Critical Analysis of Special Relativity in Reference to Energy Transformation

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This paper investigates special relativity theory (SRT) from the point of view of energy transformation. Transformation of energy conceived as transformation of work reveals contradiction within SRT. The analysis of four-momentum discloses the incorrect interpretation of its temporal component. A coherent model of energy transformation requires replacing the relativity principle by the postulate of a privileged system. This, in turn, entails the replacement of Lorentz transformation by 'inertial transformation' that forms a basis for the newly proposed privileged system theory (PST). Eventually, the general energy formula appears different from the one representing Einstein's theory.

Keywords: special relativity, transformation of energy, four-momentum, Lorentz transformation, inertial transformation, privileged system

1. Transformation of energy as transformation of four-momentum

According to the interpretation of Einstein's relativity theory [1] proposed by H. Minkowski [2], the three dimensions of space and the one dimension of time compose a single construct called spacetime or, more specifically, the Minkowski space. By analogy to the three-dimensional vector in Euclidean space, one forms the four-vector dt, dx, dy, dz in Minkowski space that subjects to Lorentz transformation. The four-vector components satisfy the equation:

$$d\tau^2 = dt^2 - dx^2 - dy^2 - dz^2 \tag{1,1}$$

where $d\tau$ is the invariant space-time interval for infinitesimal values $\Delta t, \Delta x, \Delta y, \Delta z$, for the free world line of a point particle, with τ the proper time of this particle. For the negative value of $d\tau^2$ (with τ the imaginary number) the space-time interval becomes 'spacelike', and thus does not correspond to any of the particle's possible world lines. Instead, for $d\tau = 0$, Eq. (1,1) expresses the SRT law of the constancy of the speed of light.

By dividing each of the four-vector components by $d\tau$, one gets the four-velocity vector of the components $(dt/d\tau), (dx/d\tau)$, $(dy/d\tau), (dz/d\tau)$. In turn, by multiplying the four-velocity by the rest mass of the particle (m), one obtains the four-momentum which components are:

$$\begin{aligned} p^t &= m(d\,t/d\tau) \\ p^x &= m(dx/d\tau) \\ p^y &= m(dy/d\tau) \\ p^z &= m(dz/d\tau) \end{aligned} \tag{1,2}$$

Whereas three spatial components compose the vector of momentum, the temporal component is identified with energy ($E \equiv p^t$). Since τ and m are invariants then four-momentum, likewise four-vector, subjects to Lorentz transformation and thus can be written in the covariant form. If two systems remain in mutual inertial motion in x direction with all three axes overlapping at $t = t' = 0$ (the standard configuration) then, assuming that initial point of four-vector is $x = x' = 0$, transformation of four-momentum takes the form

$$\begin{aligned} p'_x &= \gamma\left(p_x - uE\right) & p_x &= \gamma\left(p'_x + uE'\right) \\ p'_y &= p_y & p_y &= p'_y \\ p'_z &= p_z & p_z &= p'_z \\ E' &= \gamma\left(E - up_x\right) & E &= \gamma\left(E' + up'_x\right) \end{aligned} \tag{1,3}$$

The connection between energy and momentum obtained in (1,3) can be also deduced considering that energy transformation obeys the SRT velocity addition formula determined by Lorentz transformation. Let the relative velocity between two systems be u (as above), and the velocity of point mass, considered as the source of energy, be v and v' in S and S', respectively. Since the SRT velocity formula is $v = \left(u + v'\right)/\left(1 + uv'\right)$ then, taking $c = 1$, it follows

$$E = \frac{m}{\sqrt{1 - v^2}} = \frac{m}{\sqrt{\left[1 - \left(\frac{u + v'}{1 + uv'}\right)^2\right]}} =$$

$$= \frac{1}{\sqrt{1 - u^2}}\left(\frac{m}{\sqrt{1 - v'^2}} + \frac{muv'}{\sqrt{1 - v'^2}}\right) \tag{1,4}$$

Taking into account

$$E' = \frac{m}{\sqrt{1-v'^2}}, \ p'_x = \frac{mv'}{\sqrt{1-v'^2}} \tag{1,5}$$

one gets

$$E = \gamma\left(E' + up'_x\right) \tag{1,6}$$

identical with (1,3).

2. Transformation of energy as transformation of work

The main proof against SRT presented in this paper (hereafter called ‘the proof’) refers to the transformation of energy conceived as transformation of work. The proof proceeds as follows. Say, we have two inertial systems S' and S. Let all primed values relate to S', and the non-primed values relate to S. Let S' move against S with the relativistic velocity u in xx' direction. Let the source of energy, at rest in S' execute the work consisting in acceleration of a body with the rest mass m in yy' direction. The force in S' is

$$\vec{F}' = \frac{d}{dt'} m\gamma\left(v'\right)\vec{v}' \tag{2,1}$$

with $\vec{v}'$ the instantaneous velocity vector, and $\gamma\left(v'\right)$ the Lorentz factor $1\Big/\sqrt{1-v'^2/c^2}$. For the case when $\vec{F}' \parallel \vec{v}'$ Eq. (2,1) converts to the form

$$\vec{F}' = m\gamma^3\left(v'\right)dv'/dt' \tag{2,2}$$

In turn, since $\vec{F} \perp \vec{u}$ then the respective mass in S' (*i.e.* $m\gamma^3(v')$) increases in S by the constant factor $\gamma(u) = 1\big/\sqrt{1 - u^2/c^2}$. Thus, regarding v,

$$\vec{F} = m\gamma^3(v')\gamma(u)\,dv/dt \tag{2,3}$$

Since the work is executed perpendicularly to $\vec{u}$ (which, in other words, means that $d\vec{v}'/dt' \parallel d\vec{v}/dt$), so the Lorentz transformation of time, velocity and acceleration takes the form

$$dt = dt'\gamma(u)$$

$$\vec{v} = \vec{v}'/\gamma(u)$$

$$\frac{d\vec{v}}{dt} = \frac{d\vec{v}'/dt'}{\gamma^2(u)} \tag{2,4}$$

As applied to (2,3) this gives

$$\vec{F} = m\gamma^3(v')\gamma(u)\frac{d\vec{v}'/dt'}{\gamma^2(u)} \tag{2,5}$$

which means that

$$\vec{F} = \vec{F}'/\gamma(u) \tag{2,6}$$

Let us write the work executed in S' as

$$W' = \left(\vec{F}'\bullet\vec{v}'\right)t' \tag{2,7}$$

Consequently, from (2,4) it follows

$$W = \left(\frac{\vec{F}'}{\gamma(u)}\bullet\frac{\vec{v}'}{\gamma(u)}\right)t'\gamma(u) = W'/\gamma(u) \tag{2,8}$$

Considering energy as the 'capacity to do work' (according to formula $W = \Delta E_K$), we may conclude that (2,8) means also

$$E = E' / \gamma(u) \tag{2,9}$$

Meanwhile, the value expected by the relativity principle is $E = E'\gamma(u)$.

Therefore, to satisfy

$$E = E_0 \gamma(u) \tag{2,10}$$

where E_0 stands for the energy value of an identical source at rest S measured in S, we have to assume that

$$E' = mc^2 \gamma^2(u) \tag{2,11}$$

This eventually means that

$$E' \neq E_0 \tag{2,12}$$

which contradicts the relativity principle.

3. Transformation of work *vs.* transformation of four-momentum

From Eq. (1,3) it follows that the transverse components of momentum (in yz plane) do not contribute to energy transformation. Since in the case described in the proof the longitudinal energy component is $up'_x = 0$ so the respective transformation formula for energy reduces to $E = E'\gamma(u)$ as in the case of the source at rest. Meanwhile, the result obtained in the proof is $E = E'/\gamma(u)$. Thus, the results in question remain in contradiction to each other.

However, the above statement needs a closer insight. We shall try to express the work transformation in terms of the four-momentum transformation. Transformation of energy comprehended as transformation of four-momentum is tightly connected with ascribing the solely relative value to kinetic energy. One may ask, however, why energy in kinetic form has to be transformed unlike energy in potential form, whereas all energy forms are mutually exchangeable?

If we examine energy of the source in the context of virtual work (*e.g.* executed on a particle in the linear accelerator oriented in xx' direction) then we have to conclude that energy of the source, stored in potential form in the generator of electric field, gradually transforms to kinetic form (with a certain value E_K at the end of its path) while the particle accelerates. This, in general, may be written as

$$E_{source} \to W \to E_K \tag{3,1}$$

where E_{source} stands for energy descended from generator, in the part absorbed by kinetic energy of the particle. Thus, transformation of E_{source} from S' to S requires considering kinetic energy of the particle in connection with a certain value of momentum, as related to S'. From the well-known relation

$$E'v'/c = p'_x c \tag{3,2}$$

where $E' = E_0 + E'_K$ and $E'_K = \gamma E_0 - E_0$

it follows

$$p'_x = \gamma E_0 v'/c^2 \tag{3,3}$$

Therefore

$$E = \gamma\left(E' + u\gamma E_0 v'/c^2\right) \tag{3,4}$$

Hence, considering that the scalar product of $\vec{u},\vec{v}'$ is $u\cos\pi v' = -uv'$, we get

$$E_K = \gamma\left(\gamma E_0 - u\gamma E_0 v'/c^2\right) - E_0 \tag{3,5}$$

Say, we deal with a special case where $u = v'$ (which means that particle rests in S'). Then

$$E_K = \gamma\left(\gamma E_0 - u^2\gamma E_0/c^2\right) - E_0 \tag{3,6}$$

which gives

$$E_K = 0 \tag{3,7}$$

This outcome conforms the relativity principle, yet we should note that, in fact, we don't deal here with the transformation of kinetic energy in the exact sense. What we really transform in Eq. (3,5) is the total energy, whereas kinetic energy is obtained by subtracting rest energy (of the assumed constant value E_0 in each reference system) from total energy. In turn, this means that E_{source} considered as rest (potential) energy, and E_{source} considered from the point of view of virtual work, are not transformed in the same way.

On the other hand, the proof leads to such a transformation that treats equally all forms of energy (the relevant equations are formulated in chapter 7), yet contradicts the relativity principle.

We aim to show in the next two chapters that the reason of inconsistency between the way of transformation obtained from the proof, and that predicted by the covariant notation of four-momentum (*i.e.* in the shape of Lorentz transformation), lies in the incorrect interpretation of the real nature of four-momentum temporal component.

4. Four-momentum: faulty juggling with units

Each of physical dimensional units is based on a certain convention that unambiguously defines a given quantity. For example, the second is currently defined as “the duration of 9192631770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom” [3]. In turn, the meter is currently defined as “the length of the path traveled by light in vacuum during a time interval of 1/299 792 458 of a second” [4]. In the latter case, the definition of meter bases on the definition of second and the assumption of the constant speed of light.

For the sake of convenience one may express the second in meters or the meter in seconds; then one second is defined as 299792458 meters, or one meter is defined as 1/299792458 of a second. In result of such trick one obtains the dimensionless speed of light normalized to 1.

Let us call the convention that consists in expressing different quantities in their basic units (time in seconds, length in meters, energy in joules *etc*.) the ‘standard convention’ (SC), and the one that consists in expressing different quantities in the one common unit (*e.g.* time in seconds, length in seconds), the ‘reducing convention’ (RC). Let us also write the procedure of applying RC as SC$\rightarrow$RC, and the reversal procedure (*i.e.* returning to standard convention) as RC$\rightarrow$SC. The inalienable rules for applying RC are the following:

1. Transformation under RC is equivalent to transformation under SC. In other words, applying RC (at any stage of transformation) does not change the real dimension of a given quantity but only the notation of its unit.
2. RC must obey the usual rules of algebra. This means that reducing procedure (SC$\rightarrow$RC) must be equivalent to a given

mathematical operation executed on the equation (with unit symbols treated as variables) that undergoes transformation.

3. The reverse procedure (RC$\rightarrow$SC) is equivalent to the operation converse to the previous one. RC$\rightarrow$SC is possible only if SC$\rightarrow$RC has been applied before.

(‘Transformation’ means here the deriving of subsequent forms of an equation).

At first, let us consider an elementary example illustrating the above rules. Using the units instead of quantity symbols, we may write *e.g.* the equation for distance

$$m/s \times s = m \tag{4,1}$$

Under RC, with length denoted in seconds, this may be written as

$$s/s \times s = s \tag{4,2}$$

where s/s corresponds to a certain value of the dimensionless proper fraction of c. Applying SC $\rightarrow$RC to (4,1) means multiplication by s/m:

$$s = (m/s \times s)\, s/m \tag{4,3}$$

Instead, applying RC$\rightarrow$SC to (4,2) means multiplication by m/s:

$$m = (s/s \times s)\, m/s \tag{4,4}$$

Say, however, that we aim to count

$$m + s = ? \tag{4,5}$$

which is, of course, physically senseless. Yet, by replacing (4,5) with

$$s + s = s$$

or with

$$m + m = m \tag{4,6}$$

we get sensible outcomes. However, considering that the outcome of algebraic sum $m+s$ can be only $m+s$, this cannot be regarded as a permitted procedure (and thus recognized as applying SC$\rightarrow$RC). There is no operation that executed on equation $m+s=m+s$ enables its transformation to any of (4,6) forms. Besides, there is no converse operation that, as applied to any of Eqs. (4,6), would give the (physically non-existent) outcome of (4,5).

Let us examine now the four-momentum equations. Let's start from the space-time interval formula (1,1). Ignoring the inessential (here) question of the use of symbols d or Δ, it takes either the form

$$\tau^2 = t^2 - (x/c)^2 - (y/c)^2 - (z/c)^2 \tag{4,7}$$

or

$$\tau^2 = t^2c^2 - x^2 - y^2 - z^2 \tag{4,8}$$

It sometimes also appears as

$$\tau^2 = t^2 - x^2 - y^2 - z^2 \tag{4,9}$$

The common intention is to homogenize space with time, however in each case this aim is achieved in a different way. In (4,7) the spatial components of four-vector become 'time-dimensional', and thus τ is expressed in seconds. In turn, in (4,8) the temporal component of four-vector becomes 'space-dimensional', and thus τ is expressed in meters. The fact that τ is expressed either in seconds or in meters may lead to the erroneous conclusion, namely that we deal here with RC. Meanwhile, the coherence of four-vector units in the invariance formula is obtainable only if c is taken as the dimensional factor. This, in turn, means that the four-vector components in Eqs. (4,7) and (4,8) appear in their basic units, *i.e.* that both equations subject to SC.

Instead, Eq. (4,9) is physically senseless exactly in the same way as (4,5), unless we consider that it is written with the tacit assumption that either t stands for tc, or x, y, z stand for x/c, y/c, z/c, which eventually means that it takes either the form of (4,7) or (4,8).

Let us test the four-momentum from the point of view of the units ascribed to its particular components. Multiplying each component of four-vector by the factor kg/s (corresponding with m/τ) gives

$$\begin{aligned} p^t &\to kg \times s/s = kg \\ p^x &\to kg \times m/s \\ p^y &\to kg \times m/s \\ p^z &\to kg \times m/s \end{aligned} \tag{4,10}$$

Note that whereas three spatial components have the dimension of momentum, the temporal component has the dimension of mass. Meanwhile, as we have demonstrated before, all the four-vector components appear in their basic units, and thus do so the four-momentum components. Hence, if p^t stands for energy, it should be expressed in kgm^2/s^2. We conclude therefore that p^t signifies mass.

5. The real nature of four-momentum

Let us compare the Lorentz equation for the transformation of time (or, in other words, of temporal component of four-vector) with its four-momentum equivalent for energy:

$$t = \gamma\left(t' + ux'/c^2\right) \tag{5,1}$$

$$E = \gamma\left(E' + up'_x\right) \tag{5,2}$$

Substituting proper units to (5,2) requires considering the units from (4,10), and the term $1/c^2$ from (5,1). This gives

$$kg + \frac{m/s \times (kg \times m/s)}{m^2/s^2} = kg \tag{5,3}$$

which confirms that the temporal component of four-momentum refers to mass and not to energy.

Let us call the newly detected object (in which temporal component represents mass) the ‘mass-momentum four-vector’. As conformed to Lorentz transformation equations: $x' = \gamma(x - ut)$, $x = \gamma(x' + ut')$, $t' = \gamma(t - ux/c^2)$, $t = \gamma(t' + ux'/c^2)$,

it takes the shape

$$p'_x = \gamma(p_x - um) \qquad p_x = \gamma(p'_x + um')$$

$$m' = \gamma(m - up_x/c^2) \qquad m = \gamma(m' + up'_x/c^2) \tag{5,4}$$

Though we don’t intend to restore SRT by replacing four-momentum with the ‘mass-momentum four-vector’, we state however that the latter constitutes a coherent physical object within the model defined by Lorentz transformation. Let the point mass be at rest in S'. In such a case $p'_x = 0$. Hence

$$p_x = u\gamma m' \tag{5,5}$$

and

$$m = \gamma m' \tag{5,6}$$

In turn

$$m' = \gamma(m - u^2\gamma m'/c^2) \tag{5,7}$$

And, since in S' $u = 0$ then

$$m' = \gamma m \tag{5,8}$$

In fact, the conviction as to the correctness of attributing energy to the temporal component of four-momentum can be only explained by a strong desire of satisfying the relativity principle. Instead, it cannot originate from the assumption that both energy and mass transform identically because such an assumption is incorrect within SRT. If *e.g.* we consider the case $\vec{F} \parallel \vec{v}$, where $\vec{v}$ is the velocity vector describing the motion of the point mass, then the second law of dynamics takes the form

$$\vec{F} = m\gamma^3 \, d\vec{v}/dt \tag{5,9}$$

Instead, in the case when $\vec{F} \perp \vec{v}$ the second law is

$$\vec{F} = m\gamma \, d\vec{v}/dt \tag{5,10}$$

In general, the increase of mass depends on velocity and on the angle between the velocity vector and the force vector. Meanwhile, the increase of energy carried by the point mass depends solely on velocity. Thus, it is clear that energy and mass do not transform identically.

Let us summarize the way of reasoning that led us to the conclusion that temporal component of four-momentum does not represent energy:

1. The equation of space-time interval written as $\tau^2 = t^2 - x^2 - y^2 - z^2$ is physically nonsensical (incoherent in respect to the units) if all components on the right side of the equation subject to SC.
2. Therefore the factor c, considered as dimensional quantity, must be included in the invariance formula, *e.g.* in the form $\tau^2 = t^2 - (x/c)^2 - (y/c)^2 - (z/c)^2$.
3. Hence, all four-vector components remain in their basic units, and thus the relevant equation subjects to SC.

4. By multiplying each components of four-vector by m/τ, one gets the construct with three components expressed in the units of momentum and the one expressed in the unit of mass. This construct still subjects to SC.

5. By substituting the units defined in point 4 to equation $t=\gamma\left(t'+ux'/c^2\right)$, one gets the transformational equation of mass.

6. One cannot alter the unit of temporal component (from mass to energy) in equation $m=\gamma\left(m'+up'_x/c^2\right)$ by multiplying it by c^2 (*i.e.* one cannot apply RC $\to$SC) because the reverse operation SC$\to$RC has not been applied before.

7. One cannot change the sole outcome of equation $\gamma\left(m'+up'_x/c^2\right)=m$ (*i.e.* mass) for energy because the dimension obtained under RC must be equal to that obtained under SC. This means that, even if we multiply here mass by c^2, we still get mass, though expressed by the unit of energy (yet, doing this is not sensible).

8. One cannot treat mass and energy interchangeably because each of these quantities transforms (under Lorentz transform) in the different way.

Thus, eventually, it appears that (Lorentz) transformation of four-momentum does not make an argument against the proof based on the transformation of work.

6. Privileged system theory (PST): basic facts

The relations obtained from the proof:

$$E' = \gamma E$$
$$E = E'/\gamma \tag{6,1}$$
$$E' = \gamma^2 E_0$$

show that systems S and S' are not identical in the sense defined by the relativity principle. This leads directly to the idea of privileged reference frame (privileged system). Taking the SRT description of physical phenomena as a point of reference, we may define privileged system as follows:

From among all inertial systems, privileged system is the only one in which physical phenomena take the shape predicted by SRT.

'System' is understood here as a set of co-ordinate systems locally at rest to each other.

The apple core of the idea of privileged system is the assumption of the absolute character of 'relativistic' effects. According to the idea for the first time formulated by Fitzgerald [5] and Lorentz [6], length contraction and time dilation are real in the sense that (contrary to SRT) they are not the 'related-to-observer' phenomena. Instead, they can be deduced as a dynamic consequence of the electromagnetic model of matter.

Some of the followers of ethereal conception presume that Lorentz approach is reconcilable with Lorentz transformation. Such an opinion is based on supposition that 'relativistic' effects, though not relative at origin, are, however, relative from the empirical and mathematical point of view, which reduces the whole question to the merely ontological interpretation. On the other hand, if the relativistic effects take place in the only one (privileged) system then it follows that they affect physical objects in all other systems. This, in turn, makes a basis for the assumption of the reciprocal (reversal) character of relativistic effects, in the sense that contraction is responded by elongation *etc*. Formally expressed, this approach entails a different type of transformation, coincident to 'inertial transformations' [7], [8]:

$$
\begin{aligned}
x' &= x\gamma - ut\gamma & x &= x'/\gamma + ut'\gamma \\
y' &= y & y &= y' \\
z' &= z & z &= z' \\
t' &= t/\gamma & t &= t'\gamma
\end{aligned}
\tag{6,2}
$$

The inertial transformation may prove (or may not prove) operationally equivalent to Lorentz transformation (which means identical empirical expectations in spite of different predictions as to the particular quantities, taken separately). This question has been already considered elsewhere [9]; in this paper we shall quote the main conclusions only. If one considers two inertial frames (S, S'), with one of them privileged (S), then the following relations are obtained:

1. The length contraction and time dilation in S (of the measure rods and clocks at rest in S') is accompanied by the reciprocal equivalent elongation and acceleration in S' (of the rods and clocks at rest in S). This rule refers also to mass; the increase of mass in S is accompanied by the equivalent decrease of mass in S'.
2. The mutual velocities of S' in S and S in S' relate each other as

$$u/u\gamma^2 \tag{6,3}$$

with γ the Lorentz factor for S'.

3. The relative value of the Lorentz factor for two systems in absolute motion S' and S'' is determined by the ratio of their absolute Lorentz factors:

$$\gamma\left(S''/S'\right)=\gamma\left(S''/S\right)/\gamma\left(S'/S\right) \tag{6,4}$$

4. The general formula for the speed of light is

$$c'=\left(c-u\cos\theta\right)\Big/\left(1-\beta^2\cos^2\theta\right) \tag{6,5}$$

where θ is the angle between vector of absolute velocity of the system and the direction of propagation of light, and $\beta=u/c$. In reference to $x,-x$ directions, the light speed formula takes the form $c_1'=\left(c-u\right)\gamma^2$ and $c_2'=\left(c+u\right)\gamma^2$, respectively. Eq. (6,5) describes the ellipsoid of the wave front, in opposition to the spherical wave front described by c.

5. The PST velocity addition formula, as derived from inertial transformation, is

$$\sigma=x\big/t=\left(ut'\gamma+x'/\gamma\right)\big/t'\gamma=u+v'/\gamma^2 \tag{6,6}$$

This formula differs from the analogous SRT formula $\sigma=\left(u+v\right)\Big/\left(1+uv/c^2\right)$ with respect to the estimation of the added velocity in the moving frame. According to PST, $v'=v\Big/\left(1+uv/c^2\right)$.

Despite all the differences, PST appears operationally equivalent to SRT in the range of kinematics. Moreover, in result of mutual compensation of mass and velocity (which, separately, differ from those predicted by SRT), the predicted by PST momentum in the moving frame appears numerically identical with that predicted by SRT. The only one real (formal and operational) difference between PST and SRT concerns energy. Yet, just the one difference has the fundamental significance for the question of correctness of special relativity.

7. Transformation of energy according to PST.

Let us consider the energy of point mass at rest in S', and in S, estimated in S and S', respectively. Considering the complex structure of energy unit, as composed of elementary dimensions:

$$energy = \frac{mass \times length^2}{time^2} \tag{7,1}$$

we shall examine the above cases of energy transformation according to inertial transformation (6,2), taking into account the longitudinal direction (x) and the crosswise direction (in yz plane) for mass and length (related to work in these directions). Thus, for the source at rest in S', regarding x direction of work, we get in S

$$\frac{m\gamma^3 \left(l'/\gamma\right)^2}{\left(t'\gamma\right)^2} \tag{7,2}$$

with m the rest mass. This gives

$$E = mc^2/\gamma \tag{7,3}$$

In turn, regarding the crosswise direction of work, we get

$$\frac{m\gamma l'}{\left(t'\gamma\right)^2} \tag{7,4}$$

This also gives

$$E = mc^2/\gamma \tag{7,5}$$

Instead, for the source at rest in S, regarding x direction of work, we get in S'

$$\frac{\left(m/\gamma^3\right)\left(l\gamma\right)^2}{\left(t/\gamma\right)^2} \tag{7,6}$$

This gives

$$E' = m\gamma c^2 \tag{7,7}$$

In turn, regarding the crosswise direction of work, we obtain

$$\frac{\left(m/\gamma\right)l^2}{\left(t/\gamma\right)^2} \tag{7,8}$$

which also gives

$$E' = m\gamma c^2 \tag{7,9}$$

We may therefore conclude that transformation of energy does not depend on the direction of the assumed work. Admittedly we didn't examine here the general case for a free angle, yet such a generalization seems to be quite obvious.

Since in PST the momentum connected with the point source of energy does not contribute to energy transformation, the above equations refer also to general (in this regard) case, *i.e.* concern freely situated sources of energy. In other words, regardless of the state of motion of the source of energy, the only thing that counts is the estimation of energy value in a given frame.

Let us consider inertial systems S', S'' with their absolute velocities u_1, u_2, respectively. Let the value of energy estimated in these systems, connected with the freely situated energy source, be E' and E'', respectively. We ask for the mutual transformation of energy between S' and S''. Two things must be taken into account.

The first one, described by (2,10), states that energy of the point source increases proportionally to value of its absolute Lorentz factor. The second one, expressed in (6,4), states that the relationship between any two inertial systems follows from the ratio between theirs absolute Lorentz factors. Thus, considering (7,1), transformation of energy is given by

$$E' = E''\gamma(u_1)/\gamma(u_2)$$

$$E'' = E'\gamma(u_2)/\gamma(u_1) \tag{7,10}$$

Let us notice that, if one of the systems is privileged (say, this one in which energy amounts E'), then (7,10) conforms to (7,3) and (7,7), *i.e.*

$$E' = E''/\gamma(u_2)$$

$$E'' = E'\gamma(u_1) \tag{7,11}$$

From the transformation of energy defined by (7,10) it follows that Einstein's equation of energy

$$E = m\gamma c^2 \tag{7,12}$$

applies to the privileged system only. In other systems it takes the more complex form. We shall obtain the right general formula by transforming the energy measured in the privileged system to a given freely situated system. We may rewrite Eq. (2,10) in the form

$$E' = E_0\gamma_{source} \tag{7,13}$$

Considering the second equation from (7,11), we get

$$E'' = E_0\gamma_{source}\gamma_{observer} \tag{7,14}$$

Thus, ignoring the doubled prime superscript, and taking the more convenient notation for Lorentz factors, we may write the general equation of energy as

$$E = \Gamma m \gamma c^2 \tag{7,15}$$

where γ stands for the absolute Lorentz factor for the point source of energy (mass), and Γ denotes the absolute Lorentz factor for the observer.

8. Conclusions

The idea of privileged system follows the traces marked up by the prominent predecessors of Einstein, with H.A. Lorentz at the front. His research makes a particularly dramatic point in the formation of modern physics. On one hand, he gave arguments for the existence of privileged frame of reference (or, using other terminology, for the presence of motionless ether). From the other hand, however, by formulating the transformation that formally expressed the relativity principle, he crucially contributed to the removal of ether. These two ways led to opposite directions and Lorentz was undoubtedly aware of that discrepancy [10].

In face of difficulties connected with comprehending of space in general relativity, Einstein tried to re-establish the concept of ether, though, at the same time, he refused to ascribe the velocity vector to it (*e.g.* [11]). Yet, his attempts didn't meet an approval from his followers.

Most of physicists ignored the solution suggested by the electromagnetic theory of matter, declaring for special relativity in the orthodox depiction settled by Einstein and Minkowski. Some others pronounced, however, for the ontological approach represented by Lorentz, or even developed its physical grounds (*e.g.* J.S. Bell [12]).

With minor exceptions yet, their standpoint didn't involve the questioning of the SRT empirical predictions or its mathematical coherence.

The results obtained in this paper show that introducing the privileged system theory (PST) is not a matter philosophical interpretation of special relativity but rather of its necessary replacement that, first of all, concerns both of its initial postulates. This, obviously, involves the further consequences. Since special relativity makes a basis for general relativity, it follows that GRT also requires rebuilding. From that point of view the K. Gödel's 'closed timelike curve paradox' [13] (that originates from the non-existence of absolute time in SRT) also makes up an argument for the revision of GRT. Besides, as it is shown in the other author's paper [14], the Einstein's equivalence principle is tightly connected with the relativity principle in the sense that failure of the one entails the failure of the other one. This all leads to conclusion that foundations of physics demand a deep revision.

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