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Review Article

Energy of the Rest Mass of a Body

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Abstract

The formulas of the Special Theory of Relativity for rest-mass energy, the total energy of a moving body, and its kinetic and potential energies have been adjusted. Formulas for the velocity of a body's fall onto a massive object in the Universe (OU) have been derived, depending on the distance to the OU. Examples of using the updated formulas are provided.

Introduction

Einstein's formula for E_0 the rest mass energy of a body m_0 in the Special Theory of Relativity (STR) is determined by Einstein's famous formula [1]:

$$E_0 = m_0 c^2, \quad (1)$$

where is $c = 2.997925 \cdot 10^8 \text{ m/s}$ – the speed of light. If a body moves with a velocity v , then its *total* energy E in special relativity is equal to:

$$E = E_v = m_v c^2 = mc^2 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (2)$$

The kinetic energy of a body T in classical mechanics is determined by the work done by A a force F . If the body was initially at a point with coordinate x_1 , and its velocity was zero, and then after some time, under the action of this force, F it moved to a point x_2 and acquired speed v , then its kinetic energy [2]:

$$T = A = \int_{x_1}^{x_2} F dx = \int_0^v m v dv = \frac{mv^2}{2} \quad (3)$$

In STR, the kinetic part of energy $\mathfrak{J}$ is obtained by subtracting the rest energy (1), which is considered the potential energy of the body, from the expression for the total energy (2):

$$v = \sqrt{2 \frac{GM}{r_v} - 2g_0 R_0} \quad (4)$$

From both formulas (3) and (4) it follows that $V \rightarrow 0$ the kinetic energy of the body

also tends to zero. As the speed of a body increases to a value close to the speed of light $v = c - \varepsilon$, where is ε – a very small value, the limits of change in kinetic energy turn out to be different:

$$\lim_{v \rightarrow c - \varepsilon} T = \lim_{v \rightarrow c - \varepsilon} \frac{mv^2}{2} = \frac{\tilde{m}(-\varepsilon)^2}{2} \approx \frac{mc^2}{2} \quad (5)$$

$$\lim_{v \rightarrow c - \varepsilon} \mathfrak{J} = \lim_{v \rightarrow c - \varepsilon} m_0 c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \cong m_0 c^2 \frac{1}{\sqrt{1 - \frac{(\tilde{n} - \varepsilon)^2}{\tilde{n}^2}}} \quad (6)$$

In formula (6) the expression $\frac{1}{\sqrt{1 - \frac{(\tilde{n} - \varepsilon)^2}{\tilde{n}^2}}}$ represents

the usual relativistic correction, and the expressions $m_0 c^2$ and in $\frac{mc^2}{2}$ formulas (5) and (6) carry the essential meaning of the limits of the kinetic energy value. Intuitively, given that these formulas can differ only in the presence or absence of a relativistic correction, it follows that the

essential components of these formulas should be the same. The discrepancy revealed indicates a possible deficiency in the theory in this regard. The purpose of this work is to make the necessary correction to the special relativity formulas for the rest-mass energy of a body and a number of other formulas.

Correction of einstein's formula

Let's analyze the origin of formula (4) for the kinetic energy of a body in special relativity. To do this, we'll cite the reasoning given in the monograph [1] for deriving this formula from the basic equation:

$$d \left(\frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \right) = F v dt, (7)$$

where is v - the absolute value of the three-dimensional velocity of the body. "On the right in (7) is the work of the force F ; on the left should be the change in energy. We define the total energy of a free relativistic particle by the expression :

$$E = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (8)$$

We emphasize that from (7), the magnitude of the body's energy is determined only up to a constant value. Definition (8) implies that a particle at rest ($v = 0$) has energy (1). However, this choice is not at all arbitrary, but is justified by the limiting transition to the classical form of velocity addition."

"Let us assume that we define the total energy of a free relativistic particle as:

$$E = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} + C \quad (9)$$

Then in the limiting case ($v \rightarrow 0$) we would get

$$E_0 = m_0 c^2 + C \quad (10)$$

Let us now consider the transformation of momentum components when moving from one Inertial Reference Frame (IRF) to another. In the limiting case, ($v \rightarrow 0$) it would follow:

$$m_0 v'_x = m_0 v_x - m_0 V - \frac{VC}{c^2}, \quad (11)$$

where is V - the velocity of one inertial frame relative to another. But from (11) the classical law of velocity addition should follow:

$$v'_x = v_x - V \quad (12)$$

This will be so if $C = 0$. This proves the validity of (8).

But this does not yet prove formula (8) for the total energy of the body. Note that, as follows from the above, formula (8) was obtained *by definition*, and not derived from any logically sound premises. Therefore, the phrase "Let us define the total energy of a free relativistic particle by the expression ..." should be understood as "Let us agree that the total energy of the particle is determined by formula (9)." This condition ignored the fact that the work of the force F on the right-hand side of equality (7) can be equal not only to the change in the energy on the left-hand side of this equality, but also to the difference in energies multiplied by a certain correlation coefficient k that has yet to be found. The introduction of such a coefficient is insurance against the possible omission of some significant causes. If it turns out that $k = 1$, expressions (1, 2, 7, 8) will remain unchanged. But if, $k \neq 1$ then these equalities will now look like this:

$$d \left(k \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \right) = F v dt, \quad (13)$$

$$E = k \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (14)$$

$$E_0 = k m_0 c^2 \quad (15)$$

$$E = E_v = k m_0 v^2 c^2 = k \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} = k m c^2 \quad (16)$$

Determination of the coefficient K

Determining the coefficient k requires considering a given process in two ways: using formulas (15, 16) and without them. Equating the calculation results allows us to calculate the coefficient k . To this end, we will conduct a thought experiment: a test body falls *rectilinearly* from a certain height onto the center of mass of a spherical gravitating Object of the Universe (OB) of large mass (e.g., a galaxy), far from all other bodies that could influence the rectilinear trajectory of the test body's fall. Under the influence of gravity, the body will accelerate toward the OB's center of mass. We will calculate the dependence of the test body's fall velocity on the distance to the OB's center of

mass and the inverse dependence of this distance on the fall velocity at a given location in two different ways: using Einstein's formula and without it. We will compare the resulting formulas and thereby determine the coefficient k .

A method for determining the speed of a straight-line fall of a body without using Einstein's formula.

The dependence of a body's velocity on the distance between a body falling in a straight line and the Universe's Object is of particular interest, as the fall occurs toward the center of mass of the OB, which is formally at an infinite distance from the OB with an initial velocity of zero. This method relies on the body acquiring kinetic energy through the work of the OB's gravitational force. As the body approaches the OB's center of mass, the gravitational force, and therefore the acceleration due to gravity, will increase in accordance with Newton's Law of Universal Motion.

In the monographs [3-5] it is proven that the change in distance r , determined by the differential equation:

$$\left(\frac{dr}{dt}\right)^2 = \frac{2GM}{r} + h_1 - h_2 = \emptyset(r), \quad (17)$$

depends on the roots of the equation:

$$\emptyset(r) = 0, \quad (18)$$

which cannot be complex, but when

$$h_2 = 0 \quad (19)$$

equation (18) cannot have more than one root, and equation (17) itself will be simplified:

$$\left(\frac{dr}{dt}\right)^2 = \frac{2GM}{r} + h_1 \quad (20)$$

The value h_1 is determined from the following considerations.

Let the test body be on the surface of the OB, exactly above its Center of Mass at a height

$$H = R_0, \quad (21)$$

and from this position begins to fall straight down onto the OB. In this case, the change in the body's kinetic energy is equal to the work done by the forces of attraction:

$$\frac{mv^2}{2} = mgh, \quad (22)$$

where:

$$v^2 = 2gr, \quad (23)$$

Where $r = h$.

Since the body is at rest at distance R_0 from the center of mass OB, and at a distance r_v its speed is equal to v , then its kinetic energy, taking into account (21 – 23), is equal to:

$$\frac{mv^2}{2} = m \int_0^{r_v} v dv = m \int_{R_0}^{r_v} g dr \quad (24)$$

where :

$$v^2 = 2 \int_{R_0}^{r_v} g dr \quad (25)$$

Let us write the equation of motion for a body in a gravitational field OB of mass M , taking into account the Principle of Equivalence of Inertial and Gravitational Masses [6]. To do this, we equate the attractive force acting on a test particle (body) of mass m (a test particle is a particle whose contribution to the general gravitational field can be neglected) from an OB of mass M , according to the Law of Universal Gravitation:

$$F = G \frac{m \cdot M}{r^2}, \quad (26)$$

where is r - the distance between the test body and OB;

$G = 6,67259 \cdot 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$ - is the gravitational constant, with the force acting on this test body according to Newton's second law:

$$F = ma, \quad (27)$$

where is a - the acceleration of a body moving under the action of force F :

$$ma = F = m \frac{GM}{r^2} \quad (28)$$

If the force acting on the test body is the force of attraction OB, then the acceleration of the body is the acceleration due to gravity

$$a = g, \quad (29)$$

therefore from (28) it follows:

$$GM = gr^2, \quad (30)$$

where:

$$g = \frac{GM}{r^2} \quad (31)$$

Since the radius of the gravitational force of the OB is formally equal to infinity, the acceleration of gravity on the

surface of the OB is zero. However, in practice, the radius of the object is taken to be finite $r = R_0$, so the acceleration of gravity on the surface of the object will be equal to $g = g_0$, and the corresponding equality (30) will be written:

$$GM = g_0 R_0^2 \quad (32)$$

Let's substitute (31) into (25):

$$\int_{R_0}^{r_v} 2gdr = \int_{R_0}^{r_v} \frac{2GM}{r^2} dr = 2GM \left(\frac{1}{r_v} - \frac{1}{R_0} \right) = v^2 \quad (33)$$

From formula (33) we obtain:

$$\frac{1}{r_v} - \frac{1}{R_0} = \frac{v^2}{2GM}, \quad (34)$$

$$r_v = \frac{2GMR_0}{2GM + v^2 R_0} \quad (35)$$

Substituting (32) into (35), we obtain the second formula for the dependence of the distance of the body from the OB during its rectilinear fall on the OB on the speed of its fall:

$$r_v = \frac{2g_0 R_0^2}{2g_0 R_0 + v^2} \quad (36)$$

From formulas (35), (36) we find the dependence of the body's speed on its distance to the OB during a straight-line fall of the body in the direction of the OB's center of mass:

$$v^2 = 2 \frac{GM}{r_v} - 2g_0 R_0 \quad (37)$$

$$v^2 = 2 \frac{g_0 R_0^2}{r_v} - 2g_0 R_0 = 2g_0 R_0 \left(\frac{R_0}{r_v} - 1 \right) \quad (38)$$

$$v = \sqrt{2 \frac{GM}{r_v} - 2g_0 R_0} \quad (39)$$

$$v = \sqrt{2g_0 R_0 \left(\frac{R_0}{r_v} - 1 \right)} \quad (40)$$

Comparing formula (20) with (37) and (38), we see that the required constant h_1 is negative.

$$h_1 = -2g_0 R_0 \quad (41)$$

A negative value of the constant h_1 indicates that the trajectory of the rectilinear motion of the body towards OB is a limiting elliptical orbit.

In order to obtain the desired dependencies (35 – 40), for the case when the speed of the body is equal to the speed of light, it is sufficient to replace the speed in these formulas with the speed c :

$$r_c = \frac{2GMR_0}{2GM + c^2 R_0} \quad (42)$$

$$r_c = \frac{2g_0 R_0^2}{2g_0 R_0 + c^2} \quad (43)$$

$$c^2 = 2 \frac{GM}{r_c} - 2g_0 R_0 \quad (44)$$

$$c^2 = 2 \frac{g_0 R_0^2}{r_c} - 2g_0 R_0 = 2g_0 R_0 \left(\frac{R_0}{r_c} - 1 \right) \quad (45)$$

$$c = \sqrt{2 \frac{GM}{r_c} - 2g_0 R_0} \quad (46)$$

$$c = \sqrt{2g_0 R_0 \left(\frac{R_0}{r_c} - 1 \right)} \quad (47)$$

Formulas (44 – 47) show the dependence of the speed of light and the gravitational constant, which is assumed to change over time [7], on the characteristics of the Object of the Universe (size, mass, acceleration due to gravity) and can be used to determine these characteristics.

A method for determining the speed of a straight-line falling body using Einstein's formula.

This method is based on the fact that, although motion occurs under the influence of gravity, the body acquires kinetic energy by expending its rest mass. The method uses Einstein's formula (1.2) taking into account the proportionality coefficient k , which is a correlation coefficient in the form (15, 16).

The dependence of mass on the velocity of a body c can be explained by the fact that if the total mass of a body m_v , moving with velocity v , and its rest mass m_0 , expresses the amount of matter, then the law of the dependence of mass on velocity always applies not only to the moving body, but also to the physical field associated with that body. If the total mass of a body is understood as an amount of matter, then the velocity of a particle will not increase the amount of matter in the body, but rather the amount of matter in the physical field associated with the moving body [8,9].

The inertial mass of a body is caused by the dynamic effect of absolute motion relative to a disturbed fundamental field, which is substantial. This dynamic effect can be considered

as the resistance of the fundamental field and, accordingly, as an inertial force, and this state of the fundamental field relative to a non-inertial moving body is *an inertial field*. Since an inertial field is merely a modified substantial fundamental field, the inertial field is also substantial [10,11]. Considering the motion of charged particles in corresponding fields, and in particular in a gravitational field, leads to the concept of inertia. It follows that, from the moment the body begins moving with velocity v , a certain inertial additive responsible for inertia μ_v — *the added mass* — is added to the particle's normal classical mass m_0 :

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} = m_0 + \mu_v \quad (48)$$

From (48) it follows that the added mass is equal to the difference between *the total* mass of the body and its rest mass:

$$\mu_v = m_v - m_0 \quad (49)$$

The energy of added mass, by analogy with the energy of rest mass, has the physical meaning of *the energy of mass motion*. Equality (49) allows us to assume that if the added mass is equal to the difference between the total energy of a body and its rest mass, then the residual rest mass of the body itself can also be added mass to the body from the state when it was in a massless state, i.e., had zero mass. Under this assumption, the rest mass of a body can be the result of the absolute motion of the body and represents the energy that is equal to the energy released when a body falls from the very edge of the Universe (or from the surface of a sufficiently large Object in the Universe) to the center of mass of the Universe (or the center of mass of the corresponding OB).

The energy of the rest mass E_0 (15) is spent on doing work

$$W = F \cdot S, \quad (50)$$

where F is equal to the force of interaction between the body and the center of mass of the Object (3):

$$F = G \frac{m_0 \cdot M}{R_0^2}, \quad (51)$$

R_0 – The distance from the surface of the object to its center of mass, equal to the radius of the object. This work is performed by the object, which creates a gravitational field that attracts the test object. Numerically, this work is equal to the potential energy contained in the rest mass of the test object. It is equal to the work required to move this object from the surface of the object to the distance where it reaches the speed of light:

$$S = R_0 - r_c \quad (52)$$

towards the center of mass of the Object, after passing which the body will spend all its rest mass energy on this work:

$$E_0 = \int_{R_0}^{r_c} G \frac{m_0 \cdot M}{R^2} dR = m_0 GM \left(\frac{1}{r_c} - \frac{1}{R_0} \right),$$

where is r_c – the distance from the location of the test body to the center of mass of the Object. The acceleration of gravity of a body falling from the surface of the Object to its center of mass (31) is equal to:

$$g_0 = \frac{GM}{R_0^2}. \quad (54)$$

Substituting (54) into (53), we obtain:

$$E_0 = m_0 g_0 R_0^2 \left(\frac{1}{r_c} - \frac{1}{R_0} \right) \quad (55)$$

Let's substitute E_0 from (15) into equalities (53) and (55):

$$E_0 = km_0 c^2 = m_0 GM \left(\frac{1}{r_c} - \frac{1}{R_0} \right) \quad (56)$$

$$E_0 = km_0 c^2 = m_0 g_0 R_0^2 \left(\frac{1}{r_c} - \frac{1}{R_0} \right) \quad (57)$$

and we reduce both parts of the obtained equalities by m_0 , we obtain formulas that no longer contain the mass of the test body:

$$\frac{kc^2}{GM} = \frac{1}{r_c} - \frac{1}{R_0} \quad (58)$$

$$\frac{\hbar^2}{g_0 R_0^2} = \frac{1}{r_c} - \frac{1}{R_0} \quad (59)$$

Solving these equations for r_c , we obtain:

$$r_c = \frac{GMR_0}{GM + kc^2 R_0} \quad (60)$$

$$r_c = \frac{g_0 R_0^2}{g_0 R_0 + kc^2} \quad (61)$$

Let's equate the values r_c from (42, 43) and (60) (61):

$$r_c = \frac{2GMR_0}{2GM + c^2 R_0} = \frac{GMR_0}{GM + kc^2 R_0} \quad (62)$$

$$r_c = \frac{2g_0 R_0^2}{2g_0 R_0 + c^2} = \frac{g_0 R_0^2}{g_0 R_0 + kc^2} \quad (63)$$

Solving equations (62, 63) for the coefficient k , we obtain:

$$k = \frac{1}{2} \quad (64)$$

Substituting (64) into equalities (15, 16), we obtain formulas for the energy of the rest mass of the body:

$$E_0 = \frac{1}{2} m_0 c^2 \quad (65)$$

and the total energy of the body:

$$E = E_v = \frac{1}{2} m_v c^2 = \frac{1}{2} \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}, \quad (66)$$

and all theories that use formulas (1, 2) must be corrected by replacing these formulas with formulas (65, 66).

Testing the formula $E = \frac{1}{2} mc^2$

Let us consider how some formulas of STR will change when switching to the use of formulas (65, 66).

Full body energy.

The total energy of a body E in STR, previously determined by formulas (2)

$$E = E_v = m_v c^2 = mc^2 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}},$$

taking into account (64), it should be written in formulas (65 – 67)

$$E = \frac{1}{2} mc^2, \quad (67)$$

Kinetic energy of the body.

The kinetic energy of a body in classical mechanics is determined by formula (3)

$$T = \frac{mv^2}{2}.$$

In STR, the kinetic energy $\mathfrak{T}$ of a body is defined as the difference between the total energy of the body and the

potential energy of the body W according to formula (4),

$$\mathfrak{T} = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} - m_0 c^2 = m_0 c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right)$$

which is mistakenly taken to be the energy of the body's rest mass W_0 . However, the equality of potential energy and rest mass energy does not follow from anywhere. As will be shown below, they are not at all equal. The kinetic energy of a body T in special relativity must be determined using the same formula (3) as in classical mechanics, but taking into account the dependence of the body's mass on its velocity. To do this, simply substitute the value of the body's mass into formula (3), taking into account the relativistic correction, which depends on its velocity in accordance with special relativity:

$$T = \frac{mv^2}{2} = \frac{m_v v^2}{2} = \frac{m_0 v^2}{2\sqrt{1 - \frac{v^2}{c^2}}} \quad (68)$$

Potential energy of the body.

The potential energy of a body in STR is naturally found as the difference between the total energy (67) and the kinetic energy of the body (68):

$$W = \frac{m_0 c^2}{2\sqrt{1 - \frac{v^2}{c^2}}} - \frac{m_0 v^2}{2\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1}{2} m_0 c \sqrt{c^2 - v^2} \quad (69)$$

From formula (69) $v = 0$ the energy of the rest mass of the body can be easily found by substitution (65). Comparing formulas (65) and (69), we see that potential energy differs from the energy of a body at rest primarily in that the potential energy of a body takes into account the body's velocity, and the greater the body's velocity, the less potential energy it has left. A body at rest, on the other hand, possesses the maximum $v = 0$ potential energy possible for it ().

Metamorphoses

Let us solve the following problem: in the process of a test body falling on an Object of the Universe with a large mass, its rest mass is spent on increasing the kinetic energy of the test body (68); what will be the speed of the body at the moment when the body has spent all of its rest mass?

To answer this question, we equate the kinetic energy of the body (68) to its rest mass (65):

$$\frac{m_0 v^2}{2\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{2} m_0 c^2, \quad (70)$$

where

$$c^2 = \frac{v^2}{\sqrt{1-\frac{v^2}{c^2}}} \quad (71)$$

After squaring equality (71), we obtain the equation:

$$v^4 + c^2 v^2 - c^4 = 0, \quad (72)$$

Having solved which we find the required speed:

$$v = c \sqrt{\frac{(\sqrt{5}-1)}{2}} = 235696.9 \text{ km/s} = \omega_1. \quad (73)$$

The obtained value of the velocity ω_1 coincides with the value of the critical velocity ω , above which the substance turns into a substance with negative mass – *negamatter*, and the mass of such a substance becomes negative [12 – 15]. In the work [16] it is suggested that negamatter may be particles of dark matter.

We write equality (49) for the mass of a substance in the form of an equality of the corresponding energies:

$$\dot{E}_v = E_v - E_0, \quad (74)$$

where is $\dot{E}_v$ – the energy of the mass of motion (the energy of the added mass); E_v – the total energy of a body moving with velocity v (66), E_0 – the energy of the rest mass of a body (65).

Substituting (65, 66) into (74), we obtain:

$$\dot{E}_v = \frac{m_0 c^2}{2\sqrt{1-\frac{v^2}{c^2}}} - \frac{1}{2} m_0 c^2 = \frac{1}{2} m_0 c^2 \left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} - 1 \right) \quad (75)$$

From equality (75) it follows that as the velocity of a body increases to or near the speed of light, the energy of the mass of motion can increase to infinitely large values, and there are no restrictions on this. However, the entire mass of the test body's substance, consisting of the rest mass and the added mass, will already be negative. This follows from works [12–17]. The mechanism for the transition of the mass of a substance to a substance with negative

mass is described in [18], and experimental confirmation of this phenomenon is described in work [19]. Moreover, the substance itself, of which the test body is composed, has not disappeared; it has simply changed the sign of its gravitational charge, while the energy of the rest mass and even the energy of the moving body remain positive! Therefore, the formulas for the dependence of the energy of a body at rest and moving can be written as:

$$E_0 = \frac{1}{2} |m_0| c^2 \quad (76)$$

$$E_v = \frac{1}{2} |m_v| c^2, \quad (77)$$

where m_0 and m_v can take both positive and negative values.

Conclusion

Based on the analysis of the special relativity formulas for the rest-mass energy, kinetic, potential, and total energy of a body, the necessary modifications were made to these formulas. Specifically, it was substantiated that the rest-mass energy of a body should be determined not by formula (1), but by formula (65). The total energy of a body, taking into account (65), corresponds to formula (66), not formula (2).

The total energy of a body E in the STR, previously determined by formula (2), taking into account (64), must be written in the form of formulas (65 – 67).

Instead of formula (4), formula (68) should be used for the kinetic energy of a body, and for potential energy, instead of its equality to the energy of rest mass (1), formula (69) should be used.

If the topic of discussion requires taking into account the gravitational charge of a body's mass, which depends on the body's velocity, then instead of formulas (1, 2, 65, 66), one must use the more general formulas (76, 77), which indicate that the energies of the rest mass and the mass of motion of a body do not depend on the negativity or positivity of these masses. In accordance with (76) and (77), formulas (66, 68, 69) change their form:

$$E = E_v = \frac{1}{2} |m_v| c^2 = \frac{1}{2} \frac{|m_0| c^2}{\sqrt{1-\frac{v^2}{c^2}}} \quad (78)$$

$$T = \frac{|m_0| v^2}{2\sqrt{1-\frac{v^2}{c^2}}} \quad (79)$$

$$W = \frac{1}{2} |m_0| c \sqrt{c^2 - v^2} \quad (80)$$

Along the way, formulas were derived for the distance from the location of the body to the center of mass of the OB during its rectilinear fall in the direction of the center of mass of the OB, depending on the speed of its fall and, conversely, the speed of the fall of the body depending on the distance to the center of mass of the OB (35 – 47).

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