - *dt*), it follows:

  If $N_P(t) = N$, then $N_P(t - dt) = N_Q(t) = N + dN$

  The rate at which $N_P$ changes at the moment *t* is:

$$\frac{\partial N}{\partial t}=\frac{N_P(t)-N_P(t-dt)}{dt}=-\frac{dN}{dt}$$

And since: $\frac{N}{c}=n$: $\qquad \frac{1}{c}\frac{dN}{dt}=-\frac{1}{c}\frac{\partial N}{\partial t}=-\frac{\partial n}{\partial t}$

We conclude (*I*):

$$grad(N)\times\vec{s}_g=-\frac{\partial n}{\partial t}.\vec{s}_\beta$$

- The term $\{N.rot(\vec{s}_g)\}$ describes the component of $rot\vec{E}_g$ caused by the spatial variation of $\Delta\theta$ - the orientation of the g-spinvector in the vicinity of *P* - when *N* remains constant.

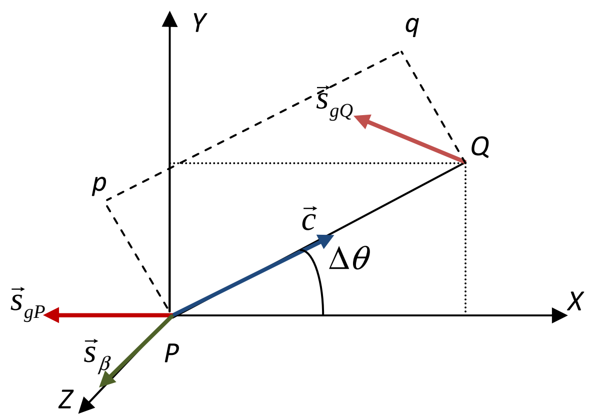


Fig 7

At the moment *t*, $(\Delta\theta)_P$ - the characteristic angle of the informatons that pass in *P* - differs from $(\Delta\theta)_Q$ - the characteristic angle of the informatons that pass in *Q*.
If $(\Delta\theta)_P = \Delta\theta$, than $(\Delta\theta)_Q = \Delta\theta + d(\Delta\theta)$ (fig 7).

For the calculation of $rot(\vec{s}_g)$, we calculate $\oint\vec{s}_g.\vec{dl}$ along the closed path *PQqpP* that encircles the area *dS = PQ.Pp = c.dt.Pp*. (*PQ* and *qp* are parallel to the flow of the informatons, *Qq* and *pP* are perpendicular to it.

$$N.rot(\vec{s}_g)=N.\frac{\oint\vec{s}_g.\vec{dl}}{dS}.\vec{e}_z=N.\frac{s_g.\sin\{\Delta\theta+d(\Delta\theta)\}.Qq-s_g.\sin(\Delta\theta).Pp}{c.dt.Pp}.\vec{e}_z$$

From the fact that the characteristic angle of the informatons in *Q* at the moment *t* is equal to the characteristic angle of the informatons in *P* at the moment (*t - dt*), it follows:

If $(\Delta\theta)_P(t) = \Delta\theta$, then $(\Delta\theta)_P(t-dt) = (\Delta\theta)_Q(t) = \Delta\theta + d(\Delta\theta)$

The rate at which $\sin(\Delta\theta)$ in *P* changes at the moment *t*, is:

$$\frac{\partial\{\sin(\Delta\theta)\}}{\partial t}=\frac{\sin(\Delta\theta)-\sin\{\Delta\theta+d(\Delta\theta)\}}{dt}=-\frac{d\{\sin(\Delta\theta)\}}{dt}$$

And since *N = c.n* , we obtain (*II*):

$$N.rot(\vec{s}_g)=N.s_g.\frac{\sin\{\Delta\theta+d(\Delta\theta)\}-\sin(\Delta\theta)}{c.dt}=\frac{\partial}{\partial t}\{n.s_g.\sin(\Delta\theta).\vec{e}_z\}=-n.\frac{\partial\vec{s}_\beta}{\partial t}$$

Combining the results (*I*) and (*II*), we obtain:

$$rot\vec{E}_g=grad(N_g)\times\vec{s}_g+N_g.rot(\vec{s}_g)=-(\frac{\partial n_g}{\partial t}.\vec{s}_\beta+n_g.\frac{\partial\vec{s}_\beta}{\partial t})=-\frac{\partial\vec{B}_g}{\partial t}$$

The relation $rot\vec{E}_g=-\frac{\partial\vec{B}_g}{\partial t}$ implies (theorem of Stokes [4]): *In a gravitational field, the rate at which the surface integral of $\vec{B}_g$ over a surface S changes is equal and opposite to the line integral of $\vec{E}_g$ over its boundery L:*

$$\oint\vec{E}_g.\overrightarrow{dl}=-\iint_S\frac{\partial\vec{B}_g}{\partial t}.\overrightarrow{dS}=-\frac{\partial}{\partial t}\iint_S\vec{B}_g.\overrightarrow{dS}=-\frac{\partial\Phi_b}{\partial t}$$

The orientation of the surface vector $\overrightarrow{dS}$ is linked to the orientation of the path on *L* by the “rule of the corkscrew”. $\Phi_b=\iint_S\vec{B}_g.\overrightarrow{dS}$ is called the “b-flux through *S*”.

**4. In a matter free point *P* of a gravitational field, the spatial variation of $\vec{B}_g$ and the rate at which $\vec{E}_g$ is changing are connected by the relation:**

$$rot\vec{B}_g=\frac{1}{c^2}\frac{\partial\vec{E}_g}{\partial t}$$

*This statement 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 variation of the product $n.\vec{s}_g$ in the vicinity of that point.*

We consider again $\vec{E}_g$ and $\vec{B}_g$, the contributions of the informatons which - at the moment t - pass through a point *P* with velocity $\vec{c}$ to the g-field and to the g-induction in that point (fig 7).

$$\vec{E}_g=N.\vec{s}_g=-N.s_g.\vec{e}_x \quad \text{and} \quad \vec{B}_g=n.\vec{s}_\beta=n.\frac{\vec{c}\times\vec{s}_g}{c}=n.s_g.\sin(\Delta\theta).\vec{e}_z$$

And we note first that $\vec{s}_g = -s_g.\vec{e}_x$ and that $\dfrac{\partial \vec{s}_g}{\partial t} = s_g.\dfrac{\partial(\Delta\theta)}{\partial t}.\vec{e}_y$

We investigate the relationship between

$$rot\vec{B}_g = \{grad(n) \times \vec{s}_\beta\} + n.rot(\vec{s}_\beta) \qquad \text{and} \qquad \frac{\partial \vec{E}_g}{\partial t} = \frac{\partial N}{\partial t}.\vec{s}_g + N.\frac{\partial \vec{s}_g}{\partial t}$$

***1°. First we calculate*** $rot\vec{B}_g$ **:**

$$rot\vec{B}_g = \{grad(n) \times \vec{s}_\beta\} + n.rot(\vec{s}_\beta)$$

- The term $\{grad(n) \times \vec{s}_\beta\}$ describes the component of $rot\vec{B}_g$ caused by the spatial variation of *n* in the vicinity of *P* when $\Delta\theta$ remains constant.

  *n* has the same value in all points of the infinitesimal surface that, in *P*, is perpendicular to the flow of informatons. So *grad(n)* is parallel to $\vec{c}$ and its magnitude is the increase of the magnitude of *n* per unit length.

  With $n_P = n$, $n_Q = n + dn$ and $PQ = c.dt$ , *grad(n)* is determined by:

$$grad(n) = \frac{n_Q - n_P}{PQ}\frac{\vec{c}}{c} = \frac{dn}{c.dt}.\frac{\vec{c}}{c}$$

  The vector $\{grad(n) \times \vec{s}_\beta\}$ is perpendicular to het plane determined by $\vec{c}$ and $\vec{s}_\beta$. So, it lies in the *XY*-plane and is there perpendicular to $\vec{c}$. Taking into account the definition of vectorial product, we obtain (fig 7):

$$grad(n) \times \vec{s}_\beta = -\frac{dn}{c.dt}.s_\beta.\vec{e}_{\perp c} = -\frac{dn}{c.dt}.s_g.\sin(\Delta\theta).\vec{e}_{\perp c}$$

  From the fact that the density of the cloud of informatons in *Q* at the moment *t* is equal to the density of that cloud in *P* at the moment (*t* - *dt*), it follows:

  If $n_P(t) = n$, then $n_P(t - dt) = n_Q(t) = n + dn$

  The rate at which $n_P$ changes at the moment *t* is:

$$\frac{\partial n}{\partial t} = \frac{1}{c}.\frac{\partial N}{\partial t} = \frac{n_P(t) - n_P(t-dt)}{dt} = \frac{n_P(t) - n_Q(t)}{dt} = -\frac{dn}{dt}$$

  And, taking into account that $n = \dfrac{N}{c}$, we obtain (*I*)

$$grad(n) \times \vec{s}_{\beta} = \frac{1}{c}.\frac{\partial n}{\partial t}.s_g.\sin(\Delta\theta).\vec{e}_{\perp c} = \frac{1}{c^2}.\frac{\partial N}{\partial t}.s_g.\sin(\Delta\theta).\vec{e}_{\perp c}$$

- The term $\{n.rot(\vec{s}_{\beta})\}$ is the component of $rot\vec{B}_g$ caused by the spatial variation of $\vec{s}_{\beta}$ in the vicinity of *P* when *n* remains constant. The fact that $\vec{s}_{\beta Q} \neq \vec{s}_{\beta P}$ at the moment *t,* follows from the fact that, at that moment, $(\Delta\theta)_P$ - the characteristic angle of the informatons that pass in *P* - differs from $(\Delta\theta)_Q$ - the characteristic angle of the informatons that pass in *Q*.

If $(\Delta\theta)_P = \Delta\theta$, than $(\Delta\theta)_Q = \Delta\theta + d(\Delta\theta)$ (fig 7)

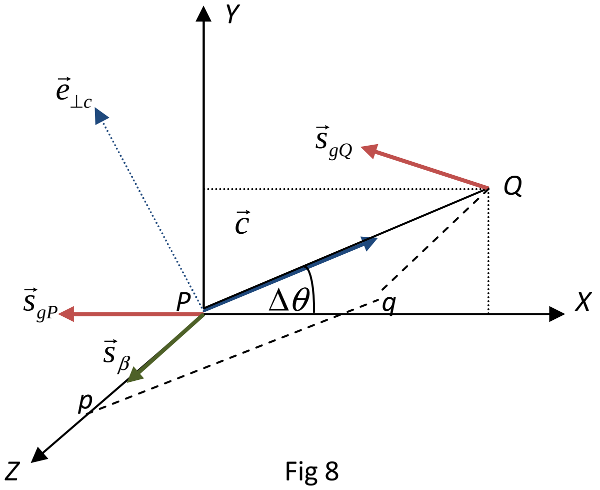


Fig 8

For the calculation of $rot(\vec{s}_g)$, we calculate $\oint \vec{s}_{\beta}.\vec{dl}$ along the closed path *PpqQP* that encircles the area *dS = PQ.Pp = c.dt.Pp*. (*PQ* and *pq* are parallel to the flow of the informatons, *qQ* and *Pp* are perpendicular to it (fig 8):

$$rot(\vec{s}_{\beta}) = \frac{\oint \vec{s}_{\beta}.\vec{dl}}{dS}.\vec{e}_{\perp c} = \frac{s_g.\sin(\Delta\theta).Pp - s_g.\sin\{(\Delta\theta) + d(\Delta\theta)\}.qQ}{c.dt.Pp}.\vec{e}_{\perp c} = -s_g \frac{d\sin(\Delta\theta)}{c.dt}.\vec{e}_{\perp c}$$

From the fact that the characteristic angle of the informatons in *Q* at the moment *t* is equal to the characteristic angle of the informatons in *P* at the moment (*t - dt*), it follows:

If $(\Delta\theta)_P(t) = \Delta\theta$, then $(\Delta\theta)_P(t - dt) = (\Delta\theta)_Q(t) = \Delta\theta + d(\Delta\theta)$

The rate at which $\sin(\Delta\theta)$ in *P* changes at the moment *t*, is:

$$\frac{\partial\{\sin(\Delta\theta)\}}{\partial t} = \frac{\sin(\Delta\theta) - \sin\{\Delta\theta + d(\Delta\theta)\}}{dt} = -\frac{d\{\sin(\Delta\theta)\}}{dt}$$

Further : $\frac{\partial}{\partial t}\{\sin(\Delta\theta)\} = \cos(\Delta\theta).\frac{\partial(\Delta\theta)}{\partial t}$ and $n = \frac{N}{c}$

Finally, we obtain (*II*): $n.rot(\vec{s}_\beta) = \frac{1}{c^2}.N.s_g.\cos(\Delta\theta).\frac{\partial(\Delta\theta)}{\partial t}.\vec{e}_{\perp c}$

Combining the results (*I*) and (*II*), we obtain:

$$rot\vec{B}_g = \frac{1}{c^2}.\{\frac{\partial N_g}{\partial t}s_g.\sin(\Delta\theta) + N_g.s_g.\cos(\Delta\theta).\frac{\partial(\Delta\theta)}{\partial t}\}.\vec{e}_{\perp c}$$

***2°. Next we calculate*** $\frac{\partial \vec{E}_g}{\partial t}$ **:**

$$\frac{\partial \vec{E}_g}{\partial t} = \frac{\partial N}{\partial t}.\vec{s}_g + N.\frac{\partial \vec{s}_g}{\partial t} = -\frac{\partial N}{\partial t}.s_g.\vec{e}_x + N.s_g.\frac{\partial(\Delta\theta)}{\partial t}.\vec{e}_y$$

Taking into account:

$$\vec{e}_x = \cos(\Delta\theta).\vec{e}_c - \sin(\Delta\theta).\vec{e}_{\perp c} \quad \text{and} \quad \vec{e}_y = \sin(\Delta\theta).\vec{e}_c + \cos(\Delta\theta).\vec{e}_{\perp c}$$

we obtain:

$$\frac{\partial \vec{E}_g}{\partial t} = \left[-\frac{\partial N}{\partial t}.s_g.\cos(\Delta\theta) + N.s_g.\frac{\partial(\Delta\theta)}{\partial t}.\sin(\Delta\theta)\right].\vec{e}_c + \left[\frac{\partial N}{\partial t}.s_g.\sin(\Delta\theta) + N.s_g.\frac{\partial(\Delta\theta)}{\partial t}.\cos(\Delta\theta)\right].\vec{e}_{\perp c}$$

From the first law of the gravitational field, it follows that the component in the direction of $\vec{e}_c$ of $\frac{\partial \vec{E}_g}{\partial t}$ is zero. Indeed.

- We know (4.1.3): $grad(N) = -\frac{1}{c^2}.\frac{\partial N}{\partial t}.\vec{c}$ , so:

$$grad(N).\vec{s}_g = \frac{1}{c}.\frac{\partial N}{\partial t}s_g.\cos(\Delta\theta) \quad (III)$$

- We determine $div(\vec{s}_g) = \frac{\oiint \vec{s}_g.\overrightarrow{dS}}{dV}$ (*IV*). For that purpose, we calculate the double integral over the closed surface *S* formed by the infinitesimal surfaces *dS* which are in *P* and *Q* perpendicular to the flow of informatons (perpendicular to $\vec{c}$) and by the tube which connects the edges of these surfaces (and that is parallel to $\vec{c}$).
  *dV =c.dt.dS* is the infinitesimal volume enclosed by *S*:

$$\frac{\oiint \vec{s}_g.\overrightarrow{dS}}{dV}=\frac{s_g.dS.\cos(\Delta\theta)-s_g.dS.\cos\{\Delta\theta+d(\Delta\theta)\}}{dS.c.dt}=-\frac{1}{c}.s_g.\frac{d\{\cos(\Delta\theta)\}}{dt}=-\frac{1}{c}.s_g.\sin(\Delta\theta).\frac{\partial(\Delta\theta)}{\partial t}$$

So (*IV*):

$$N.div(\vec{s}_g)=-\frac{1}{c}.N.s_g.\sin(\Delta\theta).\frac{\partial(\Delta\theta)}{\partial t}$$

According to the first law of the gravitational field (V):

$$-div\vec{E}_g=-div(N.\vec{s}_g)=-grad(N).\vec{s}_g-N.div(\vec{s}_g)=0$$

Substitution of (*III*) and (*IV*) in (*V*):

$$-div\vec{E}_g=-\frac{1}{c}.\frac{\partial N}{\partial t}.s_g.\cos(\Delta\theta)+\frac{1}{c}.N.s_g.\sin(\Delta\theta).\frac{\partial(\Delta\theta)}{\partial t}=0$$

So, the component of $\frac{\partial\vec{E}_g}{\partial t}$ In the direction of $\vec{e}_{\perp c}$ is zero, and:

$$\frac{\partial\vec{E}_g}{\partial t}=\{\frac{\partial N}{\partial t}.s_g.\sin(\Delta\theta)+N.s_g.\frac{\partial(\Delta\theta)}{\partial t}.\cos(\Delta\theta)\}.\vec{e}_{\perp c}$$

**3°. Conclusion:** From 1° en 2° follows:

$$rot\vec{B}_g=\frac{1}{c^2}\frac{\partial\vec{E}_g}{\partial t}$$

This relation implies (theorem of Stokes): In a gravitational field, the rate at which the surface integral of $\vec{E}_g$ over a surface *S* changes is proportional to the line integral of $\vec{B}_g$ over its boundery *L:*

$$\oint\vec{B}_g.\overrightarrow{dl}=\frac{1}{c^2}\iint_S\frac{\partial\vec{E}_g}{\partial t}.\overrightarrow{dS}=\frac{1}{c^2}\frac{\partial}{\partial t}\iint_S\vec{E}_g.\overrightarrow{dS}=\frac{1}{c^2}\frac{\partial\Phi_e}{\partial t}$$

The orientation of the surface vector $\overrightarrow{dS}$ is linked to the orientation of the path on *L* by the "rule of the corkscrew". $\Phi_e=\iint_S\vec{E}_g.\overrightarrow{dS}$ is called the "e-flux through *S*".

## 4.2. Relations between $\vec{E}_g$ and $\vec{B}_g$ in a point of a gravitational field

The volume-element in a point *P* inside a mass continuum is in any case an emitter of g-information and, if the mass is in motion, also a source of β-information. According to 2.3 , the instantenuous value of $\rho_G$ - the mass density in *P* - contributes to the instantaneous value of $div\vec{E}_g$ in that point with an amount $-\frac{\rho_G}{\eta_0}$; and according to 3.7 the instantaneous value of $\vec{J}_G$ - the mass flow density - contributes to the instantaneous value of $rot\vec{B}_g$ in *P* with an amount $-\nu_0.\vec{J}_G$ (3.7).

Generally, in a point of a gravitational field - linked to an inertial reference frame ***O*** - one must take into account the contributions of the local values of $\rho_G(x,y,z;t)$ and of $\vec{J}_G(x,y,z;t)$ . This results in the generalization and expansion of the laws in a mass free point. By superposition we obtain:

**1. In a point *P* of a gravitational field, the spatial variation of $\vec{E}_g$ obeys the law:**

$$div\vec{E}_g = -\frac{\rho_G}{\eta_0}$$

In integral form:

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

**2. In a point *P* of a gravitational field, the spatial variation of $\vec{B}_g$ obeys the law:**

$$div\vec{B}_g = 0$$

In integral form:

$$\Phi_b = \oiint_S \vec{B}_g.\overrightarrow{dS} = 0$$

**3. In a point *P* of a gravitational field, the spatial variation of $\vec{E}_g$ and the rate at which $\vec{B}_g$ is changing are connected by the relation:**

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

In integral form:

$$\oint \vec{E}_g.\overrightarrow{dl} = -\iint_S \frac{\partial\vec{B}_g}{\partial t}.\overrightarrow{dS} = -\frac{\partial}{\partial t}\iint_S \vec{B}_g.\overrightarrow{dS} = -\frac{\partial\Phi_b}{\partial t}$$

**4. In a point *P* of a gravitational field, the spatial variation of $\vec{B}_g$ and the rate at which $\vec{E}_g$ is changing are connected by the relation:**

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

In integral form:

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

*These are the laws of Heaviside-Maxwell or the laws of gravitoelectromagnetism.*

## V. The interaction between masses

## 5.1. The 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 in the following postulate.

### *5.1.1. The postulate of the gravitational action*

A free point mass *m* in a point of a gravitational field acquires an acceleration $\vec{a} = \vec{E}_g$ so that the characteristic symmetry of the g-information cloud in its direct vicinity is conserved.

A point mass who is anchored in a gravitational field cannot accelerate. In that case it *tends* to move.

We can conclude that:

*A point mass anchored in a point of a 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 $\vec{E}_g$.*

### *5.1.2. The concept force - the gravitational force*

*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 is proportional to the extent to which the characteristic symmetry - in the vicinity of *P* - of the gravitational field around *m* is disturbed by the extern g-field, thus to the value of $\vec{E}_g$ in *P.*
- It depends also on the magnitude of *m*. Indeed, the g-information cloud created and maintained by *m* is more compact if *m* is greater. That implies that the disturbing effect on the spherical symmetry around *m* by the extern g-field $\vec{E}_g$ is smaller when *m* is greater. Thus, to impose the acceleration $\vec{a} = \vec{E}_g$, the action of the gravitational field on *m* must be greater when *m* is greater.

We conclude: *The action that tend to accelerate a point mass m in a gravitational field must be proportional to $\vec{E}_g$, the g-field to which the mass is exposed; and to m, the magnitude of the mass.*

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:

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

A mass anchored in a point *P* cannot accelerate, what implies that the effect of the anchorage must compensate the gravitational force. This 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 that 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.*

Between the gravitational force on a mass *m* and the local field strength exists the following relationship:

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

So, the acceleration imposed to the mass by the gravitational force is:

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

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:

$$\vec{F} = m.\vec{a}$$

### *5.1.3. Newtons universal law of gravitation*

In fig 9 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:

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

This field exerts a gravitational force on $m_2$:

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

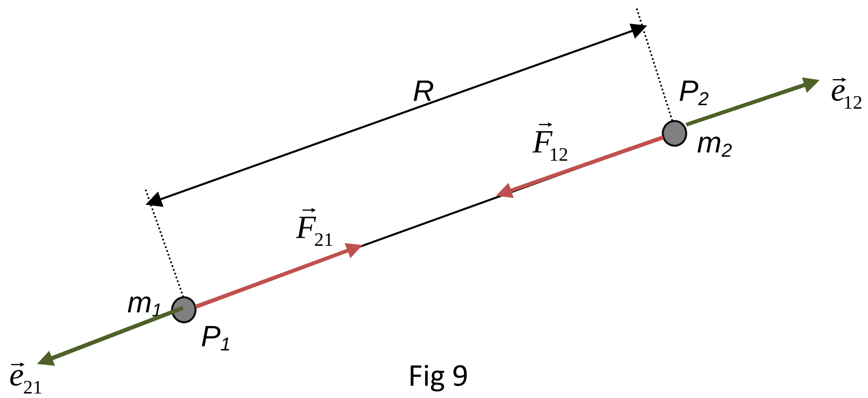


Fig 9

In a similar manner we find $\vec{F}_{21}$:

$$\vec{F}_{21} = -\frac{m_1.m_2}{4.\pi.\eta_0}.\vec{e}_{21} = -\vec{F}_{12}$$

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

## 5.2. The interaction between moving masses

We consider a number of point masses moving relative to an inertial reference frame ***O***. They create and maintain a gravitational field that in each point of the space linked to ***O*** is defined by the vectors $\vec{E}_g$ and $\vec{B}_g$. Each mass is "immersed" in a cloud of informatons carrying both g- and β-information. In each point, except its own position, each mass contributes to the construction of that cloud.

Let us consider the mass *m* that, at the moment *t*, goes through the point *P* with velocity $\vec{v}$.

- If the other masses were not there, the g-field in the vicinity of *m* (the "eigen" g-field of *m*) should be symmetric relative to the carrier of the vector $\vec{v}$. Indeed, the g-spin vectors of the informatons emitted by *m* during the interval (*t - Δt*, *t + Δt*) are all directed to that line. In reality that symmetry is disturbed by the g-information that the other masses send to *P*. $\vec{E}_g$, the instantaneous value of the g-field in *P,* defines the extent to which this occurs.

- If the other masses were not there, the β-field in the vicinity of *m* (the "eigen" β-field of *m*) should "rotate" around the carrier of the vector $\vec{v}$. The vectors of the vector field defined by the vector product of $\vec{v}$ with the g-induction that characterizes the "eigen" β-field of *m,* should - as $\vec{E}_g$ - be symmetric relative to the carrier of the vector $\vec{v}$. In reality this symmetry is disturbed by the β-information send to *P* by the other masses. The vector product $(\vec{v}\times\vec{B}_g)$ of the instantaneous values of the velocity of *m* and of the g-induction at *P*, defines the extent to which this occurs.

So, the *characteristic symmetry* of the cloud of information around a moving mass (the "eigen" gravitational field) is disturbed by $\vec{E}_g$ regarding the "eigen" g-field; and by $(\vec{v}\times B_g)$ regarding the "eigen" β-field.

If it was free to move, the point mass *m* could restore the characteristic symmetry in its direct vicinity by accelerating with an amount $\vec{a}' = \vec{E}_g + (\vec{v}\times\vec{B}_g)$ relative to its "eigen" inertial reference frame* ***O'***. In that manner it should become "blind" for the disturbance of symmetry of the gravitational field in its direct vicinity.

* The "eigen" inertial reference frame ***O'*** of the point mass *m* is the reference frame that at the moment *t* moves relative to ***O*** with the same velocity as *m*.

These insights form the basis of the following postulate.

### *5.2.1. The postulate of the gravitational action*

*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 $\vec{a}'$ :*

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

### *5.2.2. The gravitational force*

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:

$$\boxed{\vec{F}_G = m_0.\left[\vec{E}_g + (\vec{v} \times \vec{B}_g)\right]}$$

*$m_0$* 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***.

The acceleration $\vec{a}'$ of the point mass relative to the eigen inertial reference frame ***O'*** can be decomposed in a tangential ($\vec{a}_T^{'}$) and a normal component ($\vec{a}_N^{'}$).

$$\vec{a}_T^{'} = a_T^{'}.\vec{e}_T \quad \text{en} \quad \vec{a}_N^{'} = a_N^{'}.\vec{e}_N$$

$\vec{e}_T$ and $\vec{e}_N$ are the unit vectors, respectively along the tangent and along the normal to the path of the point mass in ***O'*** (and in ***O***).

We express $a_T^{'}$ en $a_N^{'}$ in function of the characteristics of the motion in the reference system ***O***:

$$a_T^{'} = \frac{1}{(1-\beta^2)^{\frac{3}{2}}}.\frac{dv}{dt} \quad \text{and} \quad a_N^{'} = \frac{v^2}{R.\sqrt{1-\beta^2}}$$

(If *R* is the curvature of the path in ***O***, the curvature in ***O'*** is $R\sqrt{1-\beta^2}$ .)

The gravitational force is:

$$\vec{F}_G = m_0.\vec{a}' = m_0.(a_T^{'}.\vec{e}_T + a_N^{'}.\vec{e}_N) = m_0.\left[\frac{1}{(1-\beta^2)^{\frac{3}{2}}}.\frac{dv}{dt}.\vec{e}_T + \frac{1}{(1-\beta^2)^{\frac{1}{2}}}.\frac{v^2}{R}.\vec{e}_N\right] = \frac{d}{dt}\left[\frac{m_0}{\sqrt{1-\beta^2}}.\vec{v}\right]$$

Finally, with:

$$\frac{m_0}{\sqrt{1-\beta^2}}.\vec{v} = \vec{p}$$

We obtain:

$$\boxed{\vec{F}_G = \frac{d\vec{p}}{dt}}$$

$\vec{p}$ is the linear momentum of the point mass relative to the inertial reference frame ***O***. It is the product of its relativistic mass $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$ with its velocity $\vec{v}$ in ***O***.

The linear momentum of a moving point mass is a measure for its inertia, for its ability to persist in its dynamic state.

### *5.2.3. The equivalence mass-energy*

The instantaneous value of the linear momentum $\vec{p} = m.\vec{v}$ of the point mass $m_0$, that freely moves relative to the inertial reference frame ***O***, and the instantaneous value of the force $\vec{F}$ that acts on it, are related by:

$$\vec{F} = \frac{d\vec{p}}{dt}$$

The elementary vectorial displacement $d\vec{r}$ of $m_0$ during the elementary time interval *dt* is:

$$d\vec{r} = \vec{v}.dt$$

And the elementary work done by $\vec{F}$ during *dt* is (7):

$$dW = \vec{F}.\overrightarrow{dr} = \vec{F}.\vec{v}.dt = \vec{v}.d\vec{p}$$

With $\vec{p} = m.\vec{v} = \frac{m_0}{\sqrt{1-(\frac{v}{c})^2}}.\vec{v}$, this becomes:

$$dW = \frac{m_0.v.dv}{\left[1-(\frac{v}{c})^2\right]^{\frac{3}{2}}} = d\left[\frac{m_0}{\sqrt{1-(\frac{v}{c})^2}}.c^2\right] = d(m.c^2)$$

The work done on the moving point mass equals, by definition, the increase of the energy of the mass. So, $d(m.c^2)$ is the increase of the energy of the mass and $m.c^2$ is the energy represented by the mass.

We conclude: *A point mass with relativistic mass m is equivalent to an amount of energy of* $m.c^2$.

### *5.2.4. The interaction between two uniform linear moving point masses*

#### 5.2.4.1. The interaction between two moving point masses according to S.R.T.

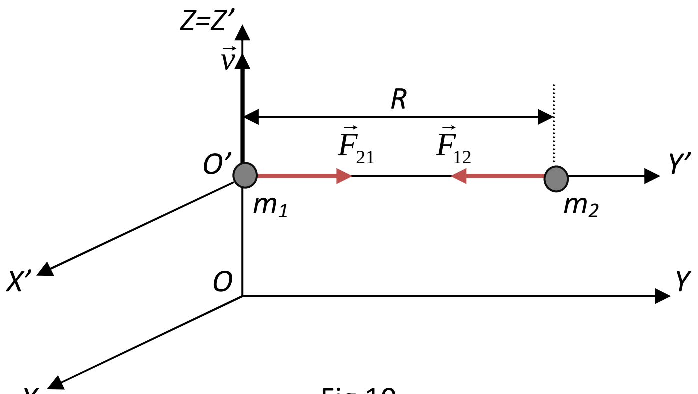


Fig 10

Two material points with rest masses $m_1$ and $m_2$ (fig 10) 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 are at rest, they don't move. According to Newton's law of universal gravitation, they exert on each other equal but opposite forces:

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

In ***O*** both masses are moving with constant speed $v$ in the direction of the *Z*-axis. From the transformation equations between an inertial frame ***O*** and another inertial frame ***O'***, in which a point mass experiencing a force *F'* is instantaneously at rest(5), we can immediately deduce the force $F$ that the point masses exert on each other in ***O***:

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

**5.2.4.2. The interaction between two moving point masses according to G.E.M.**

In 3.5, it is shown that the gravitational field ($\vec{E}_g, \vec{B}_g$) of a particle with rest mass $m_0$ that is moving with constant velocity $\vec{v} = v.\vec{e}_z$ along the *Z*-axis of an inertial frame ***O*** (fig 10) is determined by:

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

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

with $\beta = \frac{v}{c}$, the dimensionless speed of $m_0$. One can verify that these expressions satisfy the laws of G.E.M.

In the inertial frame ***O***, the masses $m_1$ and $m_2$ are moving in the direction of the *Z*-axis with speed $v$. $m_2$ moves through the G.E.M. field generated by $m_1$, and $m_1$ moves through that generated by $m_2$.

According the above formulas, the magnitude of the G.E.M. field created and maintained by $m_1$ at the position of $m_2$ is determined by:

$$E_{g2} = \frac{m_1}{4\pi\eta_0 R^2}.\frac{1}{\sqrt{1-\beta^2}} \quad \text{and} \quad B_{g2} = \frac{m_1}{4\pi\eta_0 R^2}.\frac{1}{\sqrt{1-\beta^2}}.\frac{v}{c^2}$$

And according to the force law $\vec{F}_G = m_0.\left[\vec{E}_g + (\vec{v}\times\vec{B}_g)\right]$, $F_{12}$, the magnitude of the force exerted by the gravitaltional field ($\vec{E}_{g2}, \vec{B}_{g2}$) on $m_2$ - this is the attraction force of $m_1$ on $m_2$ - is:

$$F_{12} = m_2.(E_{g2} - v.B_{g2})$$

After substitution:

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

In the same way we find: $F_{21} = \frac{1}{4\pi\eta_0}.\frac{m_1 m_2}{R^2}.\sqrt{1-\beta^2} = F_{12}^{'}.\sqrt{1-\beta^2}$

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

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

This result perfectly agrees with that based on S.R.T. (§5.2.4.1).

We can also conclude that the component of the gravitational force due to the g-induction is $\beta^2$ times smaller than that due to the g-field. *This implies that, for speeds much smaller than the speed of light, the effects of het 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 is responsible for deviations (as the advance of Mercury Perihelion) of the real orbits with respect to these predicted by that theory [(8)].

**5.2.4.3. The interaction between two moving point masses according to linearized G.R.T.**

For weak gravitational fields, the linearized form of G.R.T. turns out to be very similar to G.E.M.[(3)(8)]. The laws of the G.E.M field derived from the linear approximation of G.R.T. are the same as those derived from the dynamics of the informatons. However this does not apply to the force law. Indeed if one accepts that gravitational phenomena propagate with the speed *c*, according to linearized G.R.T. the gravitational force $\vec{F}_G$ must be expressed as:

$$\vec{F}_G = m_0.\left[\vec{E} + 2.(\vec{v}\times\vec{B})\right].$$

Starting from this force law, we become an expression for the interaction between the moving masses that is not consistent with S.R.T.

## VI. THE NATURE OF THE GRAVITATIONAL FIELD

According to the postulate of the emission of information, the gravitational field of a mass at rest is characterized by the following statement.

*1.* ***Gravitational phenomena propagate with the speed of light.*** *This is a direct consequence of the fact that - relative to an inertial reference frame - informatons move at the speed of light.*

*2.* ***The gravitational field is granular.*** *This is evident, because the elementary building blocks - the informatons - are g-information grains. Macroscopically, the granular character of the field can be neglected because of the high density of the cloud of informatons.*

*3.* ***The gravitational field continuously regenerates.*** *The informatons that constitute the field in ΔV - any volume element of space - are continuously replaced: indeed, they fly through the volume element. So, ΔV contains g-information that is continuously regenerating.*

*4.* ***The gravitational field shows fluctuations.*** *Because the emission of informatons by m is a stochastic process (* $\dot{N} = K.m$ *is the average emission rate), the rate at which informatons cross an elementary surface that in P is perpendicular to the direction of movement, fluctuates. This implies that there is noise on the g-field* $\vec{E}_g$.

*5.* ***The gravitational field expands with the speed of light.*** *The surface of the spherical cloud of informatons that is generated and maintained by m moves away from the emitter at the speed of light.*

*6.* ***In a gravitational field, there is conservation of g-information.*** *The source of g-information is mass. In a point P of an inertial reference frame, a mass continuum is macroscopically characterized by the mass density* $\rho_G$*. The rate at which g-information flows out through a closed surface equals the rate at which g-information is generated in the space enclosed by that surface. Mathematically, this can be expressed as a relation between the spatial variation of the g-field* $\vec{E}_g$ *and the mass density* $\rho_G$ *in P:* $div\vec{E}_g = -\frac{\rho_G}{\eta_0}$*.*

Complementary, the following statements are valid for the gravitational field of a uniformly moving mass:

*7.* ***The g-field*** $\vec{E}_g$ ***of a point mass that is moving with constant velocity always points to the actual position of that mass.*** *This is an obvious consequence of the fact that the g-spin vector of the informatons emitted by that mass always points to the actual position of the emitter. This implies that in a point of a gravitational field generated by a moving mass m, the g-field does not point in the direction in which m is seen (that is its light-delayed position) , but in that where m really is.*

*8.* ***The g-induction*** $\vec{B}_g$ ***shows fluctuations****. The reason for this phenomenon is the same as that for the phenomenon mentioned under 4.*

*9.* ***From the definition of the β-index, it follows****:* $div\vec{B}_g = 0$*. This relation is the expression of the fact that the β-index* $\vec{s}_\beta$ *of an informaton is always perpendicular to its velocity* $\vec{c}$ *.*

*10.****The spatial variation of the g-induction in a point of a gravitational field depends on the density of the mass flow*** $\vec{J}_G$ ***in that point:*** $rot\vec{B}_g = -\nu_0.\vec{J}_G$ *with* $\nu_0 = \frac{1}{\eta_0.c^2}$*. The source of β-information is moving mass. In a point of an inertial reference frame, a continuous mass flow is macroscopically characterized by the mass flow density* $\vec{J}_G$*. The relation* $rot\vec{B}_g = -\nu_0.\vec{J}_G$ *expresses how the generation of β-information in a point is affecting the gravitational induction in that point.*

The definitions of $\vec{E}_g$ and of $\vec{B}_g$ can be extended to the situation where the gravitational field is generated by a set of whether or not - uniformly or not uniformly - moving point masses or by a whether or not moving mass continuum. In that general case, the statements 1 - 10 stay valid. In addition:

*11.**From the dynamics of an informaton, it follows that in empty space**:*

- *11,a.* $rot\vec{E}_g = -\dfrac{\partial \vec{B}_g}{\partial t}$
- *11,b.* $rot\vec{B}_g = \dfrac{1}{c^2}.\dfrac{\partial \vec{E}_g}{\partial t}$

*12.**There is a perfect isomorphism between the gravitational field and the electromagnetic field.** From 6, 9, 10, 11, it follows that in a point P situated in a mass continuum that is characterized by the mass density* $\rho_G$ *and the mass flow density* $\vec{J}_G$, $\vec{E}_g$ *and* $\vec{B}_g$ *satisfy the following equations:*

- *12,1.* $div\vec{E}_g = -\dfrac{\rho_G}{\eta_0}$
- *12,2.* $div\vec{B}_g = 0$
- *12,3.* $rot\vec{E}_g = -\dfrac{\partial \vec{B}_g}{\partial t}$
- *12,4.* $rot\vec{B}_g = -\nu_0.\vec{J}_G + \dfrac{1}{c^2}.\dfrac{\partial \vec{E}_g}{\partial t}$

In an inertial reference system, the gravitational interaction between masses is determined by the force law of G.E.M. that is analogue to the force law of E.M. It is the expression of the fact that a point mass tends to become blind for the flow of information generated by other point masses.

*13. **A point mass with rest mass $m_0$ that moves with velocity** $\vec{v}$ **through a gravitational field (** $\vec{E}_g, \vec{B}_g$ **) experiences a force*** $\vec{F}_G = m_0.\left[\vec{E}_g + (\vec{v} \times \vec{B}_g)\right]$.

## EPILOGUE

1. The theory of informatons is also able to explain the phenomena and the laws of electromagnetism [(6), (9)]. It is sufficient to add the following rule at the postulate of the emission of informatons:

*Informatons emitted by an electrically charged point mass (a "point charge" q) at rest in an inertial reference frame, carry an attribute referring to the charge of the emitter, namely the e-spin vector. e-spin vectors are represented as* $\vec{s}_e$ *and defined by:*

1. *The e-spin vectors 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).*

2. *$s_e$, the magnitude of an e-spin vector depends on Q/m, the charge per unit of mass of the emitter. It is defined by:*

$$s_e = \frac{1}{K.\varepsilon_0}.\frac{Q}{m} = 8{,}32.10^{-40}.\frac{Q}{m} N.m^2.s.C^{-1}$$

($\varepsilon_0 = 8{,}85.10^{-12} F/m$ is the permittivity constant).

Consequently (cfr § III) , the informatons emitted by a moving point charge *q* have in the fixed point *P* - defined by the time dependant position vector $\vec{r}$ (cfr fig 5) - two attributes that are in relation with the fact that *q* is a moving point charge: their e-spin vector $\vec{s}_e$ and their b-vector $\vec{s}_b$ :

$$\vec{s}_e = \frac{q}{m}.\frac{1}{K.\varepsilon_0}.\vec{e}_r = \frac{q}{m}.\frac{1}{K.\varepsilon_0}.\frac{\vec{r}}{r} \qquad \text{and} \qquad \vec{s}_b = \frac{\vec{c}\times\vec{s}_e}{c} = \frac{\vec{v}\times\vec{s}_e}{c}$$

Macroscopically, these attributes manifest themselves as, respectively the *electric field strength* (the *e-field*) $\vec{E}$ and the *magnetic induction* (the *b-induction*) $\vec{B}$ in *P*.

2. The assumption that a photon is nothing else than an informaton transporting an energy package can explain the duality of light [(6), (9) (10)].

*3.* The fact that the "theory of informatons" permits to understand the nature of gravitation and to deduce the laws that govern the gravitational phenomena justifies the hypothesis that "information" is the substance of the gravitational field and it supports the idea that informatons really exist.

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