CHAPTER 4

THE GRAVITATIONAL FIELD OF AN OBJECT MOVING WITH CONSTANT VELOCITY

To characterize the gravitational field of a moving object we need a vector field with two components: the *g-field* $\vec{E}_g$ and the *g-induction* $\vec{B}_g$ that respectively define the density of the flow of g-information and the density of the cloud of β-information at every point of space and time. We show that the gravitational field of an object moving with constant velocity is governed by the Maxwell-Heaviside equations and that these equations in no way lead to the conclusion that there are causal relations between the changes in time and the spatial variations of $\vec{E}_g$ and $\vec{B}_g$. The gravitational field is a dual entity having a field and an induction component.

4.1 INTRODUCTION – REST MASS AND RELATIVISTIC MASS

Additional to the postulate of the emission of informatons, we posit that $\dot{N}$ - the rate at which a particle emits informatons in the space linked to an inertial reference system $\boldsymbol{O}$ – *is independent of the motion of that particle*. Thus $\dot{N}$ is completely defined by the rest mass of the particle:

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

That implies that, if the time t is read on a standard clock anchored to $\boldsymbol{O}$, dN - the number of informatons that during the interval dt is emitted by a (whether or not moving) point mass - is:

$$dN = K.m_0.dt$$

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

An observer in $\boldsymbol{O}$ can also read the time on a clock that is at rest in the inertial reference frame $\boldsymbol{O'}$ (fig 3) whose origin is anchored to the moving point mass and that at the moment $t = 0$ coincides with $\boldsymbol{O}$. Such a clock is moving relative to $\boldsymbol{O}$ with the velocity $\vec{v} = v.\vec{e}_z$, and t' is the time read on that clock (while t is the time read on the standard clock at rest in $\boldsymbol{O}$).

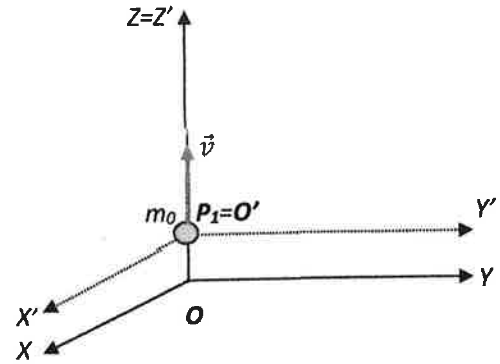

Fig 3

If the clock at rest in ***O*** indicates that the emission of *dN* informatons takes *dt* seconds, the moving clock - the clock coupled to ***O'*** - indicates a time interval of *dt'* seconds for that phenomenon. According to the Lorentz transformation equations[1], the relationship between *dt* and *dt'* is:

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

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 the emission rate determined with the moving clock is:

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

Where

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

is the "relativistic mass" of the moving particle.

We conclude:

*For an observer in **O**, the rate at which a moving object emits informatons is determined by its rest mass when the time is read on a clock at rest in **O**, and by the relativistic mass when the time is read on a moving clock that is anchored to the point mass.*

4.2 THE g-FIELD OF A PARTICLE MOVING WITH CONSTANT VELOCITY

In fig 4,a, we consider a point mass with rest mass m_0 that is moving 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. It is evident that:

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

P is an arbitrary fixed point in ***O***. In ***O***, its position relative to the moving point mass is determined by the time dependent position vector $\vec{r} = \overrightarrow{P_1P}$.

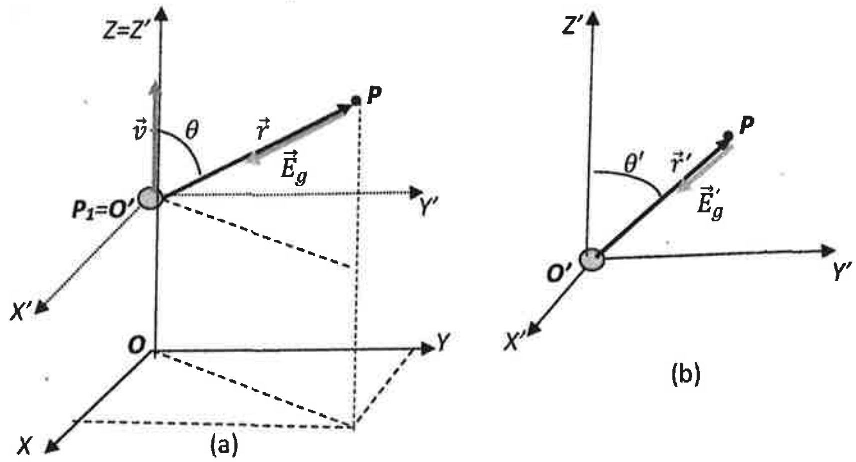

Fig 4

The origin *O'* of the inertial reference frame ***O'*** is anchored to the moving point mass and we assume that $t = t' = 0$ when that particle passes through *O*. Relative to ***O'*** (fig 4,b), the position of the point *P* is determined by the time dependent position vector $\vec{r}' = \overrightarrow{O'P}$

Because it is anchored in the inertial reference frame ***O'***, the emission of informatons by the point mass is, relative to that reference frame, governed by the rules of the postulate of the emission of informatons for a particle at rest. In that context the emission rate is - according to §4.1 - determined by the relativistic mass of the particle. So, relative to ***O'*** we can - in extension of §3.1 - conclude that the density of the flow of g-information at *P* (the g-field) is:

$$\vec{E}'_g = -\frac{m_0}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.\vec{r}\,'$$

With (*x'*, *y'*, *z'*) the Cartesian coordinates of *P* in *O'X'Y'Z'* , the components of $\vec{E}'_g$ in ***O'***, are:

$$E'_{gx'} = -\frac{m_0}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.x'$$

$$E'_{gy'} = -\frac{m_0}{4\pi\eta_0 r'^3}.y'$$

$$E'_{gz'} = -\frac{m_0}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.z'$$

They determine at *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 rates at which g-information is flowing through these different surface elements (the g-fluxes) at *P* are:

$$E'_{gx'}.dy'.dz' = -\frac{m_0.x'}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.dy'.dz'$$

$$E'_{gy'}.dz'.dx' = -\frac{m_0.y'}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.dz'.dx'$$

$$E'_{gz'}.dx'.dy' = -\frac{m_0.z'}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.dx'.dy'$$

And the quantities of g-information flowing during the time interval *dt'* through these different surface elements are:

$$E'_{gx'}.dy'.dz'.dt' = -\frac{m_0.x'}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.dy'.dz'.dt'$$

$$E'_{gy'}.dz'.dx'.dt' = -\frac{m_0.y'}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.dz'.dx'.dt'$$

$$E'_{gz'}.dx'.dy'.dt' = -\frac{m_0.z'}{4\pi\eta_0 r'^3.\sqrt{1-\beta^2}}.dx'.dy'.dt'$$

In the inertial reference system ***O*** these quantities of g-information are, during the time interval *dt*, flowing through the surface elements *dy.dz*, *dz.dx* and *dx.dy* at *P*.

- The Cartesian coordinates of *P* in the frames ***O*** and ***O'*** are related to each other by[1]:

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

- The line elements by: $dx' = dx \qquad dy' = dy \qquad dz' = \frac{dz}{\sqrt{1-\beta^2}}$

- The time elements by: $dt' = dt.\sqrt{1-\beta^2}$

- And further:

$$r' = r.\frac{\sqrt{1-\beta^2.\sin^2\theta}}{\sqrt{1-\beta^2}}$$

Indeed in ***O***:

$$r = \sqrt{x^2+y^2+(z-z_{P_1})^2}, \qquad \sin\theta = \frac{\sqrt{x^2+y^2}}{r} \quad \text{and} \quad \cos\theta = \frac{z-z_{P_1}}{r}$$

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

Expressing *r'* in function of *x*, *y* and *z* we finally obtain:

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

$$= r\frac{\sqrt{1-\beta^2.\sin^2\theta}}{\sqrt{1-\beta^2}}$$

So relative to $\boldsymbol{O}$, the quantities of g-information send by the moving particle in the positive direction through the surface elements *dy.dz*, *dz.dx* and *dx.dy* at *P* are:

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

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

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

And relative to $\boldsymbol{O}$, the rates at which g-information is flowing through these different surface elements (the g-fluxes) at *P* are:

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

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

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

By definition, the densities at *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 particle m_0 at *P* in $\boldsymbol{O}$. So:

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

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

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

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

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

If the speed of the mass is much smaller than the speed of light, this expression reduces to that valid in the case of a mass at rest. This non-relativistic result could directly be obtained if one assumes that the displacement of the point mass during the time interval that the informatons need to move from the emitter to P can be neglected compared to the distance they travel during that period.

4.3 THE EMISSION OF INFORMATONS BY A PARTICLE MOVING WITH CONSTANT VELOCITY

In fig 5 we consider a particle with rest mass m_0 that is moving with constant velocity $\vec{v}$ along the Z-axis of an inertial reference frame $\boldsymbol{O}$. 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 near P, are emitted when m_0 was at P_0. Bridging the distance $P_0P = r_0$ took the time interval $\Delta t = \frac{r_0}{c}$.

• The orientation of the field strength implies that the g-indices of the informatons that at a certain moment pass near P, point to the position of the emitting mass at that moment and not to their light delayed position.

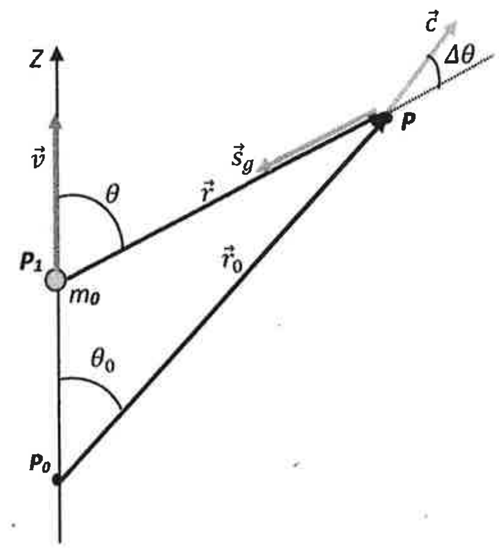

Fig 5

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

1. $\vec{c}$, the velocity of the informatons, points in the direction of their movement, thus along the radius P_0P;

2. $\vec{s}_g$, their g-index, 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, confirmed by the conclusion of §4.2.

The lines carrying $\vec{s}_g$ 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*" or the "*characteristic deviation*". The quantity $s_\beta = s_g . sin(\Delta\theta)$, referring to the speed of its emitter, is called the "*characteristic g-information*" or the "*β -information*" *of* an informaton.

We conclude that an informaton emitted by a moving particle, transports information referring to the velocity of that particle. This information is represented by its "*gravitational characteristic vector*" or its "*β -index*" $\vec{s}_\beta$ that is defined by:

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

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

- Its orientation relative to that plane is defined by the "rule of the corkscrew".
- Its magnitude is: $s_\beta = s_g . sin(\Delta\theta)$, the β *-information* of the informaton.

In the case of fig 5 the β-indices have the orientation of the positive *X*-axis.

Applying the sine-rule to the triangle P_0P_1P, we obtain:

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

From which 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 moving with constant velocity, can also be expressed as:

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

4.4 THE GRAVITIONAL INDUCTION OF A PARTICLE MOVING WITH CONSTANT VELOCITY

We consider again the situation of fig 5. All informatons in dV - the volume element at P - carry both g-information and β-information. The β-information refers to the velocity of the emitting mass and is 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 at 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 cloud of β-information (characteristic information per unit volume) at 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) vectoral quantity - that will be represented by $\vec{B}_g$ - the "*gravitational induction*" or the "*g-induction*"* at P:

- Its magnitude B_g determines the density of the β-information at P;

- Its orientation determines the orientation of the β-indices $\vec{s}_\beta$ of the informatons passing near that point.

So, the g-induction caused by the moving mass m_0 (fig 5) at P 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 at 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 at 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 at P as:

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

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

Taking the result of §4.2 into account, namely:

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

We find:

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

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

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

And finally, we obtain:

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

$\vec{B}_g$ at 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:

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

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

$$\vec{B}_g = \frac{\nu_0.m_0}{4\pi r^3} .(\vec{r} \times \vec{v})$$

This non-relativistic result could directly be obtained if one assumes that the displacement of the point mass during the time interval that the informatons need to move from the emitter to P can be neglected compared to the distance they travel during that period. This means that for situations where $v \ll c$, in the previous calculation the formula

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

can be used to express the g-field.

So if $v \ll c$, $\vec{B}_g$ at 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:

$$B_g = \frac{\nu_0.m_0}{4\pi r^2}.v.\sin\theta$$

4.5 THE GRAVITATIONAL FIELD OF A PARTICLE MOVING WITH CONSTANT VELOCITY

A particle m_0, moving with constant velocity $\vec{v} = v.\vec{e}_z$ along the Z-axis of an inertial reference frame, creates and maintains an expanding 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 vectoral quantities: the gravitational field (short: *g-field*) $\vec{E}_g$ and the gravitational induction♦ (short: *g-induction*) $\vec{B}_g$.

1. With N the density of the flow of informatons at P (the rate per unit area at which the informatons cross an elementary surface perpendicular to the direction of movement), the g-field at 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 at P is not the same as the direction of the flow of informatons.

• Also called: "gravito-electromagnetic field " (GEM field)

♦ Also called: "gravito-magnetic field" (GM field)

2. With n, the density of the cloud of informatons at P (number of informatons per unit volume), the g-induction at 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 can verify (Appendix 1) 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 GEM (Maxwell-Heaviside) in the case of the gravitational field of a particle describing a uniform rectilinear motion. It is important to notice that (3) and (4) express how the respective changes in space and time are linked to each other, and to note that (3) and (4) don't express causal relationships. The gravitational field is a dual entity having a field and an induction component.

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

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

$$\vec{B}_g = \frac{\nu_0.m_0}{4\pi r^3}.(\vec{r}\times\vec{v})$$

4.6 THE GRAVITATIONAL FIELD OF A SET OF PARTICLES MOVING WITH CONSTANT VELOCITIESs

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

1. 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 §3.2 we conclude that the effective g-field $\vec{E}_g$ at P is defined as:

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

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

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

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

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

On the basis of the superposition principle we can conclude that the laws of GEM 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 particles describing uniform rectilinear motions.

4.7 THE GRAVITATIONAL FIELD OF A STATIONARY MASS FLOW

The term "stationary mass flow" refers to 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 at an arbitrary point P is characterized by the flow density $\vec{J}_G$. The magnitude of this vectoral quantity at P equals the rate per unit area at which the mass flows through a surface element that is perpendicular to the flow at 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:

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

So, 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 at a certain 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:

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

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

One can prove[2],[3],[4] that the rules for the time independent g-induction are:

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

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

These are the laws of GEM in the case of the gravitational field of a stationary mass flow.

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