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REST MASS AND RELATIVISTIC MASS

Antoine Acke

In the paper GRAVITATION AND ELECTROMAGNETISM - Introduction to THE THEORY OF INFORMATONS by Antoine Acke - that is published in "The general science journal" (nov 5, 2009 - www.wbabin.net/astro/acke2.pdf) - we discussed the principles of "the theory of informatons".

In this paper we focus on the concept "mass". We explain - in the context of the theory of informatons- the difference between the rest mass and relativistic mass of an object, the equivalence mass-energy, and the gravitational equivalent of Maxwell's first law.

The expositions are excerpts from: ANTOINE ACKE - GRAVITATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE - Uitgave 2008 Nevelland - © D/2008/3988/1.

www.antoineacke.net

1. The concept "mass"

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".

The mass of an 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.

[*] In this context we have only to do with objects that are electrically neutral.

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 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.

In rule A of the "postulate of the emission of informatons* we define the relation between the mass of an object and its ability to emit informatons.

2. The postulate of the emission of informatons - rule A

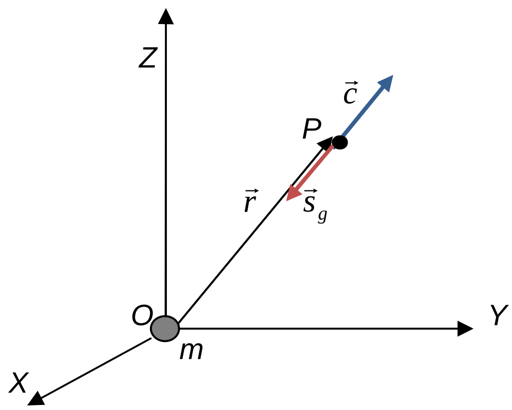

Fig. 1

We consider a material object at rest in an inertial reference frame ***O***, and we suppose that all its mass is concentrated in the origin *O* (fig 1). This implies that we identify the object with a dot and that we *neglect* its own dimensions. In ***O***, the object is a point mass at rest that, from the origin, emits information that is carried by informatons. The emission of informatons is subject to 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.*

Because the space that is connected to the inertial reference frame ***O*** is homogenous and isotropic, all directions are equivalent. That implies that the emission must be evenly distributed over all possible directions and that the velocity ($\vec{c}$) of the emitted informatons must be radial.

* GRAVITATION AND ELECTROMAGNETISM - §I.1 (www.wbabin.net/astro/acke2.pdf)

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

The rate at which a point mass emits informatons defines its magnitude.

> 3. *The constant K is equal to the ratio of the square of the speed of light (c) to the Planck constant (h):*
>
> $$K = \frac{c^2}{h} = 1{,}36.10^{50}\,kg^{-1}.s^{-1}$$

If a mass absorbs (or emits) a photon, its magnitude increases (or decreases) with a term

$\frac{h\nu}{c^2}$. Rule 3 expresses that, in that case, the rate of the emission of informatons increases (or decreases) with the frequency (ν) of the photon.

3. The rest mass of a point mass

The postulate that is formulated under 2, 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***.

The rule that defines the relation between the rest mass and the rate at which a point mass, that is anchored in an inertial reference frame, emits informatons in the space which is linked to that reference frame, may also be formulated as follows:

> *The rate* $\dot{N} = \frac{dN}{dt}$ *at which a point mass, that is at rest in the inertial frame* ***O,*** *emits informatons in the space defined by* ***O****, is related to its rest mass* m_0 *by the relation*:
>
> $$\dot{N} = K.m_0 = \frac{c^2}{h}.m_0$$

4. The relativistic mass of a point mass*

In fig 2, 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.

* GRAVITATION AND ELECTROMAGNETISM - §III.1 (www.wbabin.net/astro/acke2.pdf)

*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:*

$$\dot{N} = K_g . m_0$$

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.

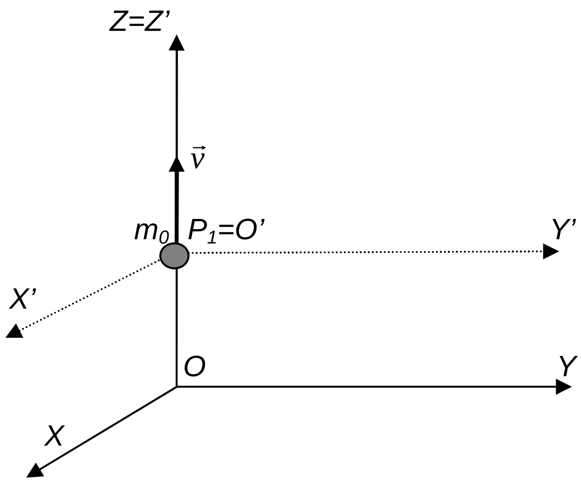

Fig 2

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:

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

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

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

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.

5. The state of motion of a point mass

In §IV of GRAVITATION AND ELECTROMAGNETISM* we show that, by accelerating relative to its eigen inertial frame, a point mass becomes blind for the disturbance of the symmetry of its g-information cloud (his gravitational field) by the gravitational field through which it moves.

The disturbance of the symmetry of the g-information cloud that the mass creates and maintains in its immediate vicinity, is relatively smaller if the cloud is more dense. The density of that cloud is determined by the rate at which the mass emits informatons in its eigen inertial frame and that rate is, according to *4*, proportional to its relativistic mass $m = \frac{m_0}{\sqrt{1-\beta^2}}$. This implies that a point mass is less sensitive to the influence of the gravitational field through which it moves, as its relativistic mass *m* is greater.

We conclude: the "inertia" of a point mass, that is its resistance against changes in its state of movement, is determined by its relativistic mass.

To characterise the state of movement of a point mass relative to an inertial frame ***O***, one introduces its *linear momentum* $\vec{p}$ *defined as:*

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

* GRAVITATION AND ELECTROMAGNETISM (www.wbabin.net/astro/acke2.pdf).

In GRAVITATIE EN ELEKTROMAGNETISME** II,§6,2 we show:

The rate of change of the linear momentum of a point mass m_0, that with velocity $\vec{v}$ moves through a gravitational field ($\vec{E}_g, \vec{B}_g$), is determined by the relation:

$$\boxed{m_0.\left[\vec{E}_g + (\vec{v}\times\vec{B}_g)\right] = \frac{d\vec{p}}{dt}}$$

$m_0.\left[\vec{E}_g + (\vec{v}\times\vec{E}_g)\right] = \vec{F}_g$ is the force exerted on the point mass by the gravitational field .

6. The equivalence mass-energy

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

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

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

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

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

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

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

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

The work done on the moving point mass equals, by definition, the increase of the energy of the mass. So, *d(m.c²)* is the increase of the energy of the mass and $m.c^2$ is the energy represented by the mass.

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

** GRAVIATIE EN ELEKTROMAGNETISME - DE INFORMATONENTHEORIE (©A. Acke - Nevelland - 2008)

7. Conservation of g-information

The informatons, emitted by a - whether or not moving - point mass are carriers of the g-information quantum s_g*. They transport g-information. The density of the flow of g-information in a point *P* (this is the rate per unit area at which the g-information flows through the surface element that is, in *P*, perpendicular on the flow of informatons) is completely characterised by the g-field strength $\vec{E}_g$.

$d\Phi_g = -\vec{E}_g.\overrightarrow{dS}$ is the g-flux througt the surface element *dS* in *P*. It is the rate at which the g-information flows through *dS* in the direction of the positive normal.

Under 4 we have posited that $\dot{N}$ - the rate at which a point mass emits informatons in the space linked to an inertial reference frame - is independent of the state of movement of the emitter and completely determined by its rest mass m_0. That hypothesis implies that the rate at which a point mass emits g-information is also independent of its state of movement, and defined by:

$$\dot{N}.s_g = K_g.m_0.s_g = \frac{m_0}{\eta_0}$$

It is evident that the rate at which m_0 emits g-information, must be equal to the g-flux passing through any closed surface that includes m_0.

So, if the closed surface *S* includes the point mass m_0, than:

$$\oiint_S \vec{E}_g.\overrightarrow{dS} = -\frac{m_0}{\eta_0}$$

This theorem (*theorem of Gauss*), that is the expression of the conservation of g-information, can be generalized:

In a point of a gravitational field where the instantaneous value of the mass density is ρ_G, the relation between the spatial variation of $\vec{E}_g$ and ρ_G is:

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

This is the *first law of the gravitational field***

Similar considerations*** in the case of the electromagnetic field lead to *Maxwell's first law.*

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* GRAVITATION AND ELECTROMAGNETISM - §I.1 (www.wbabin.net/astro/acke2.pdf)

** GRAVITATION AND ELECTROMAGNETISM - §III,6 (www.wbabin.net/astro/acke2.pdf)

*** GRAVITATION AND ELECTROMAGNETISM - §V,10 (www.wbabin.net/astro/acke2.pdf)