GRAVITATION AND ELECTROMAGNETISM

Introduction to the theory of informatons

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Abstract

In *1748* Georges-Louis Le Sage proposed in his "*Essai sur l'origine des forces mortes*" a mechanical explanation for the phenomenon of gravitational interaction by introducing tiny invisible particles. He inspired many others but it has been shown that kinetic models violate the principle of conservation of energy.

In this article, we propose an explanation of gravitation (and electromagnetism) by introducing *information* as a new physical quantity. By defining it mathematically, the everyday meaning of the term "information" is narrowed to a physical concept that has a specific sense.

We start from the idea that a material object manifests itself in space by emitting *informatons*. Informatons are mass and energy less entities without geometric dimensions that rush away with the speed of light, carrying information about the position and the velocity of the emitter. We show how informatons constitute the gravitational field of an object and how they constitute its electromagnetic field if the emitter is electrically charged. We investigate the analogy gravitation-electromagnetism and the consequences for radiation and waves.

It is an important objective of the "theory of informatons" to contribute to a better understanding of the physics studied in textbooks for a calculus based course for science and engineering students.

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 that object interacts with another object. An observer experiences the masses of objects on hand by the load they exert on him when he manipulates them. Primarily, objects manifest themselves by their "gravity", their "weight". So, the weight of an object on hand is a measure for its mass.

One can compare the mass of an object with a reference mass: the "standard kilogram" which mass is by definition *1 kg*. The quantity of standard kilograms that is equivalent to the matter of an object can be determined with a balance: a balance gives the "mass of the object in *kg*". This physical quantity is presented by *m*. A balance is only suitable if the object can be manipulated. It cannot be used in the case of very large objects (as celestial bodies), nor in the case of very small ones (as elementary particles). A consistent description of nature requires a more fundamental definition of the concept "mass".

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The mass of an (electrically neutral) object manifests itself when that object interacts with another object. A striking and fundamental form of interaction is “gravitation”: material objects (masses) attract each other and if they are free, they move to each other along the straight line that connects them.

If masses can influence each other without touching each other, they must in one way or another exchange data: each mass must emit information relative to its magnitude and its position, and must be able to “interpret” the information emitted by its neighbours. We posit that such information is carried by dot-shaped mass and energy less entities that we call “*informatons*”.

Informatons are defined by two attributes: they rush through space at the speed of light and they have a g-spin: this is a vectorial quantity that has the same magnitude for all informatons and which direction is in relation to the position of the emitter.

The rules for the emission of informatons by a point mass at rest, and the attributes of the informatons are defined by the *postulate of the emission of informatons.*

Contents

In the paragraphs *I, ...,IV* of this paper we study the consequences of the postulate of the emission of informatons for *the gravitational* and in paragraph *V* for *the electromagnetic interactions*. We give a new meaning to the physical entity “*field”* and to the physical quantities that characterize it (*field, induction*). We also deduce the laws to which these quantities are subjected (*laws of Maxwell*) and the rules that manage the mutual forces (*Newton, Coulomb, Lorentz*). We show that there is a great analogy between a gravitational and an electromagnetic field, what implies that the gravitational field has a component that is analogous to the magnetic field.

In the paragraph *VI* we use the “theory of informatons” for the study of *electromagnetic waves and radiation*. We introduce the idea that *photons* are nothing but informatons carrying an energy-packet. This leads to the view that the deflection of light passing through a narrow slit can be understood as the visible effect of the transition of an energy-packet from one informaton to another that crosses its path. Finally we investigate the implications of the *gravity-electromagnetism analogy* for the existence of *gravitational waves and gravitons*.

I. The Gravitational field of a mass at rest

1.1. The postulate of the emission of informatons

The analogy between Newton's universal law of gravitation and Coulomb's law suggests that the mechanisms behind the interactions between masses and those between electrical charges are of the same nature.

With the aim to understand and to describe these mechanisms, 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 with the speed of light (*c*) through space. 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. Informatons emitted by an electrically charged object transport also *e-information*, the cause of the electrical interaction.

The emission of informatons by a point mass (*m*) anchored in an inertial 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. $\dot{N} = \dfrac{dN}{dt}$*, 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:*

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

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

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

C. Informatons emitted by an electrically charged point mass (a "point charge" q), have a second attribute, 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).

1.2. The gravitational field of a point mass

In fig1 we consider an (electrically neutral) point mass that is anchored in the origin of an inertial frame. It continuously sends 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 $\vec{s}_g$:

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

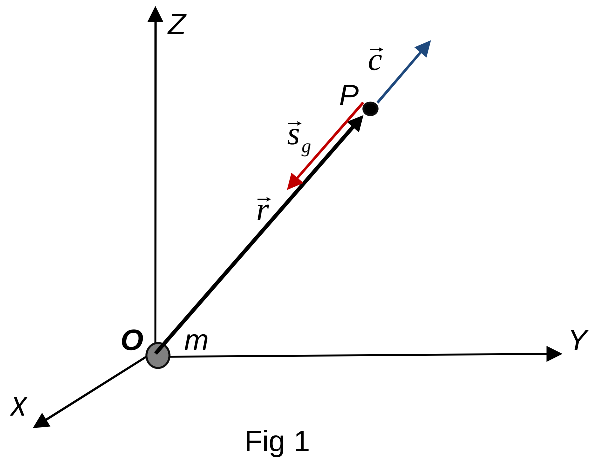


Fig 1

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: 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.

- One can identify the cloud with a *continuum*: each spatial region contains a very large number of informatons: the g-information is like continuously spread over the extent of the region.

We call the cloud of g-information surrounding *m,* the *gravitational field* * or the *g-field* of the point mass *m.*

Through any - even very small - surface in the gravitational field are rushing, without interruption, "countless" informatons: we can describe the motion of g-information through a surface as a continuous *stream* or *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 passing in the vicinity of *P,* characteristic for het gravitational field at that point.

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

* 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:

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

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

We call this quantity the *gravitational field strength* or the *g-field strenght*. In any point of the gravitational field of the point mass *m*, the orientation of $\vec{E}_g$ corresponds with the orientation of the g-spin-vectors of the informatons who are passing by in the vicinity of 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.

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)

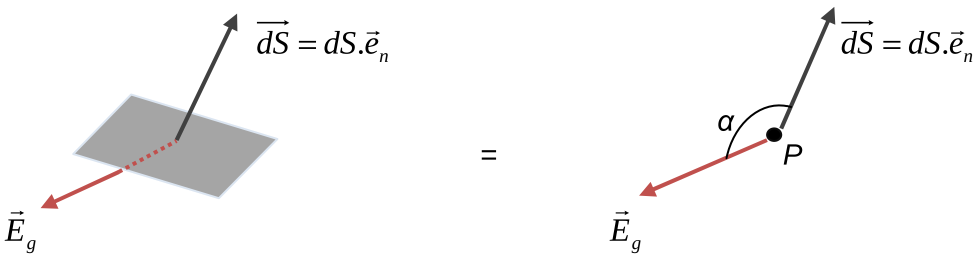


Fig 2,a   Fig 2,b

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. Consequently:

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

1.3. The gravitational field of a set of point-masses

We consider a set of point-masses $m_1,\ldots,m_i,\ldots m_n$ which are anchored in an inertial frame.

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

$d\Phi_g$, the rate at which g-informaton flows, in the sense of the positive normal, through a surface-element *dS* in *P*, 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* (the g-field strenght) in *P* is completely defined by:

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

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

Let us note that the orientation of the effective field strength has no longer a relation with the movement direction of the passing informatons.

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}:

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

1.4. The gravitational field of a mass continuum

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* ρ_G. To define this scalar quantity one considers a volume element *dV* around *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 remains evident that the outwards oriented g-flux through a closed surface only depends on the mass enclosed by the surface. That can be expressed as follows:

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

Furthermore, one can show that:

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

what implies the existence of a gravitational potential function V_g for which: $\vec{E}_g = -gradV_g$

II. The interaction between masses at rest

We consider a number of point masses anchored in an inertial frame ***O***. They create and maintain a gravitational field that, at 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 each 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* should 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 symmetry and the extent of disturbance in the direct vicinity of *m* is proportional to $\vec{E}_g$ in *P*. Indeed $\vec{E}_g$ in *P* represents the intensity of the flow of g-information send to *P* by the other masses.

If it was free to move, the point mass *m* could restore the spherical symmetry of the g-information cloud in his direct vicinity: it would be enough 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 "eigen-reference frame"[*] of *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.

2.1. The postulate of the gravitational action

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

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 field strength in that point. Once the anchorage is broken, the mass acquires a vectorial acceleration* $\vec{a}$ *that equals* $\vec{E}_g$.

2.2. The concept force - the gravitational force

[*] The "eigen reference frame" of the point mass *m* is the reference frame anchored at *m*: m is always at the origin of its "eigen reference frame".

A point mass *m*, anchored in 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 spherical symmetry of the gravitational field around *m* is disturbed by the extern g-field, thus to the local value of $\vec{E}_g$.

- It depends also on the magnitude of *m*. Indeed, the g-information cloud created and maintained by *m* is more compact when *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 field strength to which the mass is exposed - and to the 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 spherical 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 at *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 spherical symmetry 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:

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

The acceleration imposed to the mass by the gravitational force is thus:

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

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:

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

2.3. Newtons universal law of gravitation

In fig 3 we consider two point masses m_1 and m_2 anchored in the points P_1 and P_2 of an inertial frame.

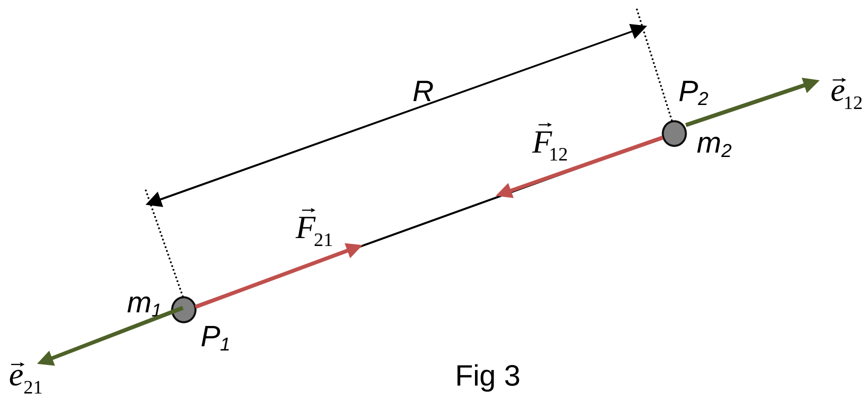


Fig 3

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

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

This field exerts a gravitational force on m_2:

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

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

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

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

III. The gravitational field of moving masses

3.1. The emission of informatons by a point mass that describes a uniform rectilinear Motion

In fig 4 we consider a point mass $m_0{}^*$ that moves with a constant velocity $\vec{v}$ along the *Z*-axis of an inertial 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 *θ* - is time dependent because the position of P_1 is constantly changing.

* For reasons that later will become clear, we indicate the mass who determines the rate of the emission of informatons - the “rest mass” - as m_0.

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

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

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

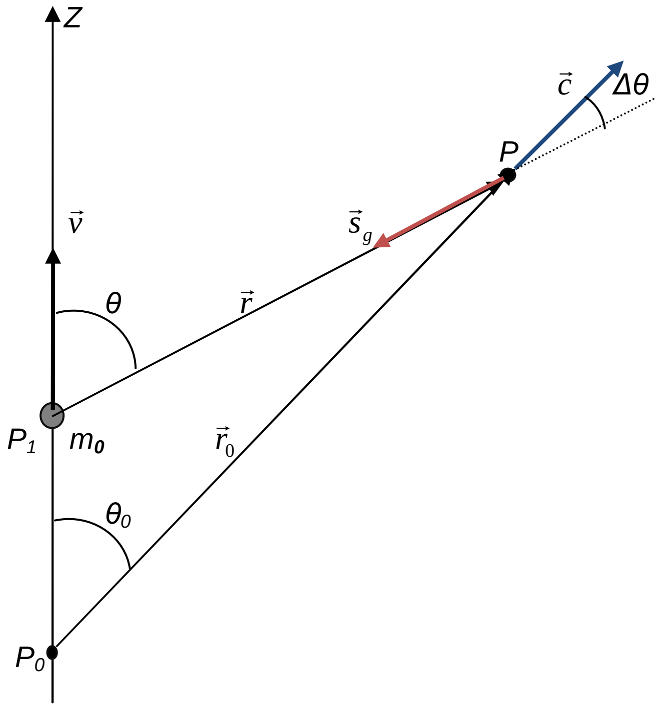


Fig 4

- 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 information.

We posit *that informatons emitted by a moving point mass transport information about the velocity of the mass.* This information is represented by the *gravitational characteristic vector* or *β-vector* $\vec{s}_\beta$ *which is defined by:*

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

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

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

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

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-vector of an information emitted by a point mass with constant velocity can also be expressed as:

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

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

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

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

With *n,* the density of the cloud of informatons at the moment *t* at *P* (number of informatons per unit volume), the 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 het *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 $\vec{s}_\beta$ at that point.

3.3. 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 strength (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 at that point is:

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

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

$$\vec{B}_g = n.\vec{s}_\beta$$

Between *N* and *n* the next relationship exists:

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

If v - the speed of het point mass m_0 - is much smaller than c - the speed of light - the distance P_0P_1 is negligible compared to the distance $P_1P = r$. Then:

$$N = \frac{\dot{N}}{4.\pi.r^2} = K.\frac{m}{4.\pi.r^2} \qquad \text{and} \qquad n = \frac{\dot{N}}{4.\pi.c.r^2} = K.\frac{m}{4.\pi.c.r^2}$$

Further (I.2):

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

Thus, if we are reasoning not relativistic, the g-field in *P* is expressed as:

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

The g-induction in *P* is:

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

And, introducing the constant ν_0 by the definition:

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

the g-induction in *P* is expressed as:

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

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

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

- Each mass m_i emits continuously g-information and contributes with an amount $\vec{E}_{gi}$ to the g-field at an arbitrary point *P*. As in I.3 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, thereby contributing to the g-induction in *P* with an amount $\vec{B}_{gi}$. It is evident that the β-information in the volume element *dV* in *P* at each moment *t* is expressed by:

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

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

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

3.5. The gravitational field of a stationary mass flow

The term “stationary mass flow” indicates the movement of a homogeneous and incompressible fluid that in an invariable way flows through a region of space.

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 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:

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

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 1.4 also apply for this time independent g-field:

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

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

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

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

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

3.6. The laws of the gravitational field

We have shown that moving (inclusive rotating) masses create and maintain a gravitational field, that in each point of space is characterised by two time dependent vectors: the (effective) g-field $\vec{E}_g$ and the (effective) g-induction $\vec{B}_g$.

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 ($n.\vec{s}_\beta$) tot the instantaneous value of the g-induction in that point.

- $\vec{s}_g$ and $\vec{s}_\beta$ respectively are their g-spin vectors and their β-vectors. 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:

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

One can prove[*] that in a **matter free** point of a gravitational field $\vec{E}_g$ en $\vec{B}_g$ obey the following laws:

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

The first law expresses the *conservation of g-information*, the second the fact that the β-vector of an informaton is always perpendicular to its g-spin vector and to its velocity. Laws 3 and 4 express that a local fluctuation of $\vec{B}_g$ ($\vec{E}_g$) is always related to a spatial change of $\vec{E}_g$ ($\vec{B}_g$).

A mass element at a point *P* in a mass continuum is always an emittor of g-information, and - - if it moves - also a source of β-information. The instantaneous value of ρ_G at *P* contributes with an amount $-\frac{\rho_G}{\eta_0}$ to the instantaneous value of $div\vec{E}_g$ at that point. And the contribution of the instantaneous value of $\vec{J}_G$ to $rot\vec{B}_g$ is $-\nu_0.\vec{J}_G$. In an **arbitrary point** of a gravitational field the previous laws become:

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

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

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

[*] See: Antoine Acke - GRAVITATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE

$$4.\quad rot\vec{B}_g = \frac{1}{c^2}.\frac{\partial \vec{E}_g}{\partial t} - \nu_0.\vec{J}_G$$

These are the *gravitational analogues of Maxwell laws*.

IV. The interaction between moving masses

We consider a number of point masses moving in an inertial frame ***O***. They create and maintain a gravitational field that in each point of the space linked at ***O*** is defined by the vectors $\vec{E}_g$ and $\vec{B}_g$.
Each mass is "immersed" in a cloud of g-information and of 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 de 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 the g-induction at *P*, defines the extent to which this occurs.

If it was free to move, the point mass *m* could restore the specific 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 frame*.
In that manner it should become "blind" for the disturbance of symmetry of het gravitational field in its direct vicinity.
These insights form the basis of the following postulate.

4.1. The postulate of the gravitational action

A point mass m, moving in a gravitational field ($\vec{E}_g, \vec{B}_g$) with velocity $\vec{v}$, 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 frame with an amount $\vec{a}'$:

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

4.2. The gravitational force

* The "eigen" inertial frame of the point mass *m* is the reference frame that at the moment *t* moves relative to ***O*** with the same velocity as *m*.

The action of the gravitational field ($\vec{E}_g, \vec{B}_g$) on a moving point mass *m* (velocity $\vec{v}$) is called the *gravitational force* $\vec{F}_G$ on *m.* In extension of 2.2, 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 of the emission of informatons by the mass within any reference frame.

The gravitational force is the cause of a change of the linear momentum $\vec{p}$ of the point mass when it is free to move in the inertial frame ***O***: the rate of change of the linear momentum equals the force:

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

The linear momentum of a moving point mass is defined as:

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

In this context *m* is its *relativistic mass*. Between both masses the relation exists:

$$m = \frac{m_0}{\sqrt{1-\beta^2}} \qquad \text{with} \qquad \beta = \frac{v}{c}$$

4.3. Rest mass and relativistic mass

The postulate that is formulated under 1.1 describes the relation between the mass of an object that is anchored in an inertial frame ***O***, and the emission of informatons in the space that is connected to that frame. To indicate that the object is at a fixed place in ***O*** - that it is motionless - we talk about its "*rest mass*". The rest mass is indicated as m_0.

There is also a standard clock connected to ***O***. It generates the "time" , this is the scalar variable *t* that allows an observer to date events and to determine the duration of phenomena in ***O***.

In fig 5, we consider a point mass that moves, with constant velocity $\vec{v} = v.\vec{e}_z$, along the *Z*-axis of the inertial 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 $\dot{N} = \frac{dN}{dt}$ *, the rate at which it emits informatons in* ***O****, is independent of its state of motion and completely determined by its rest mass* m_0*:* $$\dot{N} = K.m_0$$

We also consider the inertial frame ***O'***, whose origin is anchored at the point mass and that therefore moves with velocity $\vec{v} = v.\vec{e}_z$ with respect to ***O***. We assume that $t = t' = 0$ when the mass passes through *O* (*t* is the instantaneous value read on a standard clock in ***O***, and *t'* the instantaneous value read on a standard clock in ***O'***).
The relations between (*x, y, z; t*) - the coordinates of an event in ***O*** - and (*x', y', z'; t'*) - the coordinates of the same event in ***O'*** are determined by the Lorentz transformation.

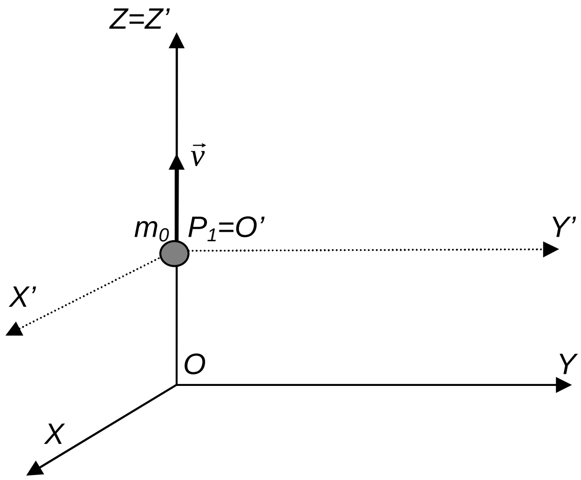


Fig 5

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, an observer in ***O'*** uses a standard clock that is linked to the frame ***O'***. According to that clock - that moves relative to ***O*** - the emission of *dN* informatons takes *dt'* seconds. We call ***O'*** the "eigen inertial frame" of the moving mass en *dt'* the "eigen duration" of the phenomenon.

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

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

So, the time-interval that passes while the moving point mass emits *dN* informatons in ***O*** is $\frac{1}{\sqrt{1-\beta^2}}$-times greater if it is measured in that reference frame, than if it is measured in the eigen inertial frame ***O'***.

The rate of emission linked to the clock in ***O'*** is:

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

With: $\dot{N} = K.m_0$, this results in:

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

Conclusion: *The rate at which the moving mass emits informatons in the inertial frame **O** is proportional to the factor* $m = \frac{m_0}{\sqrt{1-\beta^2}}$ *if it is determined in the eigen-inertial frame of the moving mass.* m is the *relativistic mass* of the moving mass.

According to 4.2, the linear momentum of a mass moving relative to the inertial reference frame ***O*** is characterised by its relativistic mass.

4.3. The interaction between two uniform linear moving point masses

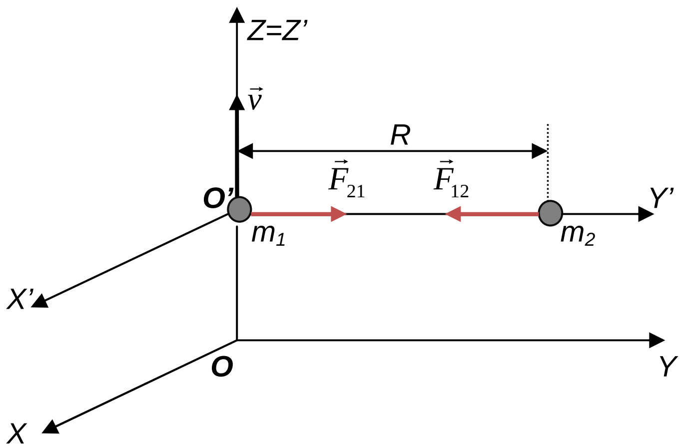


Fig 6

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

In ***O'*** the masses don't move. They are immersed in each other's g-information cloud and they attract - according Newton's law of gravitation - one another with an equal force:

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

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

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

In relativistic circumstances*, the g-fields are characterised by:

$$E_{g1} = \frac{m_2}{4\pi\eta_0 R^2}.\frac{1}{\sqrt{1-\beta^2}} \quad \text{en} \quad E_{g2} = \frac{m_1}{4\pi\eta_0 R^2}.\frac{1}{\sqrt{1-\beta^2}}$$

And the g-inductions by:

$$B_{g1} = \frac{m_2}{4\pi\eta_0 R^2}.\frac{1}{\sqrt{1-\beta^2}}.\frac{v}{c^2} \quad \text{en} \quad B_{g2} = \frac{m_1}{4\pi\eta_0 R^2}.\frac{1}{\sqrt{1-\beta^2}}.\frac{v}{c^2}$$

Substitution gives:

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

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

V. Electromagnetism

5.1. The electric field of a point charge at rest

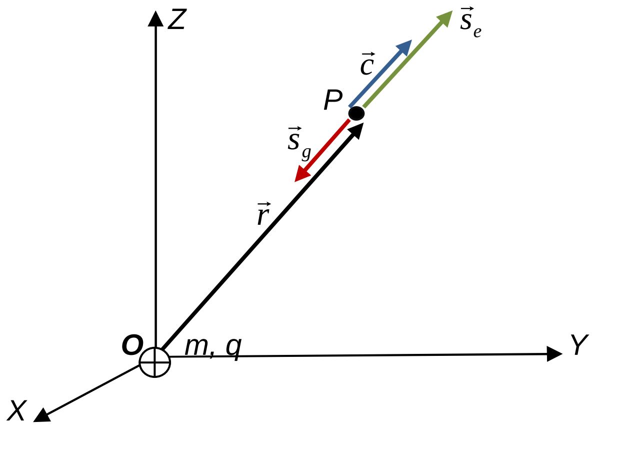


Fig 7

* See: Antoine Acke - GRAVITATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE

From the postulate of the emission of informatons follows that an electrically charged point mass at rest in an inertial frame, emits informatons that not only transport g- but also e-information.

In fig 7 we consider a material point, with mass *m* and (positive) charge *q*, that is anchored in het origin of an inertial frame ***O***.

The informatons going through the fixed point *P* - defined by the position vector $\vec{r}$ - have three attributes: their velocity $\vec{c}$, their g-spin vector $\vec{s}_g$ and their e-spin vector $\vec{s}_e$:

$$\vec{c} = c.\frac{\vec{r}}{r} = c.\vec{e}_r \qquad \vec{s}_g = -\frac{1}{K.\eta_0}.\frac{\vec{r}}{r} = -\frac{1}{K.\eta_0}.\vec{e}_r \qquad \vec{s}_e = \frac{q}{m}.\frac{1}{K.\varepsilon_0}.\frac{\vec{r}}{r} = \frac{q}{m}.\frac{1}{K.\varepsilon_0}.\vec{e}_r$$

The gravitational field of the point mass *m*, we have studied under I, is the macroscopic manifestation of het g-spin vectors of the informatons.

Their e-spin vector leads to an analogue entity: the *electric field* or the *e-field* of the point charge *q* that is characterised by the *electric field strength* or de *e-field* $\vec{E}$.

In the same way as we linked under 1.2 the g-field to the density of the g-information flow, we link the e-field to the density of the e-information flow by:

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

The role played by the factor $(-\frac{m}{\eta_0})$ in the definition of $\vec{E}_g$ is taken by the factor $(\frac{q}{\varepsilon_0})$ in het definition of $\vec{E}$.

By a reasoning analogue to that under 1.3, we show that the electric field of a set of anchored point charges is the vectorial superposition of the electric fields of the different charges.

We extend this to a charge continuum (compare with 1.4) and characterise the spatial charge distribution by defining the accumulation of charge in a point by the electric *charge density* ρ_E:

$$\rho_E = \frac{dq}{dV}$$

From the analogy gravitation-electricity we conclude that het electric field obeys to two laws (compare with 1.4):

1. $div\vec{E} = \frac{\rho_E}{\varepsilon_0}$
2. $rot\vec{E} = 0$, what implies : $\vec{E} = -gradV$

5.2. The interaction between charges at rest

We consider a number of point charges anchored in an inertial frame ***O***. They create and maintain an electric field that, at each point of the space linked to ***O***, is completely determined by the vector $\vec{E}$. Each charge is "immersed" in a cloud of e-information. In each point, except in its own anchorage, each charge contributes to the construction of that cloud.

Let us consider the charge *q* anchored in *P*. If the other charges were not there, then *q* should be at the centre of a perfectly spherical cloud of e-information. In reality this is not the case: the emission of e-information by the other charges is responsible for the disturbance of that symmetry and the extent of disturbance in the direct vicinity of *q* is proportional to $\vec{E}$ in *P*. Indeed $\vec{E}$ in *P* represents the intensity of the flow of e-information send to *P* by the other charges.

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

These insights are expressed in the following postulate: *A free point charge q acquires in a point of an electric field an acceleration* $\vec{a} = \frac{q}{m}.\vec{E}$ *so that the e-information cloud in its direct vicinity shows spherical symmetry relative to its position.*

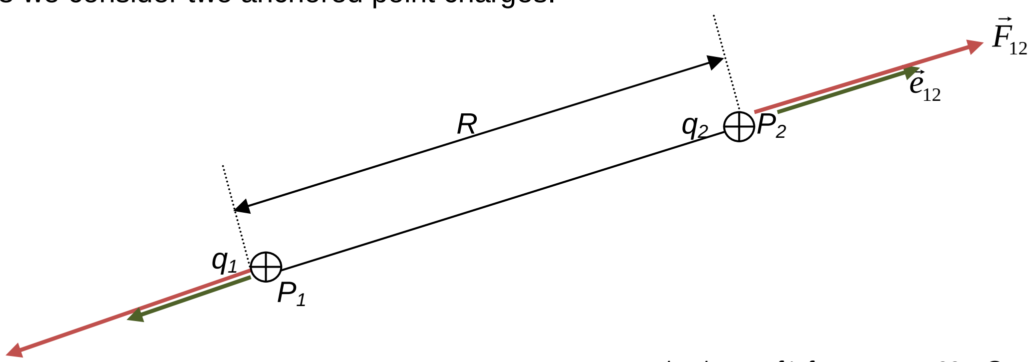
A point charge that is anchored in an electric field cannot accelerate. In that case it *tends* to move. We can conclude that:

A point charge anchored in a point of an electric field is subjected to a tendency to move in the direction defined by $\vec{E}$*, the field in that point. Once the anchorage broken, the charge acquires a vectorial acceleration* $\vec{a}$ *that equals* $\frac{q}{m}.\vec{E}$ *.*

The action exerted by the field on *q* is called the *electric force* $\vec{F}_E$ on *q*. From II.2 we conclude:

$$\boxed{\vec{F}_E = q.\vec{E}}$$

In fig 8 we consider two anchored point charges.



$\vec{F}_{21}$ $\vec{e}_{21}$ Fig. 8

It is easy to show (compare with II.3) that the mutual electric forces are expressed as:

$$\vec{F}_{12} = \frac{q_1.q_2}{4.\pi.\varepsilon_0.R^2}.\vec{e}_{12} \qquad \text{en} \qquad \vec{F}_{21} = \frac{q_1.q_2}{4.\pi.\varepsilon_0.R^2}.\vec{e}_{21}$$

This is the mathematical formulation of *Coulombs law*. There is a formal analogy with Newton's universal law of gravitation.

However there is a difference: Coulomb's law indicates that the electric interaction can be as well propulsive (the charges have the same sign) as attractive (the charges have opposite signs), where Newton's law only permits attraction (mass is always positive).

5.3. The influence of a dielectric on the electric field

Dielectrics in an electric field are POLARISED. The molecules of a dielectric behave as electric dipoles. These are neutral structures consisting of two equal and opposite point charges (-*Q*, +*Q*) which are separated by a small distance *a* and characterised by their dipole moment $\vec{p} = a.Q.\vec{e}_p$. ($\vec{e}_p$ is oriented from -*Q* to +*Q*.) Electric dipoles in an electric field have a tendency for alignment with that field: the dielectric becomes *polarised*.

The extend of polarisation in a point *P* of a dielectric is characterized by the *polarisation* $\vec{P}$. $\vec{P}$ depends on the field $\vec{E}$ in *P* and is defined by:

$$\vec{P} = \kappa_E.\varepsilon_0.\vec{E}$$

κ_E is the susceptibility of the dielectric in *P.*

One can show[*] that the electric field in an arbitrary point of space can be characterised by the vector $\vec{D}$, *that not depends on the nature of the matter at that point*. This vectorial quantity is called the *dielectric induction*. It is defined by:

$$\vec{D} = \varepsilon_0.\vec{E} + \vec{P}$$

The law that expresses the conservation of e-information (V.1) can be generalized to:

$$div\vec{D} = \rho_E$$

Let us finally note that there doesn't exist mass dipoles. That implies that in gravitation there is no analogue for dielectric polarisation.

5.4. The electromagnetic field of a uniform rectilinear moving point charge

The informatons emitted by a point charge *q*, describing a uniform rectilinear motion (fig 9) transport - besides e-information - also information relating to the velocity $\vec{v}$ of the emitter.

[*] See: Antoine Acke - GRAVITATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE

If the point charge moves, the lines carrying $\vec{s}_e$ and $\vec{c}$ no longer are parallel: they form an angle *Δθ*. This angle is the *characteristic angle* introduced in 3.1 because $\vec{s}_e$ and $\vec{s}_g$ are carried by the same line.

We call the quantity $s_b = s_e.\sin(\Delta\theta)$ that - in this context - is representative for het characteristic angle, the *characteristic e-information* or the *magnetic information* or the *b-information* of an informaton.

We posit that informatons emitted by a moving point charge transport information about the velocity of that charge. This information is represented by the electric characteristic vector or *b-vector* $\vec{s}_b$ *which is defined by:*

$$\vec{s}_b = \frac{\vec{c} \times \vec{s}_e}{c}$$

The orientation of $\vec{s}_b$ is defined by the "rule of the corkscrew". If *q > 0* (fig 9), $\vec{s}_b$ is directed into the plane of the drawing; if *q < 0* then $\vec{s}_b$ points out of the plane. The magnitude of $\vec{s}_b$ is the b-information of the information.

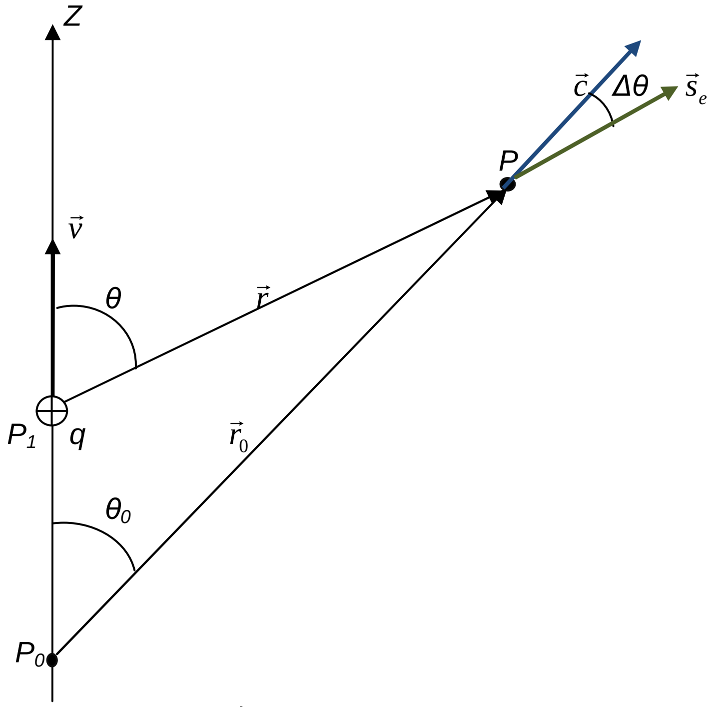


Fig 9

As in 3.1 one proves:

$$\vec{s}_b = \frac{\vec{v} \times \vec{s}_e}{c}$$

Consequently, the informatons emitted by *q* which are going through the fixed point *P* - defined by the time dependant position vector $\vec{r}$ - have 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*.

- 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 their direction of movement), the e-field in that point is:

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

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

$$\vec{B} = n.\vec{s}_b$$

If v - the speed of the point charge q - is much smaller than c - the speed of light - the distance P_0P_1 is negligible compared to the distance $P_1P = r$. Then as in 3.3:

$$\vec{E} = \frac{q}{4.\pi.\varepsilon_0.r^3}.\vec{r} \qquad \text{and} \qquad \vec{B} = \frac{\mu_0.q}{4.\pi.r^3}.(\vec{v}\times\vec{r}) \quad \text{with} \quad \mu_0 = \frac{1}{\varepsilon_0.c^2}$$

The e-information cloud defined by the vector pair $(\vec{E},\vec{B})$ is called the *electromagnetic field* of *q.* It has two components: the *electric field* and the *magnetic field*.

5.5. The electromagnetic field of a set of moving point charges

The contribution of each charge q_i to the electromagnetic field in *P* is defined by $\vec{E}_i$ and $\vec{B}_i$. The effective electromagnetic field is characterised by (analogue to III.4):

$$\vec{E} = \sum \vec{E}_i \qquad \text{and} \qquad \vec{B} = \sum \vec{B}_i$$

5.6. The electromagnetic field of a stationary charge flow

The term “stationary charge flow” indicates the movement of an homogeneous and incompressible charged fluid that - in an invariable way - flows through a region of space.

The intensity of the flow in an arbitrary point *P* is characterised by the flow density $\vec{J}_E$. The magnitude of this vectorial quantity equals the rate per unit area at which the charge flows through a surface element that is perpendicular to the flow at *P.* The orientation of $\vec{J}_E$ corresponds to the direction of the flow of positive charge carriers and is opposite to the direction of the flow of negative charge carriers (In what follows the flow of negative charge carriers is replaced by a fictive flow of positive carriers in the opposite direction). If $\vec{v}$ is the velocity of the charge element $\rho_E.dV$ that at the moment *t* flows through *P*, then:

$$\vec{J}_E = \rho_E.\vec{v}$$

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

$$di = \vec{J}_E.\overrightarrow{dS}$$

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

$$i = \iint_{\Delta S} \vec{J}_E.\overrightarrow{dS}$$

We call *i* , the intensity of the charge flow through *ΔS*, the *electric current* through *ΔS.*

Since a stationary charge flow is the macroscopic manifestation of moving charge elements $\rho_E.dV$, it creates and maintains an electromagnetic field. And since the velocity $\vec{v}$ of the charge element in each point is time independent, *the electromagnetic field of a stationary charge flow will be time independent*.

It is evident that the rules of 5.1 also apply for this time independent e-field:

- $div\vec{E} = \dfrac{\rho_E}{\varepsilon_0}$

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

One can prove that the rules for the time independent magnetic induction are:

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

- $rot\vec{B} = \mu_0.\vec{J}_E$

Let us consider the special case of a *line current*. A line current is the stationary charge flowing through a - whether or not straight - cylindrical tube. The rate at which charge is transported through an arbitrary section ΔS, is defined by:

$$i = \iint_{\Delta S} \vec{J}_E.\overrightarrow{dS}$$

This - time and position independent - quantity is called the *electric current through the line.*

The charges flow parallel to the direction of the axis of the cylindrical tube and all charge elements *dq* are moving with the same speed *v*. We can identify the tube with a string through which a current *i* flows. Each charge element is contained in a line element $\overrightarrow{dl}$ of the string. The quantities that are relevant for the electric current in the string are related to each other:

$$\vec{v}.dq = i.\overrightarrow{dl}$$

$i.\overrightarrow{dl}$ is called a *current element*.

The magnetic induction $d\vec{B}$*, caused in a point P by a current element is found by substituting* $\vec{v}.dq$ *by* $i.\overrightarrow{dl}$ *in the formula that we derived under 5.4 for a moving point charge. (*$\vec{r}$ *defines the position of P relative to the current element).* Thus:

$$\boxed{d\vec{B} = \frac{\mu_0 . i}{4.\pi.r^3}.(\overrightarrow{dl} \times \vec{r})}$$

This is the mathematical formulation of Laplace's law.

5.7. The electromagnetic field of a conductor

We can understand the current in a conductor as the drift movement of fictive positive charge carriers through a lattice of immobile negative charged entities.

A conductor in which an electric current flows causes a magnetic field, but not an electric one.

Indeed, the current is a stationary charge flow and thus the cause of a stationary magnetic field composed by contributions defined by Laplace's law. He doesn't cause an electric field, because the e-spin vectors of the informatons emitted by the moving charge carriers are neutralized by the e-spin vectors of the informatons emitted by the lattice.

Unlike a β-field - that never exists without a g-field - a magnetic field can exist without an electric field, what implies that a magnetic field is not necessarily masked in every day circumstances.

5.8. The electromagnetic interaction

Considerations as under IV lead to the *postulate of the electromagnetic interaction*:

> *A point charge q with rest mass* m_0*, moving with velocity* $\vec{v}$ *in an electromagnetic field (*$\vec{E}, \vec{B}$*), 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 frame with an amount* $\vec{a}'$ *:*
>
> $$\vec{a}' = \frac{q}{m_0}.\{\vec{E} + (\vec{v} \times \vec{B})\}$$

The action exerted by the electromagnetic field on the moving charge *q* is called the *Lorentz force* $\vec{F}_{EM}$ on *q*. From 2.2 we conclude:

$$\vec{F}_{EM} = q.\left[\vec{E} + (\vec{v} \times \vec{B})\right]$$

The Lorentz force is the cause of the change of the linear momentum $\vec{p}$ of a point charge that freely moves in an electromagnetic field (see 4.2):

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

Let us review the situation of fig 5 and assume that the two point masses that are anchored in the moving inertial frame ***O'*** carry the charges q_1 and q_2. A reasoning entirely analogous to that under 4.3 leads to the conclusion that the magnitude of the mutual electromagnetic force in ***O*** is ($\sqrt{1-\beta^2}$)-times smaller than the magnitude of that force in ***O'***. And that the magnetic component of that force is (β^2) times smaller than the electric component. In this situation, the effect of the magnetic induction is masked in every day circumstances.

Only if there is no electric field, as in the case of two conductors, the magnetic force manifests itself.

V.9. The influence of a magnetic material on the magnetic field

A magnetic material becomes *magnetized* if it is placed in a magnetic field. Its molecules behave as magnetic dipoles: neutral structures having a magnetic moment because they are the seat of circular current loops. Magnetic dipoles in a magnetic field have a tendency for alignment with that field.

The extent of the magnetization in a point *P* of a magnetic material is characterized by the *magnetization* $\vec{M}$. $\vec{M}$ depends on the induction in *P* and is defined as:

$$\vec{M} = \chi_m . \frac{\vec{B}}{\mu_0}$$

χ_m is the magnetic susceptibility of the magnetic material at *P.*

One can show* that the magnetic induction in an arbitrary point of space can be characterised by the vector $\vec{H}$, *that not depends on the nature of the matter in that point*. This vectorial quantity is called the *magnetic field strenght*. It is defined by:

$$\vec{H} = \frac{\vec{B}}{\mu_0} - \vec{M}$$

The magnetic field strength at a point *P* is related to the flow density at that point:

$$rot\vec{H} = \vec{J}_E$$

* See: Antoine Acke - GRAVITATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE

This is a generalization of 5.6

5.10. Maxwell's laws

Arguments similar to those of 3.6 lead to the following relations that stand in an arbitrary point in an electromagnetic field.

1. $div\vec{D} = \rho_E$
2. $div\vec{B} = 0$
3. $rot\vec{E} = -\frac{\partial \vec{B}}{\partial t}$
4. $rot\vec{H} = \frac{1}{c^2}.\frac{\partial \vec{D}}{\partial t} + \vec{J}_E$

VI. Waves and radiation

6.1. The electromagnetic field of an accelerated point charge

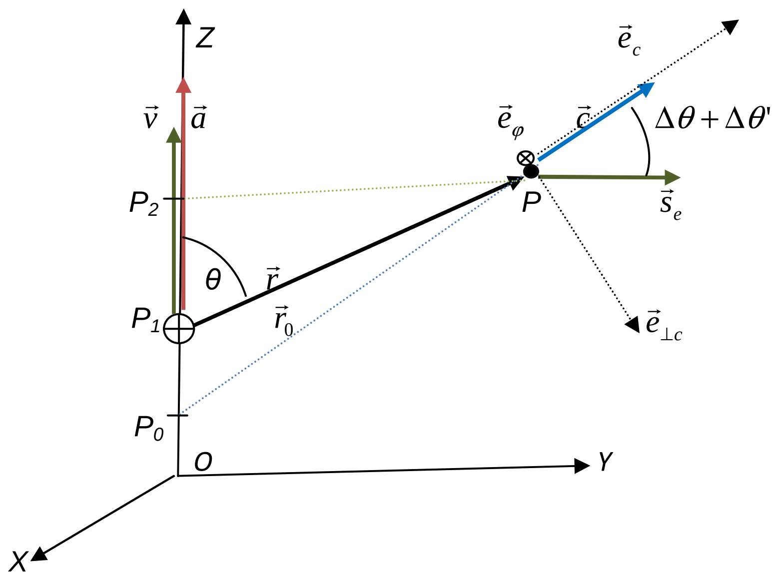


Fig 10

In fig 10 we consider a point charge *q* that, at the moment *t,* goes through P_1. The instantaneous values of its velocity and its acceleration are: $\vec{v} = v.\vec{e}_z$ and $\vec{a} = a.\vec{e}_z$. We suppose that the speed *v* remains much smaller than the speed of light.

The informatons that on the moment *t* are rushing through the fixed point *P* - defined by the time dependent position vector $\vec{r}$ - are departed from P_0. Their velocity $\vec{c}$ is on the same carrier line as $\overrightarrow{P_0P}$.
Their e-spin vector is on the carrier line P_2P. In V.I.1 of "A. Acke - GRAVITATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE " we show that P_2 is ahead of the point charge. In the case of a uniform accelerated rectilinear motion:

$$P_1P_2 = \frac{1}{2}.\frac{a.r_0^{\ 2}}{c^2} = P_0P_1$$

The characteristic angle (between the carrying lines of $\vec{s}_e$ en $\vec{c}$) has two components:

- $\Delta\theta \cong \sin(\Delta\theta) = \dfrac{v(t-\frac{r_0}{c})}{c}.\sin\theta$, the characteristic angle related to the velocity of *q* at the moment $(t-\frac{r_0}{c})$ when the considered informatons were emitted (5.4).
- $\Delta\theta' \cong \sin(\Delta\theta') = \dfrac{a(t-\frac{r_0}{c}).r_0}{c^2}.\sin\theta$, the characteristic angle related to the acceleration of *q* at the moment $(t-\frac{r_0}{c})$ when the considered informatons were emitted. If the acceleration is time independent, then $a(t-\frac{r_0}{c}) = a(t) = a$

Taking into account that P_0P_1 - the distance travelled by *q* during the interval $\Delta t = \frac{r_0}{c}$ - can be neglected compared to P_0P - the distance travelled by the light during the same interval - one can conclude that r_0 can be identified with *r* (and θ_0 with θ). Thus:

$$\boxed{\Delta\theta + \Delta\theta' = \frac{v(t-\frac{r}{c})}{c}.\sin\theta + \frac{a(r-\frac{t}{c}).r}{c^2}.\sin\theta}$$

The macroscopic effect of the emission of e-information by the accelerated charge *q* is an electromagnetic field $(\vec{E},\vec{B})$. We introduce the reference system $(\vec{e}_c, \vec{e}_{\perp c}, \vec{e}_\varphi)$ (fig 10) and obtain*:

$$\vec{E} = \frac{q}{4.\pi.\varepsilon_0.r^2}.\vec{e}_c + \{\frac{q}{4.\pi.\varepsilon_0.c.r^2}.v(t-\frac{r}{c}).\sin\theta + \frac{\mu_0.q}{4.\pi.r}.a(t-\frac{r}{c}).\sin\theta\}.\vec{e}_{\perp c}$$

* See: A. Acke - GRAVITATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE

$$\vec{B} = \{\frac{\mu_0.q}{4.\pi.r^2}.v(t-\frac{r}{c}).\sin\theta + \frac{\mu_0.q}{4.\pi.c.r}.a(t-\frac{r}{c}).\sin\theta\}.\vec{e}_\varphi$$

6.2. The electromagnetic field of an harmonically oscillating point charge

In fig 11 we consider a point charge *q* that harmonically oscillates around the origin of the inertial frame ***O*** with frequency $\nu = \frac{\omega}{2.\pi}$.

We suppose that the speed of the charge is always much smaller than the speed of light and that it is described by:

$$v(t) = V.\cos\omega t$$

The elongation *z(t)* and the acceleration *a(t)* are than expressed as:

$$z(t) = \frac{V}{\omega}.\cos(\omega t - \frac{\pi}{2}) \quad \text{and} \quad a(t) = \omega.V.\cos(\omega t + \frac{\pi}{2})$$

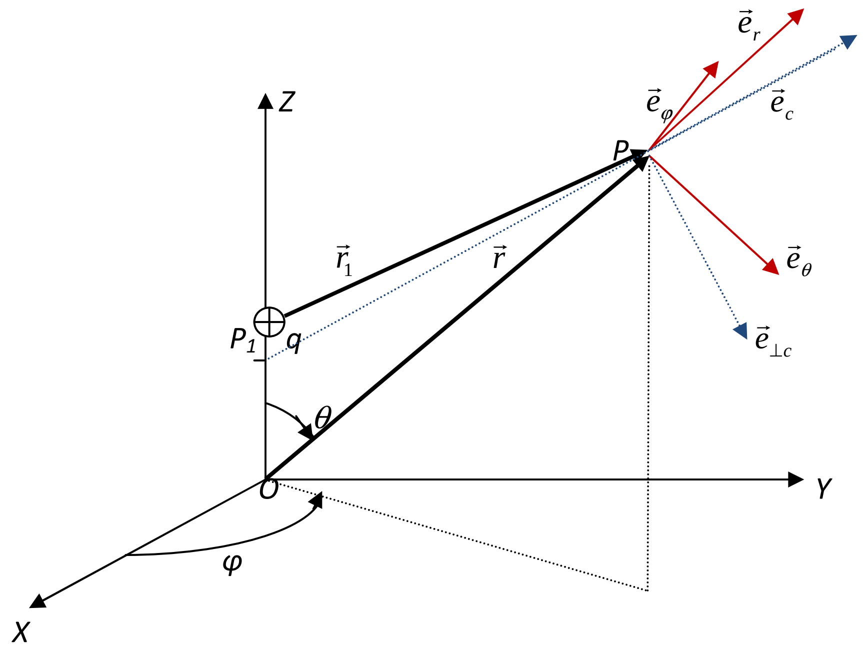


Fig 11

We restrict our considerations to points *P* that are sufficiently far away from the origin *O*. Under this condition we can posit that the fluctuation of the length of the vector $\overrightarrow{P_1P} = \vec{r}_1$ is very small relative to the length of the position vector $\vec{r}$, that defines the position of *P* relative to the origin *O.* In other words: we accept that the amplitude of the oscillation is very small relative to the distances between the origin and the points *P* on which we focus.

Starting from $\overline{V} = V.e^{j.0}$ - the complex quantity representing *v(t)* - we derive the components of the electromagnetic field in *P*. We obtain*:

$$\overline{E}_{\perp c} = \frac{q.\overline{V}}{4.\pi}.e^{-j.k.r}.(\frac{\eta}{r^2} + \frac{j.\omega.\mu_0}{r}).\sin\theta \qquad \text{and} \qquad \overline{B}_{\varphi} = \frac{\mu_0.q.\overline{V}}{4.\pi}.e^{-j.k.r}.(\frac{1}{r^2} + \frac{j.k}{r}).\sin\theta$$

With $k = \dfrac{\omega}{c}$ the phase constant, and $\eta = \mu_0.c = \dfrac{1}{\varepsilon_0.c} = \sqrt{\dfrac{\mu_0}{\varepsilon_0}} = 120.\pi$ the intrinsic impedance of free space.

So, an harmonically oscillating point charge emits an electromagnetic wave that expands with the speed of light relative to the position of the charge:

$$\boxed{B_{\varphi}(r,\theta;t) = \frac{E_{\perp c}(r,\theta;t)}{c} = \frac{\mu_0.q.V.\sin\theta.\sqrt{1+k^2r^2}}{4\pi r^2}.\cos(\omega t - kr + \Phi) \qquad \text{with} \qquad tg\Phi = kr}$$

In points at a great distance of the oscillating charge, specifically there were $r >> \dfrac{1}{k} = \dfrac{c}{\omega}$, this expression equals asymptotically:

$$B_{\varphi} = \frac{E_{\perp c}}{c} = -\frac{\mu_0.k.q.V.\sin\theta}{4\pi r}.\sin(\omega t - kr) = -\frac{\mu_0.q.\omega.V.\sin\theta}{4\pi c r}.\sin(\omega t - kr) = \frac{\mu_0.q.a(t-\frac{r}{c}).\sin\theta}{4\pi c r}$$

The intensity of the "far field" is inversely proportional to *r*, and is determined by the component of the acceleration of *q*, that is perpendicular to the direction of $\vec{e}_{\perp c}$.

VI.3. Poynting's theorem

An electromagnetic field is ful defined by the vectorial functions $\vec{E}(x,y,z;t)$ and $\vec{B}(x,y,z;t)$.

Poynting's theorem states that the expression $\dfrac{\vec{E}\times\vec{B}}{\mu_0}.\overrightarrow{dS}$ defines the rate at which energy flows through the surface element *dS* in *P* in the sense of the positive normal.
So, *the density of the energy flow in P* is $\dfrac{\vec{E}\times\vec{B}}{\mu_0}$. This vectorial quantity is called "Poynting's vector". It is represented by $\vec{S}$:

$$\boxed{\vec{S} = \frac{\vec{E}\times\vec{B}}{\mu_0}}$$

* See: A. Acke - GRAVITATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE

The amount of energy transported through the surface element *dS* in the sense of the positive normal during the interval *dt* is:

$$dU = \frac{\vec{E} \times \vec{B}}{\mu_0}.\overrightarrow{dS}.dt$$

VI.4. The energy radiated by an harmonically oscillating point charge

Under VI.2 we have showed that an harmonically oscillating point charge *q* radiates an electromagnetic wave that in a far point *P* is defined by (see fig 11):

$$\vec{E} = E_{\perp c}.\vec{e}_{\perp c} = -\frac{\mu_0.q.\omega.V.\sin\theta}{4\pi r}.\sin(\omega t - kr).\vec{e}_{\perp c}$$

$$\vec{B} = B_\varphi.\vec{e}_\varphi = -\frac{\mu_0.q.\omega.V.\sin\theta}{4\pi c r}.\sin(\omega t - kr).\vec{e}_\varphi$$

The instantaneous value of Poynting's vector in *P* is:

$$\vec{S} = \frac{\mu_0.q^2.\omega^2.V^2.\sin^2\theta}{16.\pi^2.c.r^2}.\sin^2(\omega t - kr).\vec{e}_c$$

The amount of energy that, during one period *T* , flows through the surface element *dS* that in *P* is perpendicular on the movement direction of the informatons, is:

$$dU = \int_0^T P.dt.dS = \frac{\mu_0.q^2.\omega^2.V^2.\sin^2\theta}{16.\pi^2.c.r^2}.\frac{T}{2}.dS$$

And with $\omega = \frac{2.\pi}{T}$:

$$dU = \frac{\mu_0.q^2.V^2.\sin^2\theta}{8c}.\nu.\frac{dS}{r^2}$$

$\frac{dS}{r^2} = d\Omega$ is the solid angle under which *dS* is "seen" from the origin .

So, the oscillating charge radiates, per period, an amount of energy per unit of solid angle in the direction *θ*:

$$u_\Omega = \frac{\mu_0.q^2.V^2.\sin^2\theta}{8c}.\nu$$

The density of the flux of energy is greatest in the direction defined by *θ = 90°*, thus in the direction perpendicular on the movement of the charge.

6.5. The emission of photons by an harmonically oscillating point charge

In 6.4 we have studied the energy transported by the electromagnetic wave that is radiated by an harmonically oscillating point charge. The radiated energy is proportional to the frequency of the wave, thus proportional to the frequency at which the charge oscillates.

We posit that an oscillating charge q loads some of the informatons that it emits with a discrete energy packet $h\nu$. Informatons carrying an energy packet are called photons.

Thus, we postulate that the electromagnetic energy radiated by an oscillating point charge is transported by informatons. This implies that photons rush through space with the speed of light.

Consequently, the number of photons emitted by an oscillating point charge *q* per period and per unit of solid angle in the direction *θ*, is according to 6.4:

$$N_{f\Omega} = \frac{\mu_0.q^2.V^2.\sin^2\theta}{8hc}$$

It follows that the total number of photons that it emits per period is:

$$N_f = \frac{\mu_0.q^2.V^2}{8hc}.2\pi.\int_0^\pi \sin^3\theta.d\theta = \frac{\pi}{3}.\frac{\mu_0}{h.c}.q^2.V^2$$

Let us compare N_f with *N,* the number of informatons that the electrically charged oscillating point mass *m* emits during the same interval:

$$N = \dot{N}.T = \frac{c^2}{h}.m.\frac{1}{\nu} = 1{,}36.10^{50}.\frac{m}{\nu} \qquad \text{and} \qquad N_f = \frac{\pi.\mu_0}{3.h.c}.q^2.V^2 = 6{,}63.10^{18}.q^2.V^2$$

If the oscillating entity is an electron, we obtain:

$$N = \frac{1{,}24.10^{20}}{\nu} \qquad \text{and} \qquad N_f = 1{,}70.10^{-19}.V^2$$

Since the instantaneous speed cannot reach the speed of light, we can find an absolute upper limit for N_f:

$$N_f < 1{,}70.10^{-19}.c^2 = 1{,}53.10^{-2}$$

It is impossible for an oscillating electron to emit more than $1{,}53.10^{-2}$ photons per period.

From the definition of a photon it follows that the number of photons emitted during a period must be smaller than the number of informatons emitted during the same interval:

$$1{,}53.10^{-2} < \frac{1{,}24.10^{20}}{\nu}$$

So : $\nu < 8{,}10.10^{21}$ *Hz*.

We conclude that *8,10.10^21 Hz* is an absolute upper limit for the frequency of the electromagnetic waves that can be radiated by an oscillating electron. If the source of radiation is an oscillating proton the frequency of the electromagnetic wave must be smaller than *1,50.10^25 Hz*.

6.5. Gravitational waves - gravitons

If we apply the reasoning of 6.2 on the g-information emitted by a - whether or not charged - harmonically oscillating point mass *m*, we find the description of the "far" gravitational field:

$$B_{g\varphi} = \frac{E_{g\perp c}}{c} = \frac{\nu_0.k.m.V.\sin\theta}{4\pi r}.\sin(\omega t - kr) = \frac{\nu_0.m.\omega.V.\sin\theta}{4\pi cr}.\sin(\omega t - kr) = -\frac{\nu_0.m..a_\theta(t-\frac{r}{c})}{4\pi cr}$$

This expression describes a *gravitational wave*, that expands with the speed of light.

1° Let us calculate the energy radiated by a gravi tational wave using the same method as in the case of an electromagnetic wave. If we accept that the energy in both situations is transported by photons ($h.\nu$), we must conclude that the number of photons emitted by *m* per period and per unit of solid angle, is:

$$N'_{f\Omega} = \frac{\nu_0.m^2.V^2.\sin^2\theta}{8hc}$$

Taking into account the data deduced under VI.6 for an oscillating charged particle with mass *m* and charge *Q*, we find the following relation between N'_f - the number of photons that, per period, is taken with the gravitational wave - and N_f - the number of photons that in the same interval is taken with the electromagnetic one:

$$N'_f = N_f.\frac{\nu_0}{\mu_0}.(\frac{m}{Q})^2 = 7{,}43.10^{-21}.(\frac{m}{Q})^2.N_f$$

For an electron, this gives $N'_f = 2{,}41.10^{-43}.N_f$ and in the case of a proton we find $N'_f = 8{,}12.10^{-37}.N_f$. We note that almost all photons that are emitted by an oscillating particle are related to its charge and coupled to the electromagnetic wave. *The emission of a photon by a neutral particle is very unlikely.*

2° This conclusion justifies the assumption that a gravitational wave transports energy in the form of GRAVITONS. Gravitons are energy packets *h'.*ν that are emitted by the oscillating mass and transported through space by informatons. The number of gravitons emitted per period by on oscillating mass *m* is:

$$N'_f = \frac{\pi}{3}.\frac{\nu_0}{h'.c}.m^2.V^2$$

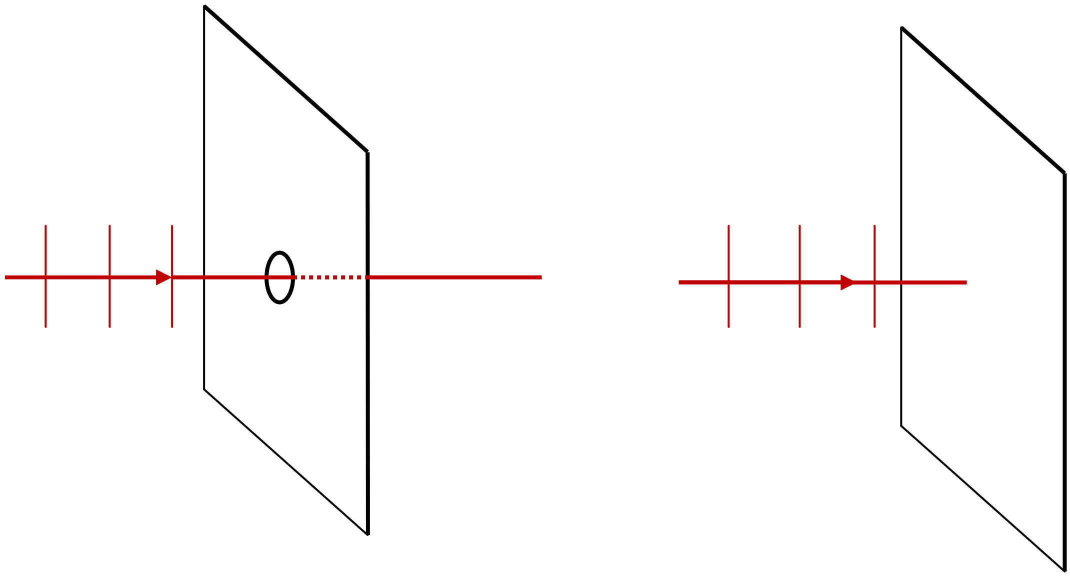
For a proton (and a neutron): $N_f^{'} = \frac{9,15.10^{-89}}{h'}.V^2$, and since the speed always must be smaller than the speed of light: $N_f^{'} < \frac{8,24.10^{-72}}{h'}$. A proton also is a source of photons, namely N_f per period. We know (VI.4) that: $N_f < \frac{\pi}{3}.\frac{\mu_0}{h.c}.q^2.c^2 = 1,53.10^{-2}$.

If we accept that the number of emitted gravitons is of the same magnitude as the number of emitted photons, we find the following rough estimation for h':

$$\boxed{h' \approx 5,40.10^{-70}\,J.s}$$

6.6. Babinet's theorem - The Huygens-Fresnel principle

In fig 12,a is shown a perfectly opaque flat plate with an opening in it. A plane electromagnetic wave *G* (a light wave) with frequency ν is send to the opening. The "wave fronts"* are parallel to the plate. *G* is constituted by a flow of informatons that are transporting e-information, some of them also are carrying a package of energy.



(a) (b)

Fig 12

In each point where the wave passes, there is a time dependent electromagnetic field: macroscopic manifest the e-spin vectors of the informatons themselves as the electric component of that field. For the existence of that field it doesn't matter whether or not the informatons are carriers of energy.

* A wave front is a surface where the electric field - and the magnetic induction - are everywhere the same.

In fig 12,b the same plate is shown but now the opening is filled with a perfectly opaque plug.

For the expansion of *G* in the space beyond the plate, nor the magnitude or the form of the opening neither the presence of the plug matters. Indeed, the plate as well as the plug are transparent for the wave since it is constituted by a flow of mass- and energyless entities.

Some of these informatons transport an energy packet. When such an informaton (a "photon") goes through the plate (or through the plug) its energy package will be absorbed by an atom in the plate (or the plug). That atom will be forced to emit a secondary electromagnetic wave with the same frequency as the incident. The movement of the informaton has not be disturbed by this phenomenon.

So, in the situation of fig 12,a the electric field in a point beyond the plate is composed by the superposition of the original plane wave *G* with the secondary waves that are emitted by the atoms in the plate.

$\vec{E}$ - the electric field in a point *P* beyond the plate - is the sum of $\vec{E}_0$ - the electric field in *P* due to the passage of the plane wave *G* - and $\vec{E}_{pl}$ - the electric field due to the passage of the secondary waves generated by the atoms in the plate:

$$\vec{E} = \vec{E}_0 + \vec{E}_{pl}$$

In the situation of fig 4,b, three sources of radiation contribute to the construction of the field beyond the plate:

- the plane wave *G* whose contribution to the field in *P* is $\vec{E}_0$,
- the part of the plate that is hit by *G*; this contributes with an amount $\vec{E}_{pl}$ to the field in *P*,
- the plug that, in this condition, also is a source of radiation. Indeed, since it is absorbing the energy packets send in its direction by *G*, some of its atoms function as emitters of electromagnetic radiation. The contribution of these atoms to the field in *P* is $\vec{E}_{plug}$.

Naturally, in this situation - where the full plate is opaque - there cannot exist a field in *P*. So:

$$\vec{E}_0 + \vec{E}_{pl} + \vec{E}_{plug} = \vec{E} + \vec{E}_{plug} = 0$$

We conclude: *In the space beyond the plate, the superposition of the field radiated by the plate and the field radiated by the plug (the "complement" of the plate) is equal and opposite to the field of the original plane wave.*

$$\boxed{\vec{E}_{pl} + \vec{E}_{plug} = -\vec{E}_0}$$

This is *Babinets theorem.*

An equivalent formulation: *In a point beyond the plate, the plug generates an electromagnetic field that is exactly equal and opposite to the field that there is if the plug is* *removed* or *the field in the space beyond the plate without plug is equal and opposite to the field generated by the plug.*

$$\vec{E} = -\vec{E}_{plug}$$

This implies that the field $\vec{E}$ beyond the plate with the opening (situation of fig. 12,a) can be found by considering the opening as the only source of radiation, what can be expressed as:

Each point of the wave front reaching the opening can be regarded as a point source emitting a spherical electromagnetic wave, the effective wave in the region beyond the opening is the superposition of all these waves.

This is the *Huygens-Fresnel principle.*

6.7. Max Born's interpretation of the diffraction of light

With the Huygens-Fresnel principle as starting point, we can calculate the strength of the electric field $\vec{E}$ in an arbitrary point in the region beyond the plate of fig 11,a. $\vec{E}$ is an harmonic function of time. E^2 , the square of the effective value of *E(t),* characterizes the intensity of het electromagnetic field (the intensity of light) in *P.*

We know that $\vec{E}$ defines the density of the flow of e-information in *P*: the greater the value of E^2 in *P*, the greater the number of informatons that passes per unit of time in the vicinity of *P.*

Some informatons that are rushing through the region beyond the plate, are carriers of an energy packet: it are photons. It is evident that het number of photons in the region around *P* is proportional to the number of informatons in that region, thus to E^2.

This explains the *interpretation of Max Born*: *the probability for a photon at a point P is proportional to* $E^2(P)$.

VI.8. Heisenberg's uncertainty principle

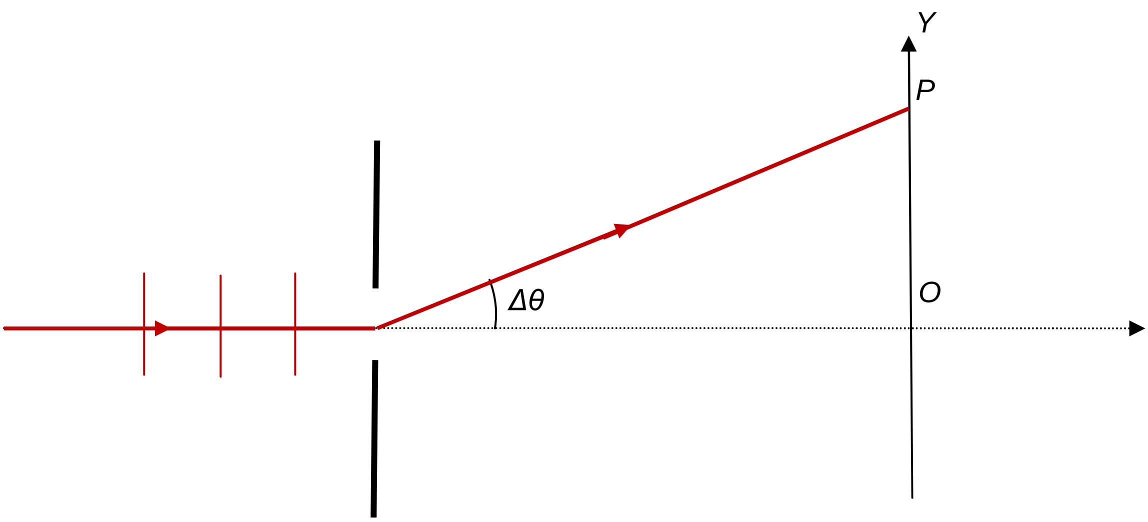


Fig 13

In fig 13 we consider a plane (light) wave *G* send through a narrow split in a perfectly opaque plate. *a* is the width of the split and λ is the wave length of the wave.

With the Huygens-Fresnel principle as starting point we calculate the intensity pattern of the light that falls on a screen beyond the plate. The distance *L* between the plate and the screen - that is parallel to the plate - is much larger than *a*.
The intensity of the light in a point *P* of the screen is proportional to the value of E^2 in that point. The calculation of $E^2(P)$ as a function of $\sin(\Delta\theta)$ learns that E^2 is maximal in the strip where $\sin(\Delta\theta) \approx 0$ (what corresponds with $y \approx 0$) and gradually decreases to *0* when $\sin(\Delta\theta) = \frac{\lambda}{a}$. With a further increase of $\Delta\theta$ corresponds an increase of E^2 until a new maximum is reached (a maximum that is smaller than the central one), etc.

Thus, in the centre of the screen (around $y = 0$) is a bright strip whose edges are defined by $\sin(\Delta\theta) = \pm\frac{\lambda}{a}$. This bright strip is caught between two dark strips, which are followed by bright strips who are less clear than the central one, etc.

Since the value of $E^2(P)$ is proportional to the number of photons that goes through *P* per unit of time, the intensity of light in a point of the screen characterizes the rate at which the screen is hit by photons in that point.

Most of the photons hit the screen in the strip defined by the condition:

$$-\frac{\lambda}{a} < \sin(\Delta\theta) < +\frac{\lambda}{a}$$

The intensity pattern we have found is only possible if the photons that rush through the split can change direction, in other words if they can "deflect", when they go through the split.

Since informatons always move straight away, the deflection of the photon can only be understood as the transition of an energy packet form one information to another that crosses its pad.

As explained under 6.6 two different sources of e-information send informatons through the region between the plate and the screen.

1. Informatons that constitute the incident wave *G* which move in the direction of the *X*-axis.

2. Informatons emitted by the part of the plate that is hit by *G*. They rush through the region beyond the plate in all possible directions.

If informatons of group 1 carrying an energy packet are crossing the path of informatons of group 2, it is likely that they transfer their energy packet. This leads to the substitution of a photon by another. This transfer of an energy packet can be interpreted as the deflection of a photon.

The deflected photon will hit the screen somewhere where $E^2 \neq 0$, thus in a point of the central strip, where:

$$-\frac{\lambda}{a} < \sin(\Delta\theta) < +\frac{\lambda}{a}$$

or in another, more remote, bright strip.

One can posit that $\Delta[\sin(\Delta\theta)]$ - the uncertainty on the magnitude of the sinus of the angle of deflection - is at least $\frac{\lambda}{a}$:

$$\Delta[\sin(\Delta\theta)] \geq \frac{\lambda}{a}$$

A photon rushing to the plate has a linear momentum:

$$\vec{p} = \frac{h.\nu}{c}.\vec{e}_x = \frac{h}{\lambda}.\vec{e}_x$$

If it hits the screen in the direction $\Delta\theta$, its linear momentum beyond the split has a component parallel to the *Y*-axis:

$$p_y = p.\sin(\Delta\theta) = \frac{h}{\lambda}.\sin(\Delta\theta)$$

The uncertainty on the magnitude of $\sin(\Delta\theta)$ corresponds to an uncertainty Δp_y on the magnitude of p_y:

$$\Delta p_y \geq \frac{h}{a}$$

The photon can have gone through each point of the split: so, $a = \Delta y$ is the uncertainty on its position:

$$\Delta y.\Delta p_y \geq h$$

This equation is one of *Heisenberg's uncertainty relations*.

6.9. Something about the movement of photons in a gravitational field

In a region of an inertial frame ***O***, a gravitational field is defined by $(\vec{E}_g, \vec{B}_g)$. A photon $h.\nu$ rushes through that region. His linear momentum is: $\vec{p} = \frac{h.\nu}{c}.\frac{\vec{c}}{c}$.

According to IV, the velocity $\vec{v}$ of a point mass that is going through a point of the gravitational field $(\vec{E}_g, \vec{B}_g)$ changes at a rate defined by:

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

If we treat the photon as an ordinary point mass with velocity $\vec{c}$, it will be imposed an acceleration $\vec{a}$:

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

Only the normal component $\vec{a}_N$ - the component of $\vec{a}$ that is perpendicular to the path of the photon - is relevant: only the direction of the velocity of the photon can change, the magnitude is the constant speed of light.

a_N is related to *R* - the radius of curvature of the path - by:

$$a_N = \frac{c^2}{R}$$

So, in the point *P, R* is defined as:

$$R = \frac{c^2}{a_N}$$

In a gravitational field, the path of a photon is curved. That implies that informatons (carriers of photons) also follow curved paths in a gravitational field: a gravitational field warps the paths of informatons.

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