How a Central Field in Motion is Described in a Stationary Reference Frame

by Flavio Barbiero
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is Described in a Stationary Reference Frame

(Flavio Barbiero)

Abstract

Analysing the propagation of a flash of light with the condition of the invariance of light's speed, we obtain a set of transformation equations between a stationary RF and one in motion that are the general expression of Lorentz' equations.

According to them, motion generates a transverse spatial component, $r\left(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}\right)$, normal to the velocity *v* and to the *x*, *y*, *z* coordinates that is also present in objects contained in it. Every object in motion, therefore, possesses a "transverse" component switched along an "imaginary" direction.

We immediately verify that the magnetic field is generated by the transverse component of an electric charge in motion and that the transverse component of a rotating electron can emit a quantum of energy with all the properties of a photon.

The transformation equations show that a mass in motion possesses a component identical to the longitudinal mass introduced by Special Relativity, but they demonstrate that its value remains constant when the speed increases and therefore that it can be accelerated well beyond the speed of light, that cannot be considered an unsurpassable limit in the universe. What is increasing with the speed is the "density" of the mass, while its volume decreases, and this explains why and how a large rotating mass might collapse in a point with infinite density.

The transverse component of a mass in motion generates a gravito-magnetic field analogous to the electro-magnetic field. Thanks to it, the transverse components associated with two masses in motion attract or repulse each other according to the direction of their motion.

Rotating masses in motion possess two types of transverse components which generate gravito-magnetic fields exerting actions at galactic level so 1 important that to justify them astrophysicists have suggested the existence of huge amounts of unknown forms of matter and energy.

1 Introduction

In his work: *On the electrodynamics of moving bodies*, June 30th, 1905, Einstein analyses how the length is modified of a "rod" moving with uniform velocity in a system of co-ordinates where the equations of Newtonian mechanics are true (i.e a Cartesian system), which he calls the stationary system, in the assumption that any ray of light moves in the stationary system with the velocity *c*, whether the ray be emitted by a stationary or by a moving source.

He then measures the space of the stationary system (defined by coordinates *x*, *y*, *z*) and that of the moving system (with coordinates *x'*, *y'*, *z'*), using the rod as a measuring device; in this way he finds out that a relation exists between the coordinates of the two systems given by the formulas:

$$x = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}}; \quad y'=y\,; \quad z'=z\,; \quad t'= \frac{t - v\frac{x}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

These formulas are known as Lorentz transformation equations, having a fundamental importance in the development of Theoretic Physics.

We might ask if Einstein would have reached the same results if he had considered, instead of a one-dimensional rod, a three-dimensional object. In order to verify if the two approaches would give the same results, we will derive the transformation equations for the spherical surface upon which the photons emitted by a moving source of light are distributed, with the same starting conditions of Einstein, that is:

- a reference stationary system of Cartesian coordinates (in which the methods of Euclidean geometry are true)
- an omnidirectional source of light moving with uniform velocity *v* in that system
- a reference Cartesian system moving together with the source of light
- the rays of light moving with the same velocity *c* in both the stationary and the moving reference frames.

2 How motion modifies the space-time

2.1 Propagation of a Beam of Light in RFs in Motion with Respect to Each Other

Let us consider two observers, A and B, moving with respect to each other at a constant velocity $\bar{v}$. Suppose that in the precise instant when the observers, and therefore the origins of the respective references RFs, R_A and R_B, coincide, a flash of light is emitted from the origin in all directions.

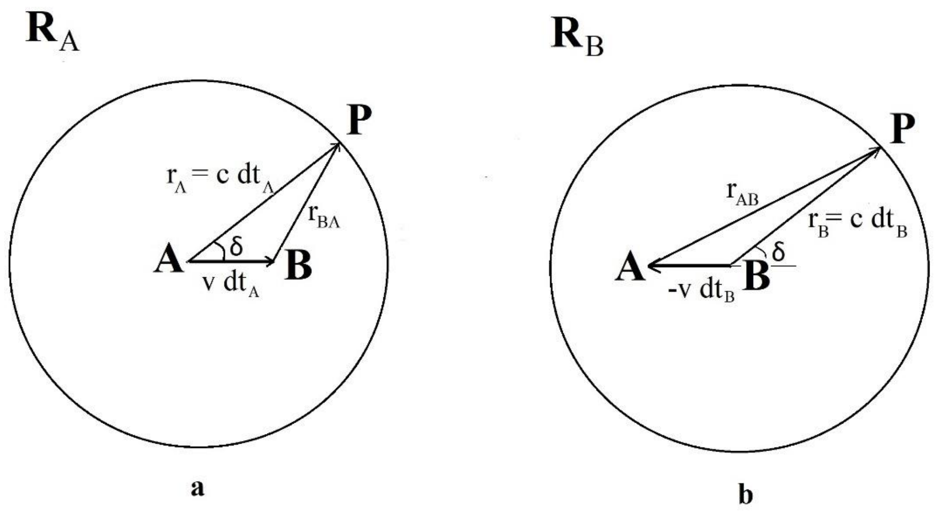

Figure 1. Propagation of a beam of light in a stationary RF, R_A, and in one in motion, R_B

The photons propagate at a same speed, *c,* in all directions in both RFs; therefore, after a while they will be distributed on the surface of a sphere whose radius is $\overrightarrow{r_A} = \mathrm{c}\frac{\overrightarrow{\mathrm{r_A}}}{r_A} dt_A$ and centre A in $\mathrm{RF_A}$, while in $\mathrm{RF_B}$ the radius is $\overrightarrow{\mathrm{r_B}} = \mathrm{c}\frac{\overrightarrow{\mathrm{r_B}}}{\mathrm{r_B}}\mathrm{dt_B}$ and the centre B.

The surface where the light is distributed is unique, but it is perceived and described by both observers respectively as in Fig.1a and Fig.1b.

Both descriptions are correct and correspond to what the two observers perceive, calculate and measure. In both RFs the laws of Euclidean geometry are valid, and therefore the centre of the sphere is unique, all its radiuses have the same length and the time needed for the light to cover them is always the same. And yet the spherical surface upon which the light is distributed, although unique, has two different centres, A and B.

This necessarily means that the structure of space-time is different in $\mathrm{RF_A}$ with respect to $\mathrm{RF_B}$. Let us see how and how much.

2.2 How a 2-D Space-Time is Modified by Motion

Let us start considering $\mathrm{RF_A}$ stationary with respect to the $\mathrm{RF_B}$ of the source of light. To better visualize the problem, we first analyse the case in which the photons are propagating on a plane, that is on a two-dimensions space-time.

After a while, they will be distributed upon a circumference with radius $\overrightarrow{r_A} = c\frac{\overrightarrow{r_A}}{r_A} dt_A$ and centre A in $\mathrm{RF_A}$ and radius $\overrightarrow{r_B} = c\frac{\overrightarrow{r_B}}{r_B} dt_B$ and centre B in $\mathrm{RF_B}$ (see Fig. 1). Let’s see in a graphic way how this could be possible.

From a geometrical point of view, A and B can have both a constant distance from the same circumference only if they are placed on a line perpendicular to the circumference's plane and passing through its centre (Fig. 2). Motion, therefore, must "create" a spatial component such as to move point B along that line.

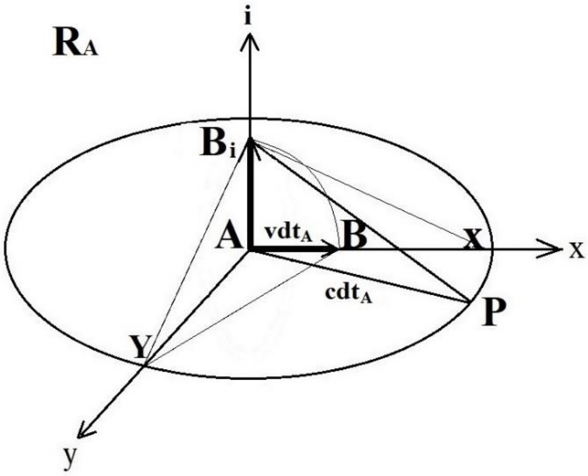

Figure 2 - Modification of the space-time in a 2-D reference frame

If A is the centre of the circle with radius $AX = c\ dt_A$, we have $\overrightarrow{AB} = \vec{v}dt_A$ and therefore $\overrightarrow{AB} = AX\frac{\vec{v}}{c}$ in the stationary RF_A; B is the position, at the time dt_A of the light's source in motion.

The only way to "force" vector $\overrightarrow{AB}$ to rotate along a line normal to both, plane *xy* and velocity $\vec{v}$, is through the following operation: $\overrightarrow{AB} \wedge \frac{\overrightarrow{AY}}{AY}$, which can be expressed in function of velocity by applying to vector $\vec{v}$ the operator "i" which makes it rotate clockwise by 90° (so, $i\frac{\vec{v}}{v}$ will coincide with $\frac{\overrightarrow{AY}}{AY}$).

The result is a vector $\overline{AB_i} = \overline{AB} \wedge i\frac{\vec{v}}{v} = AX\ \frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}$, which is directed along the imaginary line *i*, as the RF has only two dimensions.

In this way the centre of the circumference where the photons are distributed in RF_B is B_i, and all the radius $\overrightarrow{B_\iota P} = \overrightarrow{r_B}$ have the same distance from it.

Let us consider the triangle rectangle $\widehat{B_\iota AP}$; as $|\overrightarrow{AP}| = |\overrightarrow{AX}| = r_A$, we have:

$$r_B = |\overrightarrow{B_\iota P}| = |\overrightarrow{AP} + \overrightarrow{AB_\iota}| = \sqrt{\mathrm{AX}^2 + (iAX\frac{v}{c})^2} = AX\sqrt{1 - \frac{v^2}{c^2}} = r_A\sqrt{1 - \frac{v^2}{c^2}}$$

Motion, therefore, reduces the length of every radius of the circumference in RF_B.

Besides:

$$\overrightarrow{r_B} = \overrightarrow{B_\iota P} = \overrightarrow{AP} + \overrightarrow{AB_\iota} = \overrightarrow{r_A} + r_A(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}) = r_A(\frac{\overrightarrow{r_A}}{r_A} + \frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v})$$

and finally, as $c = \frac{r_A}{dt_A} = \frac{r_B}{dt_B}$, we have:

$$dt_B = dt_A \frac{r_B}{r_A} = dt_A \sqrt{1 - \frac{v^2}{c^2}}$$

In conclusion, if we put r_A=r , r_B=r', the transformation equations from the stationary RF_A to RF_B of the circumference where the photons are distributed are:

$$\overrightarrow{\boldsymbol{r}'} = \vec{\boldsymbol{r}} + \boldsymbol{r}\left(\frac{\vec{\boldsymbol{v}}}{\boldsymbol{c}} \wedge \boldsymbol{i}\frac{\vec{\boldsymbol{v}}}{\boldsymbol{v}}\right): \quad \boldsymbol{r}' = \boldsymbol{r}\sqrt{\mathbf{1} - \frac{\boldsymbol{v}^2}{\boldsymbol{c}^2}}; \quad \boldsymbol{t}' = \boldsymbol{t}\sqrt{\mathbf{1} - \frac{\boldsymbol{v}^2}{\boldsymbol{c}^2}}$$

2.3 Equivalence to Lorentz' Transformation Equations

From Fig 2 we can verify that these formulas are equivalent to Lorentz transformation equations.

In fact, $\left|\overrightarrow{B_\iota X}\right| = \frac{\left|\overrightarrow{AX} - \overrightarrow{AB}\right|}{\sqrt{1-\frac{v^2}{c^2}}}$; and because $\left|\overrightarrow{B_\iota X}\right| = x'$, $\left|\overrightarrow{AX}\right| = x$, $\left|\overrightarrow{AB}\right| = vt$, we have :

$$\mathrm{x}' = \frac{x - \mathrm{vt}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Besides $\left|\overrightarrow{B_\iota Y}\right| = \left|\overrightarrow{BY}\right|$ and therefore:

y'=y.

As for the time, its length along *x* direction is given by the time the light takes to run $\overrightarrow{AX}$, that is $t = \frac{x}{c}$, minus the time necessary to run the length $\overrightarrow{AB}$, that is $t\frac{v}{c}$:

$$\mathrm{t}' = \frac{t}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{t\frac{v}{c}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{t - x\frac{v}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}.$$

Exactly as in Lorentz' transformation equations.

2.4 How Motion Modifies a 3-D Space-Time

Let us now consider the case when a flash of light is emitted by a source moving in a three-dimensions space-time. After a time dt_A the photons will be distributed upon a spherical surface with centre A and radius $\overrightarrow{r_A} = c\frac{\overrightarrow{r_A}}{r_A}dt_A$ in RF_A and centre B with radius $\overrightarrow{r_B} = c\frac{\overrightarrow{r_B}}{r_B}dt_B$ in RF_B.

Vector $\overrightarrow{AB} = \vec{v}dt_A$ in Fig. 3 represents the distance between observers A and B in RF_A.

As we did for a 2-D space-time, in order that both, A and B, have a constant distance from the spherical surface where the photons are distributed (that is to be both at the centre of the sphere), we must rotate $\overrightarrow{AB}$ along the direction $\overrightarrow{AB_\iota} = \overrightarrow{AB} \wedge i\frac{\vec{v}}{v}$. The symbol "i" represents an operator that rotates clockwise of 90° the vector to which it is applied, $\frac{\vec{v}}{v}$; this, then, rotates in all directions laying on the plane normal to $\vec{v}$, passing through the origin (in Fig.3 the plane *yz*).

With this operation point B shifts to a position B_i.

Vector $\overrightarrow{AB_\iota}$ is perpendicular to planes *xy*, *xz* and to $\vec{v}$; therefore, it is twisted along an imaginary direction that cannot be graphically represented in a 3-D reference frame. The "point" B_i, however, is represented in Fig.3 by the circle with radius $\overrightarrow{AB_\iota}$ laying on plane *yz*, so we can obtain the transformation formulas in the same way as we did for a 2-D RF, by shifting $\overrightarrow{AB_\iota}$ through all the positions of the circle.

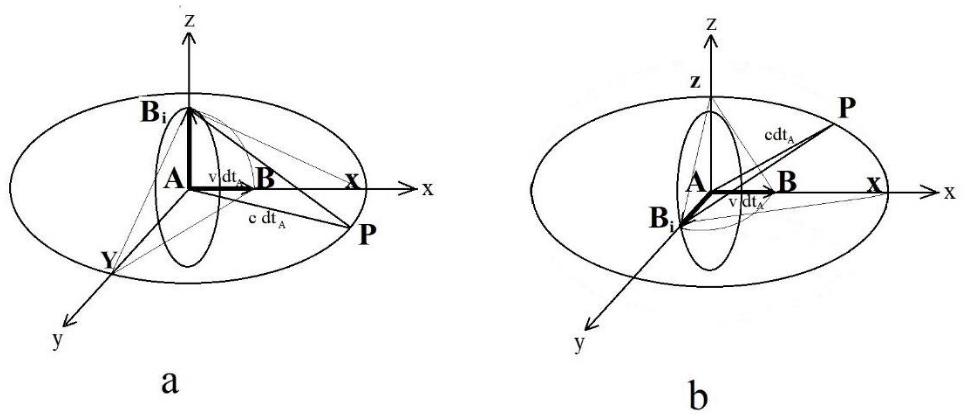

Figure 3 - Modification of the space-time in a 3-D reference frame

We have $\overrightarrow{r_A} = cdt_A = \overrightarrow{AX}$ and $\overrightarrow{AB} = \vec{v}dt_A = AX\frac{\vec{v}}{c}$, therefore $\overrightarrow{AB_\iota} = AX\,(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v})$ is the value of every radius of the circle perpendicular to $\vec{v}$ laying on plane *yz*.

For $\overrightarrow{AB_\iota}$ along the direction *z* (Fig.3,a), every radius $\overrightarrow{B_\iota P}$ of the circumference laying on plane *xy* satisfies the following relations:

$$\overrightarrow{B_\iota P} = \overrightarrow{AP} + \overrightarrow{AB_\iota} = \overrightarrow{AP} + AX\,(\frac{\vec{v}}{c} \wedge i\,\frac{\vec{v}}{v})$$

$$\left|\overrightarrow{B_\iota P}\right| = \left|\overrightarrow{AP} + \overrightarrow{AB_\iota}\right| = \sqrt{\mathrm{AP}^2 + (iAX\,\frac{\vec{v}}{c})^2} = AX\sqrt{1 - \frac{v^2}{c^2}}$$

The same relations are satisfied by the circumference of the sphere laying on plane *xz* for $\overrightarrow{AB_\iota}$ directed along *y* (Fig.3,b). And obviously they are satisfied for all circumferences laying on each plane intermediate between directions *z* and *y*, as well as for all other directions until to complete the 360° of the circle.

These are the circumferences of the sphere laying on all planes perpendicular to plane *yz* passing through axis *x*; therefore, every radius of the sphere satisfies those relations.

As $c = \frac{r_A}{dt_A} = \frac{r_B}{dt_B}$, if we put $\overrightarrow{B_\iota P} = \overrightarrow{r_A} = \vec{r}$, $\overrightarrow{AP} = \vec{r}_B = \overrightarrow{r'}$, we immediately obtain the transformation formulas of the spherical surface where the photons are distributed from RF_A to RF_B:

$$\overrightarrow{r'} = \vec{r} + \mathrm{r}\left(\frac{\vec{v}}{\mathrm{c}} \wedge \mathrm{i}\,\frac{\vec{v}}{\mathrm{v}}\right):\; r' = r\sqrt{1 - \frac{v^2}{c^2}};\quad t' = t\sqrt{1 - \frac{v^2}{c^2}} \qquad (1)$$

which are formally the same obtained for a 2 D space-time.

In the same way we can verify that they are equivalent to Lorentz equations.

It’s important, however, to highlight a fundamental difference between them: Lorentz' equations make evident the modification of lengths and times along the direction of motion, but not the fact that this modification is due to a space-time component $r\left(\frac{\vec{v}}{c} \wedge i\,\frac{\vec{v}}{v}\right)$, transverse to the motion itself. If this fact is ignored, it is unlikely that a correct insight about the effects of motion on physical reality could be reached.

3 *Relevant Questions Concerning a Space-Time Modified by Motion*

3.1 Relativity of Motion

So far, we have looked at the problem from the point of view of the stationary observer A. Let us see if something changes and how, examining the problem from the point of view of B, in motion together with the source of light.

In RF_B the light is propagating with the same velocity *c* in all directions and therefore after a time dt_B the photons will be distributed on a spherical surface with radius $\overrightarrow{r_B} = c\frac{\overrightarrow{r_B}}{r_B}dt_B$ and centre B.

The light propagates with the same velocity *c* in all directions also in RF_A and therefore we will have the same situation of a unique spherical surface with two different centres, B and A. From the point of view of B the kinematic situation will be as represented in Fig. 4, where B is the centre of the sphere and A is displaced of a value $-\vec{v}dt_B$.

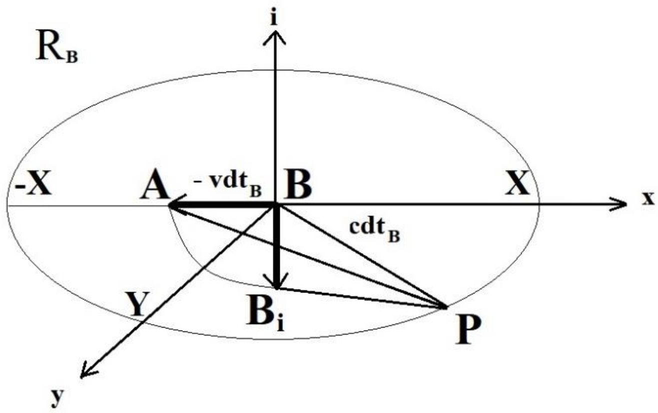

Figure 4 - The modification of the space-time is the same in the stationary and in the moving RFs with respect to each other.

Let us start also in this case from a 2-D space-time. B and A can have both a constant distance from the same circumference only if we force vector $-\vec{v}dt_B$ to rotate along a line normal to the plane of the circumference, passing through its centre, with the operation $\overrightarrow{BA} \wedge \frac{\vec{B}Y}{BY}$, which can be written in the following way $\overrightarrow{BA_\iota} = BX\,(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v})$, where the symbol "i" represents the usual operator that rotates $i\frac{\vec{v}}{v}$ clockwise of 90°, in this case along the negative y axis.

As $-\overrightarrow{BX} = cdt_B$, and $\overrightarrow{BA} = \overrightarrow{BX}\frac{\vec{v}}{c}$, the resulting vector $\overrightarrow{BA_\iota} = BX\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}$ is directed towards the bottom, along an imaginary direction.

From Fig.4 we have:

$$\left|\overrightarrow{A_\iota P}\right| = \left|\overrightarrow{BP} + \overrightarrow{BA_\iota}\right| = \sqrt{BP^2 + (iBX\frac{v}{c})^2} = BX\sqrt{1 - \frac{v^2}{c^2}}$$

$$\overrightarrow{A_\iota P} = \overrightarrow{BP} + \overrightarrow{BA_\iota} = \overrightarrow{BP} + BX\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}$$

As: $\overrightarrow{A_\iota P} = \overrightarrow{r_A}$ and $\overrightarrow{BP} = \overrightarrow{r_B}$, with the usual procedure we finally get the same results obtained considering the phenomenon from the point of view of A, with only the indexes $_A$ and $_B$ exchanged:

$$\vec{r}_A = \overrightarrow{r_B} + r_B\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}; \quad r_A = r_B\sqrt{1 - \frac{v^2}{c^2}}; \quad dt_A = dt_B\sqrt{1 - \frac{v^2}{c^2}}$$

This means that if two observers are moving with respect to each other, it doesn't matter who is stationary with respect to the other: the transformation equations from one RF to the other will be the same.

There is no difference if A is moving towards the source of light held by B or if B is moving towards A; neither if they exchange the source between them.

The paradox according to which two persons age in a different way if one of them makes a long trip outside Earth, therefore, is a false problem. Motion is relative: if A is moving away from B at a certain speed, B too is moving away from A at the same speed.

If A can check the clock of B, he will see it running slower than his; but also B will see the clock of A running slower than his. And the slowing down of time is the same if they are going one way or the other. Therefore, when A and B meet again and stop, their clocks mark the same hour, and A and B have aged of the same amount.

3.2 Does Motion Modify Objects?

From the above analysis it appears that motion does not modify the surface where the photons are distributed, but only the space in which their propagation takes place. The stationary observer, in fact, measures the radius of the sphere, and the time that the light takes to run it, reduced by a value $\sqrt{1 - \frac{v^2}{c^2}}$; this means that motion modifies the "density" of the space-time in which light is propagating.

The same happens if the observer looks at a moving object, like Einstein's "rod". In this case too motion modifies the density of the space-time in which the rod is moving and that is why its measured length is shorter. Is it a real effect or only one perceived?

The constancy of light velocity in every RF is a real phenomenon, verified by experience. Thus the modification of space-time induced by motion must be real and not a mere perception of our senses. What is modified by motion is only the space-time in which an object is immersed, but we cannot "separate" the object from its space. If the density of space changes, so does the density of the object; and if the space has a transverse component, the object too has a component transverse to the motion.

3.3 Which Space-Time is modified by Motion?

At this point a question arises: which is the space-time modified by motion? The one of the observers or of the objects and physical phenomena observed? Of observer A or B? Of the whole space-time or only of a portion of it?

From whatever point of view we look at the problem, it's always the space-time of an entity "looked at" by an observer that is changing, no matter who is stationary or in motion. The observer is the "centre" of the observed reality and his RF is the "meter" versus which all other RFs are measured.

The observer perceives and describes all the surrounding objects, whether stationary or in motion, in a unique Cartesian RF each of them with a different density and endowed of a transverse dimension according to their relative motion.

This opens the way to another question. A starting condition of this analysis was that the RFs of both observers are Cartesian. Now we discover that because of motion and, primarily, of the constancy of light speed, they are both modified with respect to each other by a space-time component transverse to the motion.

What happened to the starting condition? Are those RFs still Cartesian? The answer is yes: all the RFs, whether stationary or in motion, remain Cartesian for all observers. The additional spatial component, $r\left(\frac{\vec{v}}{c} \wedge i\,\frac{\vec{v}}{v}\right)$, has only two dimensions, laying on a plane perpendicular to the motion. We can imagine it as a "blade" that cuts the space-time of an observed object in motion, passing through it.

Does it modify its space-time? Yes, because it modifies its density in a way that we can preview and calculate. Being a "blade" with no thickness, however, it does not modify its structure. In fact, if we consider the sphere defined by photons of the initial example, its radius is shorter, but the space inside it is still Cartesian and the Euclidean geometry is still valid in it, as the centre is unique, the radius are all equal, the right-angle triangles are still right-angle, the lines still straight and so on.

This example helps us, if not to understand, at least to figure out how the perception works for an observer in a world populated by moving objects. He perceives and measures all those objects in his RF, which is Cartesian and of course unique; but each of them is “cut”, transversely to its movement, by a spatial “blade” that modifies its dimensions.

4 How a Source Generating a Central Field is Modified by Motion

4.1 Definition of Central Field

Let us first define what we intend here for central field: it is a field that “emanates” from a source A and propagates in its own Reference Frame (Cartesian) according to the following law:

$$\overrightarrow{C_o} = k\frac{A}{r^2}\frac{\vec{r}}{r} \qquad (2)$$

Such a field is equivalent to a source of light emanating photons in all directions, we assume therefore as a key condition that the field emanates from the source with the same modalities of light, thus propagating with constant velocity c independently from the state of motion of the reference frame.

Let us suppose that the source A is moving with constant linear velocity *v* and that at an instant T_o passes through the origin of the reference frame of a stationary observer, O. After a certain time dt, the field emitted from this point will be distributed upon a spherical surface where all its vectors are oriented (in one direction or the opposite) exactly towards O. Due to the starting condition, however, the same field radiates from A with constant velocity c also in the RF in motion of A, therefore after the time dt it will be distributed upon a spherical surface with all the vectors pointing towards the actual position of A (fig. 5)

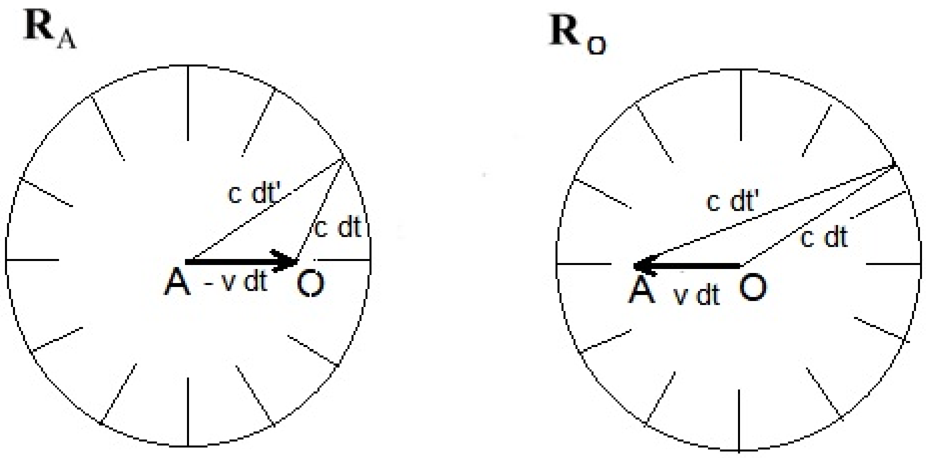

Figure 5 - Propagation of a vectorial field with respect to a stationary RF, R_O, and one in motion, R_A .

We have then the same situation found for the propagation of an omnidirectional flash of light, that is a unique spherical surface with two different centres, which means that the space-time in the stationary RF is different from that of the RF in motion in the same way and therefore the same transformation equations (1) are applicable.

Replacing them in relation (2) we obtain how the field of a source A in motion is perceived by the stationary observer O:

$$\vec{C} = k \frac{A}{r^2\left(1-\frac{v^2}{c^2}\right)} \left(\frac{\vec{r}}{r} + \frac{\vec{v}}{c} \wedge i \frac{\vec{v}}{v}\right) \qquad (3)$$

From a physical point of view relation (3) expresses the fact that vector OA (fig.5b) is “switched” for a value $\frac{\vec{v}}{c} \wedge i \frac{\vec{v}}{v}$ along an “imaginary” direction normal to $\vec{v}$ and to the three axis *x*, *y*, *z*; which means that the source A is “displaced” of a value v/c outside the three-dimensional RF of the observer in a fourth spatial dimension. This conclusion is unavoidable if really the propagation of the field is invariant with respect to the RF.

A four-dimensional space-time cannot be represented graphically, therefore we are not able to visualise how a field propagates in it. However, we can have a precise idea on how it interferes with the three-dimensional RF of the observer by examining how a field emanating from a 3_D space interferes with a 2-D RF. (fig 6)

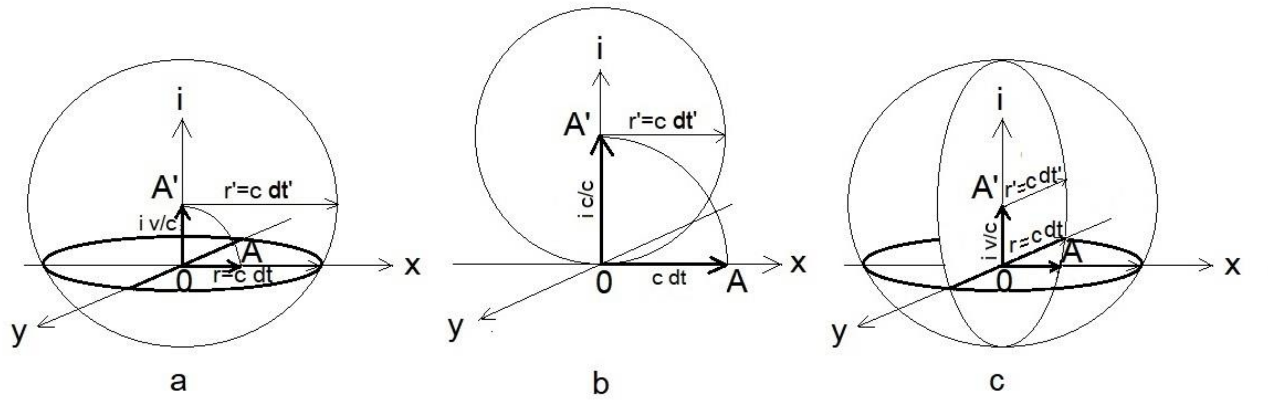

Figure 6: How the field of a source A emanating from a 3-D RF intersects a 2-D RF

In a 2-D RF the observer, O, and the source of the field in motion, A, can have both a constant distance from the circumference where the field is distributed only if they are placed on a line perpendicular to the center of that circumference. Motion, therefore, must "rotate" vector OA along an imaginary direction, normal to v and to both axis x and y. This means that the source of the field is shifted in a position A' outside the 2-D space-time, in a RF of superior order (fig. 6).

In this 3-D space the field emanates from A' along three directions, therefore generating spherical surfaces that expand with velocity c. Each spherical surface intersects the 2-D RF forming a circle that expands from O (stationary observer) with the same speed c, but with a radius which is shorter than that of the spherical surface emanating from A'.

We are not able to represent a field expanding in a 4-D space-time, but from the example of fig.6a we must deduce that it intersects the RF of a lower order, that is the 3-D RF of the stationary observer, forming a spherical surface, propagating from O with speed c and with a shorter radius $r = r'\sqrt{1-\frac{v^2}{c^2}}$.

This means that the "density" of the space-time of the RF in motion increases with the increase of the speed of A, to become infinite when v=c, but in the same time the value of r is reduced to zero (fig. 6b).

4.2 Longitudinal and Transverse Fields

Relation (3) shows that the field emanated from a source A in motion has two different components in the RF of the stationary observer. I will call the first "longitudinal" field, to distinguish it from the second which is rightly named "transverse" field, as it is transverse to the motion.

The longitudinal field is defined as follows:

$$\overrightarrow{C_L} = k \frac{A}{r^2\left(1-\frac{v^2}{c^2}\right)}\left(\frac{\vec{r}}{r}\right)$$

This relation shows that the observer describes this field as if it was emanated by a stationary source A, but he perceives that source with a different value:

$$A' = \frac{A}{1-\frac{v^2}{c^2}}$$

Apparently, then, the value of the source increases with the speed to become infinite when v=c. From fig.6, however, it is evident that the value of A does not change, because it is instead the space-time of the RF of A in motion that “shrinks” when the speed increases. As a consequence also the volume of the source shrinks.

Therefore, what the stationary observer perceives is that the “density” of the source A increases with the increase of the speed, while its volume decreases. For v = c the density becomes infinite and the volume is reduced to a point.

Can the source A surpass the velocity of light? If A is a mass, according to Special Relativity its value becomes infinite when its speed matches that 13 of light and therefore an infinite amount of energy is necessary to reach this level for whatever initial value of A; as a consequence the speed of light is considered a limit that nothing can surpass in the universe.

We have seen, instead, that it is not the value of the mass that is increasing, but its density. From a mathematical point of view, therefore, nothing prevents the velocity of the source to surpass that of light, as nothing prevents a flying object to surpass the velocity of sound.

In absence of braking factors the amount of energy necessary to accelerate the source is proportional to the increment of its velocity. To reach an infinite velocity, an infinite amount of energy is necessary, but as the speed of light is finite also the energy necessary to reach this level is finite. For a mass, this amount must be equivalent to the kinetic energy acquired during this process.

What happens if the source overtakes this limit? From fig. 6 we see that at this point the field emitted by A’ stops to interfere with the stationary RF, which means that the source “exits” the space-time of the observer and continues to move in the hyperspace, presumably unaffected.

4. 3 The Transverse Field

Besides the longitudinal central field, the observer perceives the existence of a completely different one:

$$\overrightarrow{C_T} = k \frac{A}{r^2\left(1-\frac{v^2}{c^2}\right)}\left(\frac{\vec{v}}{c} \wedge i \frac{\vec{v}}{v}\right)$$

Vector $(\frac{\vec{v}}{c} \wedge i \frac{\vec{v}}{v})$ has a module $\frac{v}{c}$ and indicates the direction of $\overrightarrow{C_T}$, which is a field that "radiates" from A along a plane perpendicular to $\vec{v}$. It is therefore a field transverse to the motion. In the example of fig. 6 this field propagates with velocity c from the source A' along a plane normal to $\vec{v}$, forming circumferences that intersect the 2-D RF along a line, that is axis y. We then deduce that the transverse field propagates in the 4-D space-time along three directions, forming spherical surfaces which intersect the 3-D RF of the observer forming circumferences propagating along a plane perpendicular to the motion at the same speed c but with the radius $r = r'\sqrt{1-\frac{v^2}{c^2}}$.

What we said for the longitudinal field applies also to the transverse one, that is that the density of the source increases with the velocity while its radius shrinks down to zero when v=c. Beyond this limit the source "exits" the space-time of the observer and therefore its field does not interfere with it anymore.

4.4 Field of Forces

The vectors of field C become forces when besides the source A we introduce a second source a of the same nature. If they are both stationary, they attract or repulse (according to their nature and sign) each other with a force which value is given by the following relation:

$$\overrightarrow{F_o} = k\frac{A\,a}{r^2}\frac{\vec{r}}{r} \qquad (4)$$

where r is the distance between them .

Let us consider the general case, when both A and a are moving with respect to the stationary RF of the observer with velocities v_A and v_a. Each of them will have a longitudinal and a transverse component and therefore applying the transformation equations to relation (4) we will have:

$$\vec{F} = \frac{k}{r^2}\frac{A}{(1-\frac{v_A^2}{c^2})}\frac{a}{(1-\frac{v_a^2}{c^2})}\frac{\vec{r}}{r} + \frac{k}{r^2}\frac{A}{(1-\frac{v_A^2}{c^2})}\left(\frac{\overrightarrow{v_A}}{c} \wedge i\frac{\overrightarrow{v_A}}{v_A}\right)\frac{a}{(1-\frac{v_a^2}{c^2})}\left(\frac{\overrightarrow{v_a}}{c} \wedge i\frac{\overrightarrow{v_a}}{v_a}\right)$$

We have then two quite different components of the force. The first

$$\overrightarrow{F_L} = \frac{k}{r^2}\frac{A}{(1-\frac{v_A^2}{c^2})}\ \frac{a}{(1-\frac{v_a^2}{c^2})}\frac{\vec{r}}{r} \qquad (5)$$

is a force (attractive or repulsive, according to the nature and sign of the source) directed along the line $\vec{r}$ joining the longitudinal components of the sources, and therefore can be called “longitudinal” force. Its value depends not only on the distance between them but also on the value of their respective velocities, no matter what their direction is.

To the stationary observer this force appears to be always stronger than that of relation (4), when the two items are also stationary. This might look awkward, as we know that the value of A and a are not increasing with the speed, but it can be explained considering that it is the measure of the space-time, therefore the distance r between them, that is shrinking with the speed, which make the force look stronger.

The second component

$$\overrightarrow{F_T} = \frac{k}{r^2}\frac{A}{(1-\frac{v_A^2}{c^2})}\left(\frac{\overrightarrow{v_A}}{c}\wedge i\frac{\overrightarrow{v_A}}{v_A}\right)\ \frac{a}{(1-\frac{v_a^2}{c^2})}\left(\frac{\overrightarrow{v_a}}{c}\wedge i\frac{\overrightarrow{v_a}}{v_a}\right)$$

is a force exerted between the transverse components of the sources, which are vectors directed along “imaginary” directions.

The module of this force is given by the scalar product of these vectors and therefore:

$$\boldsymbol{F_T = X\ \cos\alpha} \qquad (6)$$

Where: $X = \frac{k}{r^2}\frac{A}{(1-\frac{v_A^2}{c^2})}\frac{v_A}{c}\ \frac{a}{(1-\frac{v_a^2}{c^2})}\frac{v_a}{c}$ and $\boldsymbol{\alpha}$ is the angle between the two imaginary vectors, evidently the same between $\vec{\boldsymbol{v}}_{\boldsymbol{A}}$ e $\overrightarrow{\boldsymbol{v_a}}$. Therefore, the value of $\boldsymbol{F_T}$ would be positive or negative (or viceversa) or even nil according to that angle.

Concluding, while the longitudinal force is always positive (or negative, according to the nature and sign of the source) whatever the state of motion of the two items, the transverse force depends not only on the value of the respective velocities, but also on their direction, and can be positive or negative if these are concordant or discordant, or nil if they are normal to each other.

5 *The Electro-Magnetic Field*

The field produced by a stationary electric charge is:

$$\vec{E}_o = \mathrm{k}\frac{Q}{r^2}\frac{\overline{\mathrm{r}}}{\mathrm{r}}$$

If the charge is moving, a stationary observer perceives this field in a space-time modified according to the transformation equations:

$$\vec{E} = k\frac{Q}{r^2\left(1-\frac{v^2}{c^2}\right)}\left(\frac{\vec{r}}{r}+\frac{\vec{v}}{c}\wedge i\frac{\vec{v}}{v}\right)$$

To simplify the formulas, we examine the case when v << c , so the term v^2/c^2 can be ignored; we will have then:

$$\vec{E} \cong \vec{E}_o + k\frac{Q}{r^2}\left(\frac{\vec{v}}{c}\wedge i\frac{\vec{v}}{v}\right) \qquad (7)$$

This formula evidences the existence of two completely different types of field; the first one is a “central” field produced by the charge Q; the second one is a field transverse to the motion, due to the transverse charge $Q\left(\frac{\vec{v}}{c}\wedge i\frac{\vec{v}}{v}\right)$.

We immediately verify that

$$\vec{H} = k\frac{Q}{r^2}\left(\frac{\vec{v}}{c}\wedge i\frac{\vec{v}}{v}\right)$$

coincides with the magnetic field generated by the motion of charge Q:

$$\vec{H} = k\frac{Q}{r^2}\frac{1}{c}\left(\frac{\vec{ds}}{dt}\wedge i\frac{\vec{v}}{v}\right) = h\frac{I}{r^2}\left(\overrightarrow{ds}\wedge i\frac{\vec{v}}{v}\right),$$

$$H = h\frac{I}{r^2}ds$$

where $I = \frac{Q}{dt}$ has the dimension of an electric current and $h = \frac{k}{c}$ is the electrostatic constant divided by the speed of light (this was the starting point for Maxwell to develop his famous equations).

The field produced by a single electric charge in motion does not coincide with the magnetic field as we know it, because it is a 2-dimensional field radiating from Q along a plane normal to the motion (vectors $\vec{H}$ and $i\frac{\vec{v}}{v}$ lay on a plane normal to $\vec{d}s$ and are perpendicular to each other).

A 3-dimensional magnetic field will be produced only by a continuous flow of electric charges, that is by an electric current I along a wire. The sum of the 2-dimensional fields generated by the single electric charges forms a 3-D magnetic field, the lines of force of which are circumferences on planes normal to the wire.

The value of a field produced by an electric current in a point P at a distance d from the wire can be calculated by summing the fields produced by every single element I ds for the total length of the wire:

$$dH = h\frac{I}{r^2}ds.\sin\alpha \qquad (8)$$

where *r* is the distance of the element *ds* from point P, while α is the angle between the directions ds and *r*.

This formula is the same that Laplace, starting from the results by Biot and Savart's experiments, designed with the purpose of calculating the magnetic field produced by an electric current flowing in a circuit of whatever form.

Integrating that formula for a straight wire of infinite length we obtain:

$$H = \frac{2hI}{d} \qquad (9)$$

where *d* is the distance from the wire.

From relation (6) we know that this field exerts a force only vs. items of the same nature, that is electric charges in motion, and that the value of that force depends on the angles between the directions of their motion. Therefore, it does not exert any force vs a parallel wire with no current flowing in it, no matter how huge its electric static charge is. But if there is some electric current in it, the field attracts or repulses the wire according to the direction of the respective currents. This force decreases if we rotate one of the two wires until becoming nil when they are perpendicular to each other.

These are exactly the results of Biot and Savart's experiments, from which the actual magneto-electric theory started. They confirm that the magnetic field is produced by the flow of the transverse charges $Q\left(\frac{\vec{v}}{c}\wedge i\frac{\vec{v}}{v}\right)$ which are always and only associated with electric charges in motion.

If we have an electric current circulating in a coil with radius *r* we have at its centre:

$$H = \frac{2\,\pi h I}{r} \qquad (10)$$

which is a field directed along the axis of the coil. It is then a polarised field, with a positive and a negative side. Two coils put in front to each other attract or repulse each other according to the direction of the current flowing in them. A coil run by an electric current, therefore, is the equivalent of a magnet.

The force exerted by a magnetic field $\vec{H}$ vs a charge q in motion has been determined experimentally in the following way:

$$\vec{F} = kq\left(\vec{v} \wedge \vec{H}\right)$$

which is a force directed transversely with respect to the motion of q, thus demonstrating that it is exerted directly versus the transverse charge $q\left(\frac{\vec{v}}{c} \wedge i\,\frac{\vec{v}}{v}\right)$.

Finally, alternate electric currents produce an alternate magnetic field with the well known characteristics of the electro-magnetic fields.

6 The Gravitational Field

6.1 Field of a Mass in Motion

The gravitational field for a stationary mass is given by:

$$\overrightarrow{G_o} = k\frac{M}{r^2}.\frac{\vec{r}}{r}$$

If the mass is moving, for the transformation equations (3) we have:

$$\bar{G} = \frac{k}{r^2}\frac{M}{\left(1-\frac{v^2}{c^2}\right)}\frac{\vec{r}}{r} + \frac{k}{r^2}\frac{M}{\left(1-\frac{v^2}{c^2}\right)}\left(\frac{\vec{v}}{c} \wedge i\,\frac{\vec{v}}{v}\right)$$

From the above formula we can see that the field produced by a mass in motion is perceived by the stationary observer with two quite different components.

The first

$$\overrightarrow{G_L} = \frac{k}{r^2}\frac{M}{\left(1-\frac{v^2}{c^2}\right)}\frac{\vec{r}}{r}$$

produced by the "longitudinal" mass, is a field that propagates in the RF of the observer with the same law of a stationary central field, but with a value of the mass apparently increased: $M_L = \frac{M}{1-\frac{v^2}{c^2}}$.

The second

$$\overrightarrow{H_G} = \frac{k}{r^2}\frac{M}{\left(1-\frac{v^2}{c^2}\right)}\left(\frac{\vec{v}}{c}\wedge i\frac{\vec{v}}{v}\right)$$

produced by the "transverse" mass, is a two-dimensional field that propagates along a plane normal to the motion with no thickness in the observer's RF.

6.2 Longitudinal Mass and Black Holes

The concepts of "longitudinal" and "transverse" mass were introduced by Lorenz, who defined them not as physical masses, but as "*the ratio of force to acceleration*" and therefore he needed to distinguish between the mass parallel to the direction of motion (longitudinal) and the mass perpendicular to it (transverse).

In his work of 1905 Einstein calculates their value for an electron moving in an electro-magnetic field, utilizing the formula $f = ma$. For the longitudinal mass he finds the following value:

$$F = M\ \frac{d^2r}{dt^2} = \frac{M}{1-\frac{v^2}{c^2}}.\frac{\sqrt{1-\frac{v^2}{c^2}}}{1-\frac{v^2}{c^2}}a = \frac{M}{\sqrt{\left(1-\frac{v^2}{c^2}\right)^3}}\ a$$

From relations of this kind he makes the conclusion that the value of the mass increases with the speed and becomes infinite when v = c, that to accelerate a mass to the speed c an infinite amount of energy is needed and that for this reason nothing in the universe can surpass the speed of light.

We have seen in paragraph 4.1, instead, that it is not the value of the mass that is increasing with the speed but its density, while its volume shrinks.

The amount of energy necessary to accelerate a mass to a speed v is proportional to the increase of its kinetic energy. Therefore, to accelerate a mass from 0 to c the energy is ½ M c^2. At this speed the density of the mass becomes infinite, but its volume is reduced to zero.

There is in nature a physical phenomenon capable of accelerating the speed of mass up to the light's speed, that is the shrinking of a rotating mass. Astrophysicists maintain that at the end of their life stars with a mass around two solar masses collapse reducing their diameter to about 15 km. In this process their density becomes extremely high as well as their rotational speed, that can become of the order of thousands of turns per second. They are called "neutrons stars". However, if a star has a mass larger than two solar masses, the astrophysicists say that it collapses in a "black hole", where the entire mass is concentrated in a point with infinite density.

Why and how this happens? In a rotating star the mass at its equator is moving with velocity v = ω r, where r is the distance from the axis of rotation. If, for example, a star has a diameter of 16 km and a rotational speed of 6,000 turns per second, the matter along its equator is moving with a velocity almost equal to that of light, therefore its density tends to infinity, thus reducing its volume, which makes the star shrinking with consequent increase of its rotational speed. More matter, then, reaches a velocity near that of light, thus reducing its volume with consequent acceleration of the rotational speed and so on and on until the whole matter reaches the speed of light and an infinite density, but at this point its volume is reduced to zero. We have then a black hole.

What happens to the star at this point it is not clear. If a mass is moving along a line, when it reaches the speed of light it "exits" the space-time of the observer and it continues to move in the hyperspace presumably unaffected. In this case, instead, the mass reaches the speed of light thanks to a rotation, which does not move the mass away from the observer. Besides, once it reaches the dimension of a point, we cannot imagine that it can shrink even more. It might be, then, that a black hole could remain forever at the edges of the observer's RF.

6.3. The Transverse Mass and the Gravito-Magnetic Field

In his work of 1905 Einstein calculates the value of the transverse mass of an electron in the same way he calculates the value of the longitudinal mass, obtaining:

$$M_T = \frac{M}{1 - \frac{v^2}{c^2}}$$

However, its value cannot be calculated in that way because the dimension of the transverse mass along the direction of the motion is nil.

In the scientific literature (see for example: Cinquant'anni di relativit`a, Editrice Universitaria, Firenze, 1955) we often find a different value:

$$M_T = \frac{M}{\sqrt{1 - \frac{v^2}{c^2}}}$$

These differences are due to what seems to be a limit of Lorentz transformation equations, which do not make evident the fact that the deformation of space-time induced by motion is owed to a spatial component "transverse" to it, found also in the objects that "occupy" that space. If this fact is ignored, the physical meaning of the transverse mass cannot be understood.

The transverse mass is defined as "*the ratio of the accelerating force to the acceleration when the acceleration is perpendicular to the line of motion*"; an elegant way to avoid the answer to the simple question: what is the physical nature of that mass? A "*ratio*" is an abstract mathematical concept, while the transverse mass has a precise physical meaning, expressed in the following relation that describes the field that it produces:

$$\overrightarrow{H_G} = \frac{k}{r^2}\frac{M}{\left(1-\frac{v^2}{c^2}\right)}\left(\frac{\vec{v}}{c} \wedge i\,\frac{\vec{v}}{v}\right)$$

To simplify the formulas, we consider the case when $v \ll c$ so the term $\frac{v^2}{c^2}$ can be ignored, hence obtaining:

$$\overrightarrow{H_G} \cong k\frac{M}{r^2}\left(\frac{\vec{v}}{c} \wedge i\,\frac{\vec{v}}{v}\right) = \frac{h}{r^2}\frac{M}{dt}\left(\vec{d}s \wedge i\,\frac{\vec{v}}{v}\right)$$

where $h = \frac{k}{c}$ is the gravitational constant divided by the speed of light.

This field is the exact equivalent of that produced by an electric charge in motion. It is a 2-dimensions field which radiates from M along a plane normal to the motion.

A 3-dimensions field in the RF of the observer is produced only by a continuous flow of masses which can be achieved, for example, making water flowing in a pipe. In this case through each segment *ds* of the pipe flows a quantity $\frac{M}{dt}$ of water that we can define "*current of mass*", I_G, in analogy with the electric current.

For a straight pipe of indefinite length, the value of the field at a distance *d* from the pipe calculated with Laplace's formula (8) is:

$$H_G = \frac{2hI_G}{d} \qquad (11)$$

We have seen in paragraph 4.4 that this field exerts actions only versus entities of the same type, that is transverse masses associated with masses in motion, and that their value depends on the angle between the direction of their respective motions.

Therefore, two parallel pipes in which water flows attract or repulse each other according to the direction of the flows, exactly as two electric wires.

No actions are exerted on the matter of the pipes or on stationary masses nearby, because the. force is exerted only vs the transverse mass associated with the water in motion.

The same happens if we coil two pipes and put one in front of the other. The field produced by each of them is normal to the flow, therefore it is directed along the axis of the coil, and has the following value:

$$H_G = \frac{2\pi h}{r} I_G \qquad (12)$$

where *r* is the radius of the coil.

The force exerted between the two coils is attractive or repulsive according to the direction of their respective flows.

Of course, the intensity of that force is so weak that it would be impossible to realize an instrument capable of measuring it, but we can increase that force by utilizing heavy materials and high speeds.

A metallic ring rotating with angular speed ω is equivalent to a coil run by a current of mass, $I_G = M \omega r$, which might be large enough to produce measurable forces between two rotating rings placed one in front of the other. The field produced by each of them is directed in the same direction of ω and therefore the force is attractive or repulsive according to their rotation. The same happens if we face to each other two spherical rotating masses.

It is important to note that two rotating masses attract or repulse each other with the same force at whatever distance, even infinite, provided that their axis of rotation are perfectly aligned.

The lines of flux of the field produced by a rotating body is more or less the same usually represented for the magnetic field produced by a current circulating in a spire, that is lines coming out from the positive pole and closing through the negative. There is a fundamental difference, however.

In a rotating body each elementary particle produces a field which radiates from it along a plane normal to the velocity, therefore aligned with the axis of rotation. To each particle corresponds on the other side of the axis another particle which is moving in exactly the opposite direction, thus producing a field on the same plane, but with opposite rotation of the lines of flux. The field produced by each of them, therefore, is reduced in all directions but one, that of the axis of rotation. The field produced by the sum of all particles, therefore, has the strongest value along this direction and what is more important the lines of flux are all parallel to the axis and propagate in that direction indefinitely all together, without diverging.

We have then a field which propagates indefinitely without attenuation inside a “cylinder” with the same diameter of the rotating body.

6.4 Differences between Longitudinal and Transverse Masses

The longitudinal and transverse masses are strictly associated and indivisible in every mass in motion, but their physical characteristics are completely different.

To begin with, the longitudinal mass has inertia, while the transverse does not.

The longitudinal masses generate a central field and always attract each other according to Newton's law, while they do not exert any direct action versus the transverse masses.

The transverse masses, instead, generate a 2-dimensional field, transverse to the motion, which can be considered 3-dimensional, but not central, in case of a continuous flow, like in rotating bodies. They do not exert any direct action versus the longitudinal masses, but exert repulsive or attractive actions, according to the direction of their motion, versus other transverse masses.

However, as they are strictly associated in every mass in motion, an action exerted versus one of them inevitably provokes a variation of value or motion of the other. There is a continuous interaction between them. For example, if a mass is moving in a gravito-magnetic field, the transverse mass is subject to a force normal to the motion, and therefore to an acceleration proportional to the speed and normal to it, "dragging" together also the longitudinal mass.

6.5 Dark Matter and Dark Energy

For the motion on a straight line the transverse mass is:

$$M_T = \frac{M}{1 - \frac{v^2}{c^2}} \cdot \frac{v}{c} \cong M \frac{v}{c}$$

For a rotating body with radius *r* we have:

$$M_T \cong M \frac{\omega r}{c}$$

These two types of transverse mass produce fields with a different structure and a different range of action. A rotating body in motion is associated with both transverse masses and produces both types of field.

The first one produces a 2-dimensions field transverse to the motion, that becomes 3-dimensional for a continuous flow, i.e. a "current" of masses. This field acts only vs masses in motion with a force that decreases linearly with the distance and which value can be positive or negative according to the direction of the respective motions.

The second is equivalent to a flow of matter in a close circuit and therefore produces a polarized field that propagates indefinitely without attenuation inside a cylindrical volume with the same diameter of the rotating body.

A rotating body in motion is associated with both transverse masses and produces both types of field that exert actions vs surrounding masses in motion and are in their turn subject to actions from them.

The forces exerted by these two types of transverse mass are by far smaller than the Newtonian forces exerted by the longitudinal masses, but in any case they produce detectable effects both at microscopic and macroscopic levels.

It is a well-known fact that an electron moving in an electro-magnetic field is subject to a force that is normal to the direction of motion. A theoretic explanation of this phenomenon has not been provided yet, but it is thanks to it that the transverse mass of the electron has been determined through experimental measures.

At macroscopic level the phenomenon has not been observed through experiments, but it can be evaluated monitoring the movements of the stars in the galaxies and that of the galaxies in the universe.

The speed of the stars at the outskirts of a galaxy should decrease with the distance from the center according to the third law of Kepler (from which Newton's law has been deduced). Astronomical measures, instead, have ascertained that this is not happening, because after a certain point the speed of the stars does not decrease and becomes constant.

To explain this phenomenon several hypotheses have been proposed the most successful of which among scientists suggests that it should be provoked by the presence of huge amounts of undetectable mass, the so called "dark matter", that would constitute no less than 90% of the matter of the whole universe.

A simpler explanation can be found if we consider that a flow of masses produces a transverse gravito-magnetic field which intensity decreases linearly with the distance and which exerts an attractive or repulsing force vs masses of the same nature (that is in motion) according to the direction of their motion.

In a galaxy we have billions of stars moving around a centre of gravitation. Each flow of stars produces a gravito-magnetic field that attracts all the stars flowing in the same direction with a force that decreases in a linear way with the distance, thus balancing after a certain point the centrifugal force. From this point on, the velocity of the stars becomes constant.

The transverse field produced by rotating bodies is of no less importance at galactic level. Rotation realizes a continuous flow of matter in a close circuit and produces a polarized field which propagates indefinitely along the direction of ω, with no attenuation. Every star (and planet) rotates around 24 itself, thus producing this type of field. Clusters of stars rotating in the same direction would produce transverse fields strong enough to influence the motion of other stars even at the longest distance.

Besides, a galaxy is formed by billions of stars rotating around the same axis, therefore it can be assimilated to a gigantic rotating ring which produces a transverse field directed along its axis of rotations, that propagates indefinitely with no attenuation in a beam with the same diameter of the galaxy.

All rotating bodies exert actions towards each other that should be carefully evaluated before claiming the existence of some mysterious dark energy able to explain them.

6.6 Gravito-Magnetic Waves

Finally, a not negligible aspect that might have future technological developments, is the fact that an alternate flow of masses generates an alternate transverse field, equivalent to that generated by an alternate electric current. In theory, therefore, it should be possible to generate gravito-magnetic waves obeying to physical laws analogous to those of the electro-magnetic waves.

There are in the universe phenomena that generate alternate gravito-magnetic waves, eg. the pulsating stars.

These stars, quite common in the universe, besides rotating around themselves, for some reason pulse with a constant frequency that goes from 5 hours to several days. Now, when the star shrinks its rotational velocity increases and decreases again when it rebounds. The main rotation of the star produces a field which propagates indefinitely along the ω with no attenuation inside a cylindric volume with the same diameter of the star. When the star starts pulsating with frequency Ω, the rotational speed ω varies with the same frequency, thus producing alternate gravito-magnetic waves which propagate along that cylinder carrying away the energy that is dissipated in the pulsing process.

For stars of the same size the amount of energy dissipated with each wave is proportional to the frequency of the pulsations. Therefore, it is a process through which a star expels a certain amount of energy in a precise direction by means of a train of gravito-magnetic waves that propagate indefinitely “confined” in a cylinder with the same diameter of the star.

6.7 How a Photon is Emitted

Is that the same for an electric charge? In an electron the charge is always associated with a mass. The theory says that in certain conditions the electron emits a quantum of energy with the characteristics of a photon. How can this happen?

We do not know how the charge is connected to the mass of the electron, but we can reasonably assume that it participates to every motion of the mass and therefore also to its rotation. As every electron rotates around itself, also the charge connected to it must rotate, thus generating a transverse field propagating indefinitely in the same direction of the axis of rotation inside a cylinder with the same diameter of the charge.

Suppose that for some reason the mass starts pulsating with frequency ν. Its velocity of rotation will vary with the same frequency dragging together the charge, which will generate alternate transverse waves.

We will have then a train of waves carrying away the energy dissipated by the electron in the pulsating process with all the characteristics of a photon: it is undoubtedly made by electro-magnetic waves, but at the same time it can be assimilated to a corpuscle, because it is contained in a beam with the same diameter of the electron, that propagates indefinitely with no attenuation and has an energy that can be assimilated to the kinetic energy when hitting a target, but the value of which is proportional to the frequency of the waves. All characteristics that have been ascertained through ad hoc experiments.

But there is more about it. Some experiments highlight strange behaviours of photons which defy common sense, as if they could have instant connections through a means outside the space-time of the observer. At this purpose we must not forget that the electro-magnetic waves are produced by transverse charges and that a transverse charge is "displaced" along an imaginary direction, that is a fourth spatial dimension, from where the photon is emitted.

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