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RESEARCH ARTICLE

MASS AND ENERGY OF THE BODY IN MOTION MSR (MOTION SHAPES REALITY)

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ABSTRACT

If the mass-energy equivalence is introduced into the Newtonian dynamics, the altered formulae for inertia (inertial mass), force and acceleration, momentum and energy are obtained. All the mentioned quantities are in the function of the relative velocity of two bodies and they are essentially classical Newton's formulae for low velocities (the velocities significantly lower than the speed of light), while for high velocities (the velocities comparable with the speed of light) they are significantly different from classical Newton's formulae. The results of this paper show that STR (Special Theory of Relativity) is not correct. In addition, this paper has studied the mass and energy of photons and it has been shown that they also depend on the speed of two bodies (the body emitting photons and the body receiving photons) and on the relationship of the masses of these two bodies. Thus, photons with the same frequencies can have different speed, wavelength and energy depending on the Doppler Effect (which is in the function of speed of two bodies and the relationship of their masses).

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INTRODUCTION

The classical Newtonian dynamics uses the notion of mass which expresses the quantity of substance which is unique and independent of the body's speed [Newton, 1999]. Thus, for Newton, inertial mass m_i which resists the change of motion is constant and equal to the quantity of substance m_0. This results from the premise that the inertial mass and the energy of the body are independent quantities and that the body which is relatively motionless (in relation to the reference body) has no energy. However, the studies of Lorentz [1904], Poincaré [1900] and others have shown that there is dependence between the total mass and total energy of the body, i.e. that the total mass has the energy equivalent and that the total energy has the mass equivalent, and that the body which is relatively motionless (in relation to the reference body) has energy. It is the "hidden" energy, the rest energy E_0, equivalent to the body mass (the quantity of the substance), which would be released if the total body mass m_0 was turned into the electromagnetic radiation in the direction of the body's motion, into the photons with the speed c_0. When a body moves at the velocity of v, it also gains the kinetic energy E_k, so the total energy of the body in motion E is the sum of the rest energy E_0 and kinetic energy E_k.

In accordance with the above mentioned, inertial mass, force, acceleration, momentum and energy are in the function of the body mass m_0, the relative velocity of the body v and the speed of the emitted photons c_0. Since the photon reaching the reference body from another body which is in relative motion in relation to the reference body has different frequency from the emitted frequency (the Doppler shift) and different energy, and since the mass of the emitted photon (as the quantity of the substance) is unchangeable, and due to the fact that the photon's energy is in the function of its frequency and its speed, it means that the received photon has the speed different from the emitted photon, and it is in the function of changing the frequency (the Doppler shift), i.e. in the function of the relative velocity of the two bodies (emitter and receiver) and the relationship between their masses.

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The subject of this paper is to propose a new theory called MSR (Motion Shapes Reality) about the mass and energy of two bodies in mutual motion, based on Newton's laws while introducing the mass-energy equivalence. In addition, this paper suggests a hypothesis about different characteristics of different photons on the same frequencies in the function of the velocity of two bodies (the body emitting photons and the body receiving photons) and the relationship between their masses.

The Concept of Mass and Energy of the Body in Motion

The mass of a body is defined as the quantity of substance and it is unchangeable. Let us call it the passive mass m_0. If, theoretically, the total passive mass m_0 of a body was transformed into electromagnetic radiation, into the photons of the speed c_0, the total energy of the radiation (the total energy of the emitted photons) E_0 would be obtained, which represents the rest energy of the body. When a body moves at the velocity of v, it also gains the energy of motion (kinetic energy) E_k so the total energy of the body in motion E is the sum of the rest energy E_0 and the energy of motion E_k.

$$E = E_0 + E_k \tag{2.1}$$

The relationship between the body mass m_0 and its rest energy E_0 can be expressed by the following relation

$$E_0 = k m_0 c_0^2 \tag{2.2}$$

that is: $m_0 = E_0/kc_0^2$

where m_0 is the body mass and k is the coefficient of equivalence.

Similarly, the relationship $m_i = E/kc_0^2$ can express the mass equivalent of the total energy of the body in motion, i.e. the inertial mass m_i, and it follows that $E = k m_i c_0^2$

The energy of a body's motion (kinetic energy) is defined by the expression $E_k = mv^2/2$, where v is the velocity of the body. The question is what kind of mass is the mass m in the expression for the kinetic energy. Since the *inertial mass* is a measure of an object's resistance to the alteration of its state of motion (Newton), thus, while changing the state of motion the force is applied to this inertial mass m_i, so the equation for the kinetic energy becomes $E_k = m_i v^2/2$.
Now the formula for the total energy of the body in motion can be expressed by the relation:

$$k m_i c_0^2 = k m_0 c_0^2 + m_i \frac{v^2}{2} \tag{2.3}$$

that is:

$$m_i = m_0 + m_i v^2/2kc_0^2 = m_0 + m_k \tag{2.4}$$

where the expression $m_k = m_i v^2/2kc_0^2$ represents the mass equivalent of the kinetic energy which will be named active (kinetic) mass.

Thus, the expression for the total energy of the body in motion $E = E_0 + E_k$ can be formulated as follows:

$$m_i c_0^2 = m_0 c_0^2 + m_k c_0^2 \tag{2.5}$$

Solving the equation (2.3) for m_i it is obtained as follows:

$$m_i = m_0 \frac{2kc_0^2}{2kc_0^2 - v^2} \qquad m_k = m_0 \frac{v^2}{2kc_0^2 - v^2} \tag{2.6}$$

Mass and Energy of the Emitted Photon

Let us apply the above mentioned derivation procedure to the photon as a particle. The photon does not emit other particles which could express its rest energy, i.e. the photon can be considered to emit itself at the speed of $c=0$, so the rest energy of the photon is:

$$E_{f0} = m_{f0} * 0 = 0 \tag{3.1}$$

Therefore, the photon has no rest energy, so the expression $E_f= E_{fo}+ E_{fk}$ for the total energy of the photon in motion at the emitted speed of c_0 becomes

$$E_f = km_{fi}{c_0}^2 = E_{fk} = m_{fi}\frac{{c_0}^2}{2} \qquad k = 1/2 \tag{3.2}$$

where m_{fi} is the inertial mass of the photon and E_{fk} is its kinetic energy.

Thus, the total energy of the photon equals its kinetic energy.

Using the expression $E_{fk}=m_{fk}\ c_0^2= m_{fi}\ c_0^2/2$ (m_{fk} is the active, kinetic mass of the photon), $m_{fk}= m_{fi}\ /2$ is obtained, so the expressions for the inertial (total) mass and energy of the photon are as follows:

$$m_{fi} = m_{f0} + \frac{m_{fi}}{2} \qquad \text{i.e.} \qquad m_{fi} = 2m_{f0} \qquad m_{fk} = m_{f0} \tag{3.3}$$

$$E_f = \frac{1}{2}m_{fi}{c_0}^2 = E_{fk} = m_{f0}{c_0}^2 \tag{3.4}$$

Mass and Energy of the Body in Motion

Let us consider the expression $E_0= k\ m_0c_0^2$ for the total energy of the emitted photons.

Since the total energy of a photon is its kinetic energy, the expressions (3.2) and (3.3) imply the following:

$$E_0 = m_0\,\frac{m_{fi}}{m_{f0}}\,\frac{{c_0}^2}{2} = 2m_0\frac{{c_0}^2}{2} = m_0{c_0}^2 \qquad k = 1 \tag{4.1}$$

Introducing k=1 into the expressions (2.6) and (2.5), it is obtained as follows:

$$m_i = m_0\frac{2{c_0}^2}{2{c_0}^2 - v^2} = m_0\frac{2}{2-\left(\frac{v}{c_0}\right)^2} \qquad m_k = m_0\frac{v^2}{2{c_0}^2 - v^2}$$

$$E = m_0{c_0}^2\frac{2{c_0}^2}{2{c_0}^2 - v^2} = E_0\frac{2}{2-\left(\frac{v}{c_0}\right)^2} \tag{4.2}$$

$$E_k = m_0v^2\,\frac{{c_0}^2}{2{c_0}^2 - v^2} = m_0v^2\frac{1}{2-\left(\frac{v}{c_0}\right)^2}$$

Terminal velocity of a body is obtained from the expression (4.2):

$$2{c_0}^2 - v^2 > 0 \qquad v < c_0\sqrt{2} \tag{4.3}$$

Figure 1 represents the dependence of the inertial mass of the body in motion on the velocity according to STR (Special Theory of Relativity) and according to MSR (Motion Shapes Reality).

Momentum, Force, Acceleration

Momentum (the quantity of motion) is defined as the product of the inertial mass of a body and its relative velocity:

$$p = m_iv = m_0v\frac{2{c_0}^2}{2{c_0}^2 - v^2} = m_0v\left(1 + \frac{v^2}{2{c_0}^2 - v^2}\right) \tag{5.1}$$

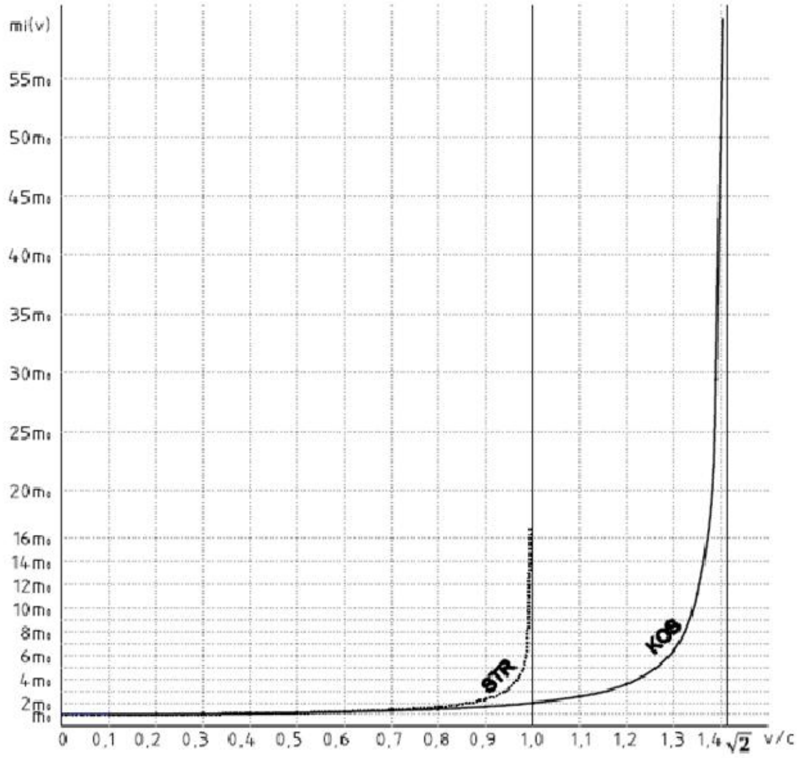

Fig.1. Dependence of the inertial mass on the velocity of the body

The relationship between the momentum and kinetic energy is represented by the expression:

$$\frac{E_k}{p} = \frac{v}{2} \qquad (5.2)$$

Figure 2 represents the dependence of the momentum on the velocity according to STR (Special Theory of Relativity) and according to MSR (Motion Shapes Reality). Force is defined as the measure of the mutual interaction of two bodies. Generally, force represents the change of momentum in the unit of time, that is: $F = \frac{dp}{dt} =$. Since the inertial mass is not a constant quantity and depends on the velocity, it cannot be treated as a constant while differentiating.

$$F = \frac{dp}{dt} = \frac{d(m_i v)}{dt} = m_i \frac{dv}{dt} + v\frac{dm_i}{dt} = m_i a + v a_m \qquad (5.3)$$

Newton's second law defines force as the product of inertial mass of a body m_i and acceleration a_e:

$$F = m_i a_e \qquad (5.4)$$

Equalizing the expressions (5.3) and (5.4) and dividing by m_i it is obtained as follows:

$$a_e = \frac{dv}{dt} + \frac{v}{m_i}\,\frac{dm_i}{dt} = a + \frac{v}{m_i} a_m \qquad (5.5)$$

where: $\alpha_e$effective acceleration of the body

$a = \frac{av}{dt}$ acceleration as the change of velocity in the unit of time

$a_m = \frac{dm_i}{dt}$ acceleration as the change of inertial mass in the unit of time

$v = at$ velocity as the product of acceleration and time

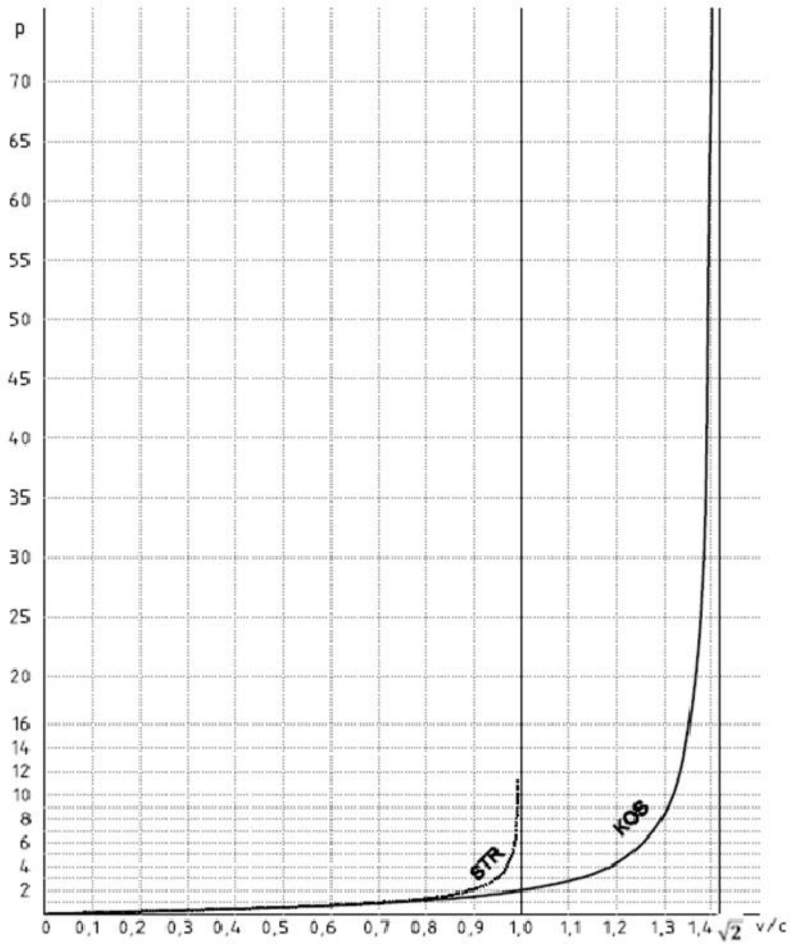

Fig.2. Dependence of the momentum on the velocity of a body

$$a_m = \frac{dm_i}{dt} = \frac{d(\frac{2m_0 c_0^2}{2c_0^2 - v^2})}{dt} = 2m_0 \frac{d\frac{c_0^2}{2c_0^2 - v^2}}{dv}\frac{dv}{dt}$$

$$a_m = 2m_0 a \frac{2c_0^2 v}{(2c_0^2 - v^2)^2} = a \frac{4m_0 v c_0^2}{(2c_0^2 - v^2)^2}$$

$$a_e = a\left[1 + \frac{v}{m_i}\frac{4m_0 v c_0^2}{(2c_0^2 - v^2)^2}\right] = a\,\frac{2c_0^2 + v^2}{2c_0^2 - v^2} = a\,\frac{2 + (v/c_0)^2}{2 - (v/c_0)^2}$$

$$F = m_i a_e = m_0 a \frac{2c_0^2}{2c_0^2 - v^2}\,\frac{2c_0^2 + v^2}{2c_0^2 - v^2} \qquad (5.6)$$

$$F = 2m_0 c_0^2 a \frac{2c_0^2 + v^2}{(2c_0^2 - v^2)^2} = 2m_0 a\,\frac{2 + \frac{v^2}{c_0^2}}{\left(2 - \frac{v^2}{c_0^2}\right)^2} \qquad (5.7)$$

Work and Energy

Work is defined as acting of force over a particular distance.

If the beginning of the distance is the starting point of motion (t= 0, v= 0, m_i=m_0), work will be equal to the kinetic energy (energy of motion) E_k:

$$E_k = \int_0^s F\,ds = \int_0^t \left(m_i \frac{dv}{dt}\right) v\,dt = \int_0^v m_i v\,dv$$

Since prior to the beginning of motion it is ($t= 0$, $v= 0$) $m_i= m_0$, it is obtained as follows:

$$E_k = m_i \frac{v^2}{2} = m_0 \frac{2{c_0}^2}{2{c_0}^2-v^2} \frac{v^2}{2} = m_0 {c_0}^2 \frac{v^2}{2{c_0}^2-v^2} \tag{6.1}$$

For a part of the distance from point A ($t= t_1$, $v= v_1$, $m_i=m_{i1}$) to point B ($t= t_2$, $v= v_2$, $m_i=m_{i2}$) work is:

$$W = \int_A^B F\,ds = \int_0^B F\,ds - \int_0^A F\,ds = {v_2}^2 \frac{m_{i2}}{2} - {v_1}^2 \frac{m_{i1}}{2}$$

$$W = E_{k_2} - E_{k_1} = \frac{m_0}{2}\left[{v_2}^2 \frac{2{c_0}^2}{2{c_0}^2 - {v_2}^2} - {v_1}^2 \frac{2{c_0}^2}{2{c_0}^2 - {v_1}^2}\right]$$

$$W = m_0 {c_0}^2 \left[\frac{{v_2}^2}{2{c_0}^2 - {v_2}^2} - \frac{{v_1}^2}{2{c_0}^2 - {v_1}^2}\right] \tag{6.2}$$

On Mass and Energy of Photon

Since the emitted photon has the energy of $E_{fE}= hf_0$ [Plannck, 1900] and considering (3.4) it follows:

$$m_{f0}{c_0}^2 = hf_0 \qquad m_{f0} = m_{fk} = hf_0/{c_0}^2 \qquad m_{fi} = 2hf_0/{c_0}^2 \tag{7.1}$$

where:

h	the Planck constant
f_0	the emitted frequency of the photon
c_0	the emitted speed of the photon

The momentum of the emitted photon is:

$$p_{f0} = m_{fi}c_0 = 2hf_0/c_0 = 2h/\lambda_0 \tag{7.2}$$

where:

p_{f0}	the momentum of the emitted photon
λ_0	the wavelength of the emitted photon

When it comes to bodies in mutual motion, the light of the emitted frequency f_0 (emitted photon) from one body reaches the other body (received photon) with the frequency of $f \neq f_0$. The relationship between the emitted frequency f_0 and received frequency f is defined by the Doppler shift z:

$$z \quad f_0/f\text{-}1 \qquad f_0/f \quad z+1 \qquad f/f_0 \quad 1/(z-1) \tag{7.3}$$

The relationship between the Doppler shift z and the relative motion of two bodies is represented in the relation [[Jeremić, 2016]:

$$z= \gamma\text{-}1 \qquad \gamma= (c_0+v_E)/(c_0\text{-}v_P) \qquad v= v_E+v_P \tag{7.4}$$

where:

c_0	the speed of the emitted photon in vacuum
v	the relative velocity of two bodies (emitter and receiver)
$v_E = vm_R/(m_E+m_R)$	the velocity of the emitter in relation to the center of mass of the two bodies
$v_R = vm_E/(m_E+m_R)$	the velocity of the receiver in relation to the center of mass of the two bodies
m_E, m_R	the mass of the emitter, the mass of the receiver

Due to the fact that the received photon has the energy $E_f = E_{fk} = hf$, it follows that $E_f \neq E_{fE.}$

If the mass of the photon m_{f0} (as the quantity of the substance) is unchangeable, the change of the photon's energy implies the change of the photon's speed, i.e. the speed c of the received photon is different from the speed of the emitted photon ($c \neq c_0$). Thus it follows:

$$m_k c^2 = hf \qquad m_0 = hf_0/c_0^2 \qquad m_k = m_i/2 = hf/c^2 \qquad m_i = 2hf/c^2$$

$$m_i = m_0 + m_k \qquad 2hf/c^2 = hf_0/c_0^2 + hf/c^2 \qquad f/c^2 = f_0/c_0^2$$

$$\frac{f}{f_0} = \frac{c^2}{c_0^2} \qquad c^2 = \frac{fc_0^2}{f_0} \qquad c = c_0\sqrt{\frac{f}{f_0}} \qquad c = \frac{c_0}{\sqrt{z+1}} = \frac{c_0}{\sqrt{\gamma}} \tag{7.5}$$

The momentum of the received photon is:

$$p_f = m \cdot c = \frac{2hf}{c} = \frac{2h}{\lambda} = \frac{p_{f0}}{\sqrt{z+1}} = \frac{p_{f0}}{\sqrt{\gamma}} \tag{7.6}$$

and its wavelength is:

$$\lambda = \frac{c}{f} = \frac{\frac{c_0}{\sqrt{z+1}}}{\frac{f_0}{z+1}} = \lambda_0\sqrt{z+1} = \lambda_0\sqrt{\gamma} \tag{7.7}$$

where:

p_f	the momentum of the received photon
f	the frequency of the received photon
$\lambda = c/f$	the wavelength of the received photon
c	the speed of the received photon

Therefore, photons with the same frequencies can have different masses, different speed, different energy and different wavelength depending on the size of the Doppler shift, i.e. depending on the relative velocities of the emitter and receiver and depending on the relationship between their masses.

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