Mass and energy in the fundamental theory of space and time*

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Abstract

As we have seen in previous papers [1,2], the space-time transformations derived from the Lorentz postulates conceal hidden variables. So, a priori, they seemed at variance with the law of variation of mass with speed $(m = m_0\gamma)$.

At first sight this result appeared as an important objection against the Lorentz assumptions, but we demonstrate here that the objection can be overcome.

Now, we will realize that the law $m = m_0\gamma$ would be completely exact exclusively if the observer who makes the measurement were at rest in the aether frame. It is only approximately exact when the measurement is made from the Earth frame, whose speed with respect to the aether frame is weak in comparison with the speed of light.

Some results of this approach differentiate completely the fundamental aether theory from the conventional theory of relativity.

I. Introduction

As demonstrated in ref [1], the Lorentz-Poincaré transformations conceal hidden variables. This is also the case for the fundamental extended space-time transformations studied in ref [2]. In effect, after correction of the systematic errors of measurement due to length contraction, clock retardation and imperfect clock synchronization, they reduce to the Galilean relationships, $x' = x \pm vt$, $t' = t$.

This poses a problem: if the real transformations are the Galilean relationships, the total relativistic momentum, in the course of a collision, is not conserved in any inertial frame. But this law of conservation is considered as a necessary condition to demonstrate $m = m_0\gamma$. This seems, a priori, an important objection against the fundamental approach based on the Lorentz postulates, which, at first, rendered them suspect to us [3].

Nevertheless, in ref [4] and [5], we have become aware that the relativity principle can be refuted, and, for this reason, the laws of physics must not be perfectly invariant. Then, there is no necessity for the total relativistic quantity of motion to be exactly conserved in any inertial frame.

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This, I realize, will surprise the readers and needs an explanation: in fundamental theories, an aether wind exists which blows the opposite way from the absolute motion of the reference frame in which the collision occurs.

In the course of the collision (between marbles or particles), these are slowed down by the aether wind, and therefore their total quantity of motion cannot be exactly the same before and after the collision.

This is particularly true when the particles move at high speed with respect to the aether frame ($V>10^5$ km/sec), but, at low speeds ($V<<C$), the action of the aether wind should, most often, be ignored. (It is probably for this reason that the aether wind does not perceptibly disturb the orbital motion of the Earth).

Note that, if the total quantity of motion is not conserved, the so called "law of conservation of the total relativistic momentum" can be used, neither to demonstrate $m = m_0\gamma$, nor to disprove it. In fact, using other arguments, we will demonstrate that the law $m = m_0\gamma$ applies, but as we will see later, contrary to relativity, m_0 is the rest mass in the fundamental frame: it is not the rest mass in all inertial frames.

For the following it is important to note that, in the particular cases where the total quantity of motion is conserved, the conservation must be effective for all observers, no matter if they are at rest or in motion with respect to the system in which the collision occurs (see the example given below).

This fact will be used to demonstrate the law $E = mC^2$. We will not refer to relativistic arguments for this. Then we will deduce $m = m_0\gamma$.

II. Demonstration of $E=mC^2$ without relativistic arguments

Consider a body at rest in the fundamental frame S_0, which emits N identical photons simultaneously in two opposite directions $(+x \text{ and} -x)$, see figure 1. (For this demonstration, we will follow one given in ref [6], but with different assumptions).

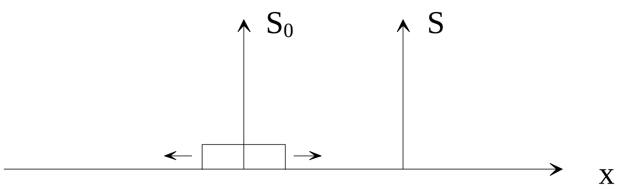

Figure 1

Consider now another inertial frame S moving along the *x* axis at speed v. In frame S_0, the total momentum is conserved. This must also be true for any observer moving with respect to frame S_0. With respect to frame S, we have:

$$P_0 = P_1 + N\frac{h\nu}{C}\left(1+\frac{v}{C}\right) - N\frac{h\nu}{C}\left(1-\frac{v}{C}\right) \qquad (1)$$

where P_0 is the initial momentum, and P_1 the final momentum of the body. The other terms are the momenta of the photons altered by the Doppler shift. (Note that $p = \frac{h\nu}{C}$ is a formula of classical electrodynamics independent of relativity).

The loss in source momentum $\Delta(mv)$ viewed from frame S will be :

$$P_0 - P_1 = 2N\frac{h\nu}{C^2}v \qquad (2)$$

Since, obviously, the source is at rest in frame S_0 both before and after emission, with respect to frame S it must have the speed v both before and after emission, so:

$$\Delta(mv) = v\Delta m = \frac{2Nh\nu}{C^2}v \qquad (3)$$

Now, according to the energy conservation law:

$$E_0 = E_1 + Nh\nu\left(1+\frac{v}{c}\right) + Nh\nu\left(1-\frac{v}{c}\right) = E_1 + \Delta E \qquad (4)$$

$$= E_1 + 2Nh\nu \qquad (5)$$

$\Delta E = 2Nh\nu$ is the variation of energy resulting from the emission of the photons. From (3) and (5) we obtain

$$\Delta E = \Delta m C^2 \qquad (6)$$

Note that this mass-energy equivalence formula has been obtained without the help of the Lorentz-Poincaré transformations.

III. Variation of mass with speed.

Consider a body *at rest in the fundamental frame*, which is subjected to a force F. The elementary expression of the kinetic energy is.

$$dE_C = Fd\ell \qquad (7)$$

where $Fd\ell$ is the work carried out by the force F in the displacement $d\ell$. (We suppose that F and $d\ell$ are aligned).

This expression can also be written as follows :

$$\frac{dE_C}{dt} = Fv \qquad (8)$$

From $F = \frac{dp}{dt}$ we obtain

$$\frac{dE_C}{dt} = v\frac{dp}{dt} \qquad (9)$$

and

$$\frac{dE_C}{dv}\dot{v} = \frac{dp}{dv}v\,\dot{v} \qquad (10)$$

and finally

$$\frac{dE_C}{dv} = v\frac{dp}{dv} \qquad (11)$$

This expression, which connects the kinetic energy and the momentum was derived by Lewis [7] in 1908.

Now, as seen previously, the equivalence of mass and energy takes the form

$$E = mC^2 = E_C + m_0C^2 \qquad (12)$$

From the expression of the momentum $p = mv$ (13)

and that of the energy, we can write:

$$p = \frac{E}{C^2}v \qquad (14)$$

From (11) and (12) we have:

$$\frac{dE}{dv} = v\frac{dp}{dv} \qquad (15)$$

replacing E and p by their expressions given in (12) and (13), we obtain

$$\frac{dm}{dv}C^2 = \frac{dm}{dv}v^2 + mv \qquad (16)$$

so

$$\frac{dm}{m} = \frac{v}{C^2 - v^2}dv \qquad (17)$$

designating $C^2 - v^2$ as u so that $v\,d\,v = -\frac{du}{2}$ we find successively

$$\operatorname{Log} m = -\frac{1}{2}\operatorname{Log}\left(C^2 - v^2\right) + \operatorname{Log} k \qquad (18)$$

$$= \operatorname{Log} k\left(C^2 - v^2\right)^{-1/2} \qquad (19)$$

so $$m = \frac{k}{C\sqrt{1 - v^2/C^2}} \qquad (20)$$

for $v = 0 \;\Rightarrow\; m = \frac{k}{C} = m_0$ so

$$m = \frac{m_0}{\sqrt{1 - v^2/C^2}} \qquad (21)$$

m_0 is the rest mass. As we will now see, expression (21) is completely exact exclusively when m_0 is the mass at rest in the fundamental frame.

IV. Variation of mass with speed in relativity and in the fundamental aether theory.

In relativity, since no absolute frame exists, the mass of a body at rest in a given inertial frame, viewed by an observer of this frame, is always identical, whatever this inertial frame may be. This mass is defined as the proper mass or the rest mass of the body.

If the body moves with respect to a reference frame S with velocity v, its mass with respect to S is supposed to be:

$$m = \frac{m_0}{\sqrt{1 - v^2/C^2}} \qquad (22)$$

whatever the reference frame S may be.

The point of view of the fundamental theory is completely different. In effect, consider a body having the mass m_0 in the fundamental frame S_0. Since it is necessary to provide this body with the kinetic energy E_C in order to pass from S_0 to any other inertial frame S_1, the rest mass of the body in this frame will be $m_0 + \frac{E_C}{C^2}$.

So, a hierarchy of rest masses, as a function of the absolute speed of the body, exists.

(Note that it is necessary to distinguish the real mass from the measured one, which can be falsely estimated. In effect, if one measures the mass m_0 of a body in the fundamental frame by comparison with a standard μ_0, if m_0 and μ_0 are transported in another inertial frame, they modify in the same ratio. So the mass m_0 does not seem to have changed, which is inexact).

We have seen in ref [4] and [5] that, contrary to what is often claimed, the existence of a fundamental frame is not compatible with the relativity principle.

We will verify this in the following example. Consider three inertial frames S_0, S_1 and S_2, and let three bodies of masses m_0, m_1 and m_2 be respectively at rest in these three frames. The said masses were initially identical in reference frame S_0 and equal to m_0, before having been transported in their respective reference frame. We propose to appraise the effect of motion on these masses (see figure 2).

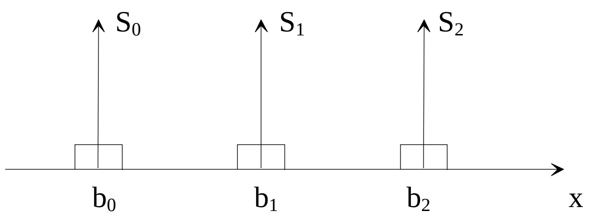

Figure 2

1/Point of view of the conventional theory of relativity.

Measured by an observer at rest with respect to one of the masses, this one remains, in all cases, equal to m_0. Therefore, for observer S_1, we have

$$m_2^1 = \frac{m_0}{\sqrt{1 - v_{12}^2 / C^2}} \qquad (23)$$

where m_2^1 designates the relativistic mass of body b_2 as measured by observer S_1 and v_{12} designates the relative speed of reference frames S_1 and S_2.

If one supposes that $v_{12} << C$, expression (23) can be written to first order as follows

$$m_2^1 \cong m_0 \left(1 + \frac{1}{2} v_{12}^2 / C^2\right) \qquad (24)$$

So that, viewed by observer S_1, the energy of body b_2 is

$$m_2^1 C^2 \cong m_0 C^2 + \frac{1}{2} m_0 v_{12}^2 \qquad (25)$$

(This corresponds to the sum of the rest energy and the kinetic energy needed by b_2 to pass from S_1 to S_2).

For an observer of reference frame S_0, the energy of b_2 is different. Designating as m_2^0 the mass of body b_2 as measured by an observer of S_0, we have, (for $v_{02} << C$):

$$m_2^0 C^2 \cong m_0 C^2 + \frac{1}{2} m_0 v_{02}^2 \qquad (26)$$

and the energy of body b_1 is assumed to be

$$m_1^0 C^2 \cong m_0 C^2 + \frac{1}{2} m_0 v_{01}^2 \qquad (27)$$

so that, for observer S_0 the kinetic energy needed by the body b_2 to pass from S_1 to S_2 is

$$\left(m_2^0 - m_1^0\right) C^2 \cong \frac{1}{2} m_0 \left(v_{02}^2 - v_{01}^2\right) \qquad (28)$$

This result is different from the one measured by observer S_1, $\frac{1}{2} m_0 v_{12}^2$, although, obviously, it should be the same.

2/Point of view of the fundamental aether theory

In our book "Relativité et Substratum Cosmique [8]", the results that will follow were considered as a stumbling block for the fundamental aether theory, because they lead to an expression of the kinetic energy different from the usual one. Nevertheless, the questioning of the relativity principle and the present day arguments in favour of the aether and of the anisotropy of the speed of light, compel us to reappraise our past point of view.

Let us reconsider the figure with the three bodies, and suppose that S_0 is the fundamental inertial frame, and S_1 and S_2 two inertial frames aligned with S_0.

According to the fundamental assumptions, m_2^0 and m_2^1 have no meaning. A body at rest in a given inertial frame has only one real mass. The mass of the body b_2 is:

$$m_2 = \frac{m_0}{\sqrt{1 - v_{02}^2 / C^2}} \qquad (29)$$

and the mass of b_1:

$$m_1 = \frac{m_0}{\sqrt{1 - v_{01}^2 / C^2}} \qquad (30)$$

Conversely, as we will see, the rest mass of a body will not be m_0 in the different inertial frames, from (29) and (30) we obtain

$$m_2 = m_1 \frac{\sqrt{1 - v_{01}^2 / C^2}}{\sqrt{1 - v_{02}^2 / C^2}} \tag{31}$$

If one supposes that $v_{02} << C$, m_2 reduces to

$$m_2 \cong m_1 + \frac{m_1}{2C^2}\left(v_{02}^2 - v_{01}^2\right) \tag{32}$$

$$\cong m_1 + \frac{m_1}{2C^2}\left(v_{12}^2 + 2v_{01}v_{12}\right) \tag{33}$$

This expression is different from (24). It contains a term in v_{01} which vanishes when S_1 is at rest with respect to S_0, in contradiction with the relativity principle. We also realize that expression (31) which connects any couple of inertial frames, assumes a mathematical form different from (29) and (30). This is another argument which also demonstrates that the existence of a fundamental inertial frame is incompatible with the relativity principle.

We also note that, when $v_{12} \to 0$ or in other words when $v_{02} \to v_{01}$, the terms depending on v_{01} and v_{02} in expression (32) cancel. Thus, m_1 represents the rest mass assumed by the aforementioned bodies when they stand in reference frame S_1. This is different from special relativity for which the rest mass is m_0 in any inertial frame.

Nevertheless, we must distinguish the absolute rest mass m_0 from the other rest masses standing in inertial frames which are in motion with respect to the aether frame.

Note however that when $v_{12} >> v_{01}$, and $v_{01} << C$ expression (31) reduces to

$$m_2 \cong \frac{m_1}{\sqrt{1 - v_{02}^2 / C^2}} \cong \frac{m_1}{\sqrt{1 - v_{12}^2 / C^2}} \tag{34}$$

and since $m_1 \cong m_0$, we obtain

$$m_2 \cong \frac{m_0}{\sqrt{1 - v_{02}^2 / C^2}} \tag{35}$$

It is the case of particles moving at high speed with respect to the Earth frame, (while the Earth moves with respect to the fundamental frame at low speed (≅ 300 km/sec)). In such cases the Earth can be considered as almost at rest with respect to the fundamental frame. So the relativistic approach and the fundamental one lead to practically equivalent results.

3/The question of reciprocity.

This question makes a great difference between relativity and fundamental theories. In effect, according to relativity, when a mass is transported from one inertial system S_0 to another S_1, viewed from S_0, this mass is supposed to be

$$m_1 = \frac{m_0}{\sqrt{1 - v_{01}^2 / C^2}} \tag{36}$$

but conversely, if the mass comes back to S_0, viewed from S_1 it will also appear equal to m_1

$$m_1 = \frac{m_0}{\sqrt{1 - v_{01}^2 / C^2}} \tag{37}$$

According to the fundamental theory, suppose that S_0 is the fundamental frame. If the mass is at rest in frame S_1, we also have

$$m_1 = \frac{m_0}{\sqrt{1 - v_{01}{}^2 / C^2}} \quad (38)$$

m_1 is $> m_0$. In effect we have been compelled to supply energy in order to pass from S_0 to S_1,but if the mass comes back to S_0, the energy is restituted. All observers (including the one of frame S_1) will conclude that the real mass is equal to m_0.

$$m_0 = m_1 \sqrt{1 - v_{01}{}^2 / C^2} \quad (39)$$

This result is completely in contradiction with relativity, but it is the only one which is in accordance with mass-energy conservation.

Important remarks.

In fundamental theories, we must distinguish the total available energy of a body (which is equal to the sum of the rest energy $m_0 C^2$ and the kinetic energy with respect to the fundamental frame), from the available energy of the body with respect to any other inertial frame, which is weaker than the previous one, and takes another mathematical form.

In the example previously quoted, the total available energy of body b_2 is

$$m_2 \, C^2 = m_0 C^2 \left(1 + \frac{1}{2} v_{02}{}^2 / C^2 \right) + \text{small terms of higher order} \quad (40)$$

(This notion has no equivalence in conventional relativity for which the energy of a body is completely relative and depends on its speed with respect to another body).

And the available energy with respect to frame S_1 is

$$m_2 C^2 - \frac{1}{2} m_0 v_{01}{}^2 = m_0 C^2 + \frac{1}{2} m_0 \left(v_{02}{}^2 - v_{01}{}^2 \right) \quad (41)$$

4/Possible measurement of the absolute speed of an inertial system

Assuming that $v_{01} << C$, the kinetic energy needed to pass from S_1 to S_2 reduces to:

$$\Delta E_C \cong \frac{1}{2} m_0 \left(v_{12}{}^2 + 2 v_{01} v_{12} \right) \quad (42)$$

knowing ΔE_C and v_{12}, it is theoretically possible to measure the absolute speed, v_{01}, of the inertial system S_1, that is:

$$v_{01} \cong \frac{\Delta E_C - \frac{1}{2} m_0 v_{12}{}^2}{m_0 v_{12}} \quad (43)$$

This result is also in contradiction with the relativity principle.

5/Conservation of energy

In our opinion, the mass-energy conservation law should not be questioned and should apply exactly in any inertial frame. Note nevertheless that, at high speeds, the role of the aether wind would not be completely negligible and should be taken into account in any event where an exchange of energy occurs.

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