Category: mathematical physics

Topic: special theory of relativity

Cochetkov Victor Nikolayevich

chief specialist FSUE “Center for exploitation of space ground-based infrastructure facilities” (FSUE “TSENKI”)

vnkochetkov@gmail.com

Using the law of conservation of momentum for determine the constant in the special theory of relativity

This article attempts to use the law of conservation of momentum of a closed system for determining the value of the constant in the transformation of coordinates and time in inertial reference systems.

PACS number: 03.30.+p

Content

1. The introduction

In special theory of relativity, the dependence of point mass of the material body on its velocity is set based on the mandatory implementation of the laws of conservation of momentum and energy in the inertial reference systems, when considering the specific examples of the interaction of the bodies, constituting a closed mechanical system.

It is proposed to use the law of conservation of momentum to determine the value of the constant in the transformations of coordinates and time in the inertial reference systems, when considering cases with constant interaction of the bodies, constituting a closed mechanical system.

2. The main dependence of the special theory of relativity

Assume that there are two inertial reference systems, shown in Fig.1, stationary $O_1x_1y_1z_1$ and mobile $O_2x_2y_2z_2$, in which:

- similar the axis of the Cartesian coordinate systems $O_1x_1y_1z_1$ and $O_2x_2y_2z_2$ are pairs parallel and equally directed;

- system $O_2x_2y_2z_2$ moves relative to the system $O_1x_1y_1z_1$ with constant speed V along the axis O_1x_1;

- in both systems as the start timing (t_1=0 and t_2=0) is selected when the origin O_1 and O_2 of these systems are identical.

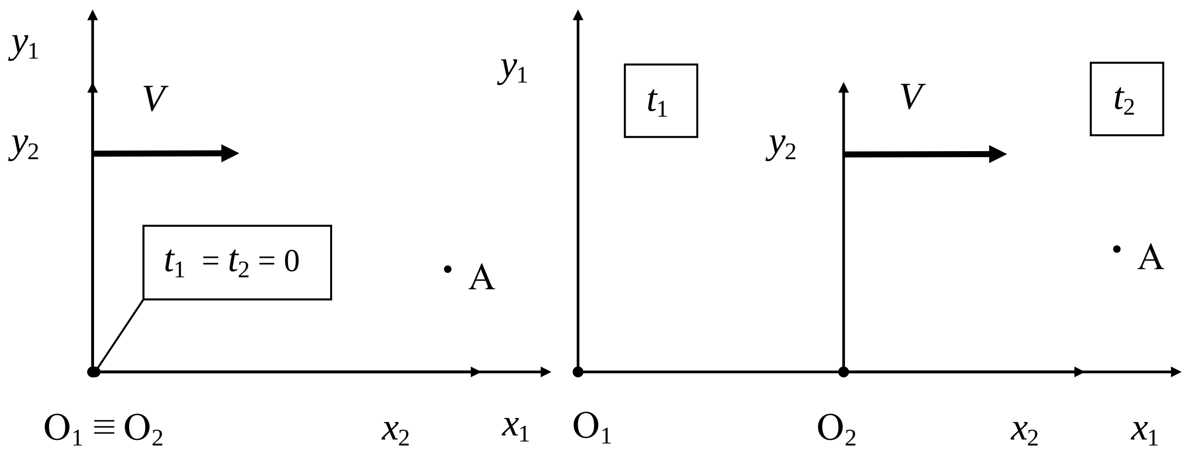

Fig.1

In the special theory of relativity as the baselines used:

- the symmetry of space and time [1], [2], [3], [4], [5];

- the principle of relativity [6], [7], [8] [9], [10], [11], [12], 13];

- the principle of invariance of the speed of light [6], [7], [8] [9], [10], [11],

[12], 13];

- the inertial of the considered reference systems [1], [2], [3], [4], [5], [6], [7], [8] [9], [10], [11], [12], 13].

Using the principle of relativity and the symmetry of space and time, by analogy with [8], [9], [10], [14], [15], provides a link between the coordinates x_1, y_1, z_1 of point A at time t_1 in a stationary inertial reference system $O_1x_1y_1z_1$ and coordinates x_2, y_2, z_2 of the same point A in the mobile inertial reference system $O_2x_2y_2z_2$ at the time t_2, corresponding to time t_1 in the stationary inertial reference system $O_1x_1y_1z_1$:

$$x_1 = \gamma_V \cdot [x_2 + (V \cdot t_2)] \quad (1)$$

$$x_2 = \gamma_V \cdot [x_1 - (V \cdot t_1)] \quad (2)$$

$$y_1 = y_2 \quad (3)$$

$$z_1 = z_2 \quad (4)$$

where: γ_V - coefficient of proportionality (the transition), which based on the principle of invariance of the speed of light is equal to:

$$\gamma_V^2 = \frac{1}{1 - \frac{V^2}{c^2}} \quad (5)$$

where: c - a constant - the speed of light in a vacuum.

From formulas (1) and (2) we can write the dependence for times t_1 and t_2 :

$$t_1 = \frac{(\gamma_V^2 - 1) \cdot x_2}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \quad (6)$$

$$t_2 = \frac{(1 - \gamma_V^2) \cdot x_1}{\gamma_V \cdot V} + (\gamma_V \cdot t_1) \quad (7)$$

Using the derivation of equations (1) - (4), (6) and (7), we can obtain the relationship between the projections v_{x1}, v_{y1} and v_{z1} of the speed of a point on the axis of the Cartesian coordinates in time t_1 in the stationary inertial reference system $O_1x_1y_1z_1$ and similar projections v_{x2}, v_{y2} and v_{z2} of the speed of the same point in the mobile inertial reference system $O_2x_2y_2z_2$ at time t_2, corresponding to time t_1 in the stationary inertial reference system $O_1x_1y_1z_1$:

$$v_{x1} = \frac{v_{x2} + V}{\frac{(\gamma_V^2 - 1) \cdot v_{x2}}{\gamma_V^2 \cdot V} + 1} \qquad (8)$$

$$v_{x2} = \frac{v_{x1} - V}{\frac{(1 - \gamma_V^2) \cdot v_{x1}}{\gamma_V^2 \cdot V} + 1} \qquad (9)$$

$$v_{y1} = \frac{v_{y2}}{\frac{(\gamma_V^2 - 1) \cdot v_{x2}}{\gamma_V \cdot V} + \gamma_V} \qquad (10)$$

$$v_{y2} = \frac{v_{y1}}{\frac{(1 - \gamma_V^2) \cdot v_{x1}}{\gamma_V \cdot V} + \gamma_V} \qquad (11)$$

$$v_{z1} = \frac{v_{z2}}{\frac{(\gamma_V^2 - 1) \cdot v_{x2}}{\gamma_V \cdot V} + \gamma_V} \qquad (12)$$

$$v_{z2} = \frac{v_{z1}}{\frac{(1 - \gamma_V^2) \cdot v_{x1}}{\gamma_V \cdot V} + \gamma_V} \qquad (13)$$

In the special theory of relativity, based on the mandatory implementation of the laws of conservation of momentum and energy of a closed mechanical system, the dependence of mass $M(v)$ of a moving body on the speed v can be obtained using the Lagrangian [1], [8], [9], [12], [16], [17], when considering the perfectly elastic or perfectly plastic collision [14], [18], [19], [20], [21], [22], [23].

Also, the dependence of mass $M(v)$ of the moving the body on the speed v can be obtained by selecting the function of this dependence in the equations, written for two inertial reference systems, based on the laws of conservation of momentum and energy of a closed mechanical system consisting of two bodies facing perfectly elastic direct central collision, bearing short-term nature, with different positions of the system of bodies in space [24].

Summarizing the results of the findings [8], [13], [24], [25], the dependence of mass $M(v)$ of the moving body, having a rest mass M_o , on the speed v is as follows:

$$M(v) = M_o \cdot \gamma_v \qquad (14)$$

where: γ_v - coefficient of proportionality with the speed *V*, equal to *v*.

Knowing the relationship [1], [24] between the mass of the moving body and its momentum $P(v)$ and the kinetic energy $E_{kin}(v)$, we can write:

$$P(v) = M_o \cdot \gamma_v \cdot v \qquad (15)$$

$$E_{kin}(v) = \frac{M_0 \cdot \gamma_v^2 \cdot v^2}{\gamma_v + 1} \qquad (16)$$

3. Determination of the value of the constant c in the consideration of example 1

The law of conservation of momentum of a closed mechanical system of bodies, connected with the symmetry properties of space - the homogeneity of space [2], states, that the momentum of a closed mechanical system of bodies (which is not acted upon by external forces) is a constant value, ie in any inertial reference system for any point in time the value of the momentum of a closed mechanical system of bodies is a constant value (because there is no external influence).

In the following the above example 1 in the inertial reference system with the help of the special theory of relativity will determine the momentums of the bodies, constituting a closed mechanical system and have been under constant interaction, for two moments of time, then, applying the law of conservation of momentum of a closed mechanical system, will be determined by the value of the constant c .

Assume that there are two inertial reference systems, similar to those of reference systems, shown in Fig.1, stationary $O_1x_1y_1z_1$ and mobile $O_2x_2y_2z_2$, which moves with speed *V* parallel to the axis O_1x_1 relative to the system $O_1x_1y_1z_1$.

Suppose that there is a closed mechanical system of bodies, shown in Fig.2 and consisting of point bodies 1 and 2, with equal mass M_o at rest, and a string 3.

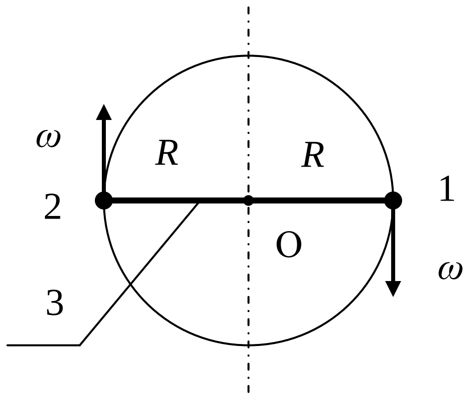

Fig.2

Bodies 1 and 2 are connected by a string 3, the mass of which can be neglected because of its smallness.

Bodies 1 and 2 rotate with angular speed ω around a common center of mass - the point O.

Distance from the point body 1 (body 2) to point O is equal to R.

Let's put a closed mechanical system of bodies 1 and 2 with a string 3 in the moving reference system $O_2x_2y_2z_2$ so, that the point O would be stationary in this reference system, and coincided with the origin O_2, and the rotation of bodies 1 and 2 around it would occur in a clockwise direction in the plane of $O_2x_2y_2$, as shown in Fig.3.

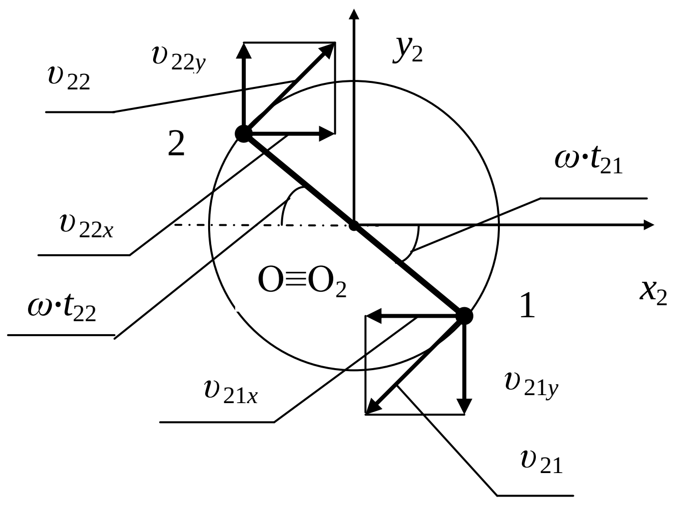

Fig.3

Also assume, that at the start of timing (t_2=0) in the reference system $O_2x_2y_2z_2$ bodies 1 and 2 were on the axis O_2x_2 , with the body 1 had a positive coordinate, and the body 2 - negative.

In the mobile reference system $O_2x_2y_2z_2$ at any time t_2 bodies 1 and 2 will have the speeds υ_{21} and υ_{22}, equal v_R :

$$v_{21} = v_{22} = v_R = \omega \cdot R \qquad (17)$$

In this case, the projections υ_{21x} and υ_{21y} of speed of the body 1 and the projections υ_{22x} and υ_{22y} of speed of the body 2 on the axis O_2x_2 and O_2y_2 , respectively, for times t_{21} and t_{22} will be equal to:

$$v_{21\,x} = -[v_R \cdot \sin(\omega \cdot t_{21})] \qquad (18)$$

$$v_{21\,y} = -[v_R \cdot \cos(\omega \cdot t_{21})] \qquad (19)$$

$$v_{22\,x} = v_R \cdot \sin(\omega \cdot t_{22}) \qquad (20)$$

$$v_{22\,y} = v_R \cdot \cos(\omega \cdot t_{22}) \qquad (21)$$

The relationship between the coordinates x_{21} and y_{21} of the body 1 depending on time t_{21} and the relationship between the coordinates x_{22} and y_{22} of the body 2 depending on the time t_{22} in the mobile reference system $O_2x_2y_2z_2$ can be written as:

$$x_{21} = R \cdot \cos(\omega \cdot t_{21}) \qquad (22)$$

$$y_{21} = -[R \cdot \sin(\omega \cdot t_{21})] \qquad (23)$$

$$x_{22} = -[R \cdot \cos(\omega \cdot t_{22})] \qquad (24)$$

$$y_{22} = R \cdot \sin(\omega \cdot t_{22}) \qquad (25)$$

Based on the equations (1) and (3), we can write the relationships between:

- coordinates x_{11} and y_{11} of the body 1 at time t_{11} in the stationary reference system $O_1x_1y_1z_1$ and coordinates x_{21} and y_{21} of the body 1 in the mobile reference system $O_2x_2y_2z_2$ at time t_{21} , which corresponds to the time t_{11} in the stationary reference system $O_1x_1y_1z_1$:

$$x_{11} = \gamma_V \cdot [x_{21} + (V \cdot t_{21})] \qquad (26)$$

$$y_{11} = y_{21} \qquad (27)$$

- coordinates x_{12} and y_{12} of the body 2 at time t_{12} in the stationary reference system $O_1x_1y_1z_1$ and coordinates x_{22} and y_{22} of the body 2 in the mobile reference system $O_2x_2y_2z_2$ at time t_{22} , which corresponds to the time t_{12} in the stationary reference system $O_1x_1y_1z_1$:

$$x_{12} = \gamma_V \cdot [x_{22} + (V \cdot t_{22})] \quad (28)$$

$$y_{12} = y_{22} \quad (29)$$

Using formula (6) relationship between the values of the times t_{11} and t_{21} , t_{12} and t_{22} will look like this:

$$t_{11} = \frac{(\gamma_V^2 - 1) \cdot x_{21}}{\gamma_V \cdot V} + (\gamma_V \cdot t_{21}) \quad (30)$$

$$t_{12} = \frac{(\gamma_V^2 - 1) \cdot x_{22}}{\gamma_V \cdot V} + (\gamma_V \cdot t_{22}) \quad (31)$$

In the considered example 1, we are interested in the position of bodies 1 and 2 in the stationary reference system $O_1x_1y_1z_1$ at the same time, ie where:

$$t_{11} = t_{12} \quad (32)$$

Then equation (32) taking into account formulas (22), (24), (26), (28), (30) and (31) becomes:

$$\frac{(\gamma_V^2 - 1) \cdot R \cdot \cos(\omega \cdot t_{21})}{\gamma_V \cdot V} + (\gamma_V \cdot t_{21}) =$$

$$= \frac{(1 - \gamma_V^2) \cdot R \cdot \cos(\omega \cdot t_{22})}{\gamma_V \cdot V} + (\gamma_V \cdot t_{22}) \quad (33)$$

In the mobile reference system $O_2x_2y_2z_2$ when performing the condition (32) it is interesting position of the bodies 1 and 2 at the time t_{2p} , when:

$$t_{21} = t_{22} = t_{2p} \quad (34)$$

Substituting condition (34) in equation (33) for the case when $(\omega \cdot t_{2p}) < \pi$, we obtain:

$$\omega \cdot t_{2p} = \frac{\pi}{2} \quad (35)$$

Ie to meet the conditions (32) and (34) during the time t_{2p} the bodies 1 and 2 should be on a line parallel to the axis O_2y_2.

Also in the mobile reference system $O_2x_2y_2z_2$ when performing the condition (32) it is interesting position of body 2 when finding the body 1 on the axis O_2x_2 at time t_{21} , equal to t_{21h} , where:

$$t_{21h} = 0 \tag{36}$$

The value of time t_{22}, when performing the conditions (32) and (36), denote t_{22h}, for which the equation (33) becomes:

$$t_{22h} = \left(1 - \frac{1}{\gamma_V^2}\right) \cdot [1 + \cos(\omega \cdot t_{22h})] \cdot \frac{R}{V} \tag{37}$$

or:

$$\omega \cdot t_{22h} = \left(1 - \frac{1}{\gamma_V^2}\right) \cdot [1 + \cos(\omega \cdot t_{22h})] \cdot \frac{v_R}{V} \tag{38}$$

As seen from equation (38), depending on the value of the coefficient of proportionality γ_V the value of time t_{22h} can be:

- $t_{22h} > 0$ when $\gamma_V > 1$;
- $t_{22h} = 0$ when $\gamma_V = 1$.

Now we can begin to use the law of conservation of momentum for the preparation of equations.

Consider two points in time in the stationary reference system $O_1x_1y_1z_1$.

As a first point in time we choose t_{1p} .

Under the terms of (32), (34) and (35) in the moving mobile reference system $O_2x_2y_2z_2$ at time t_{2p} the bodies 1 and 2 are on a line parallel to the axis O_2y_2 and in the stationary reference system $O_1x_1y_1z_1$ the bodies 1 and 2 will be on a line parallel to the axis O_1y_1 at time t_{11} (t_{12}), equal t_{1p} and which corresponds to the time t_{2p} in the mobile reference system $O_2x_2y_2z_2$.

As shown in Fig.4, according to equations (35), (18) - (21) in the mobile reference system $O_2x_2y_2z_2$ at time t_{2p} the bodies 1 and 2, respectively, have the following values of the projections v_{21xp} , v_{21yp} and v_{22xp} , v_{22yp} of speeds of his movement on the axis O_2x_2 and O_2y_2 :

$$v_{21xp} = - v_R \tag{39}$$

$$v_{21yp} = 0 \tag{40}$$

$$v_{22xp} = v_R \tag{41}$$

$$v_{22yp} = 0 \tag{42}$$

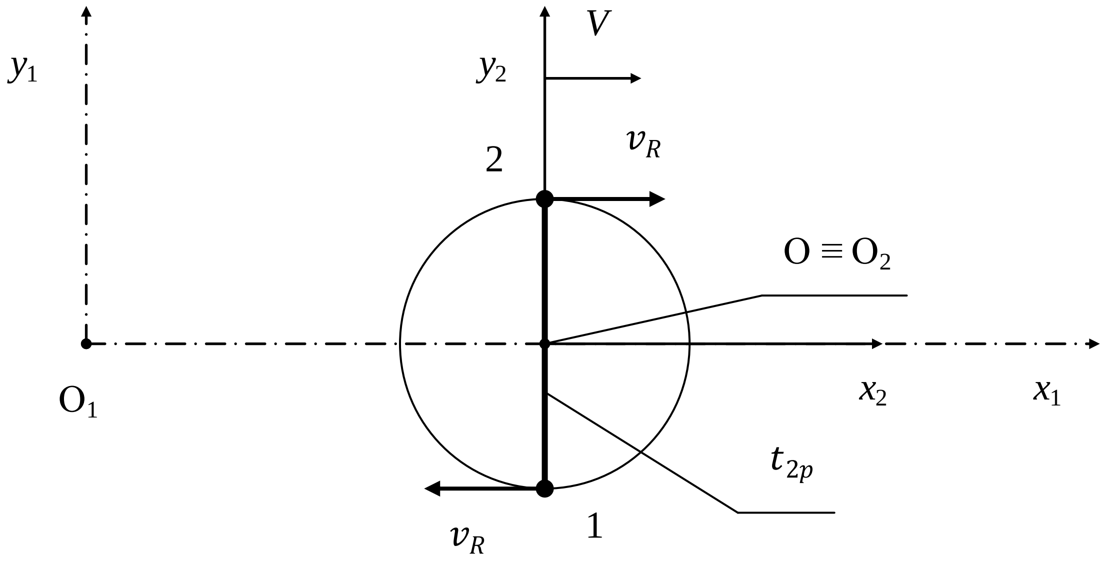

Fig.4

Then, on the basis of formulas (8), (10) and equalities (39) - (42), in the stationary reference system $O_1x_1y_1z_1$ at time t_{1p} the body 1 and the body 2, respectively, will have the following values of the projections $v_{11\,xp}$, $v_{11\,yp}$ and $v_{12\,xp}$, $v_{12\,yp}$ of speeds of his movement on the axis O_1x_1 and O_1y_1 :

$$v_{11\,xp} = \frac{V - v_R}{1 - \frac{(\gamma_V^2 - 1) \cdot v_R}{\gamma_V^2 \cdot V}} \quad (43)$$

$$v_{11\,yp} = 0 \quad (44)$$

$$v_{12\,xp} = \frac{V + v_R}{\frac{(\gamma_V^2 - 1) \cdot v_R}{\gamma_V^2 \cdot V} + 1} \quad (45)$$

$$v_{12\,yp} = 0 \quad (46)$$

Hence, using formula (15), may be noted that in the stationary reference system $O_1x_1y_1z_1$ at time t_{1p} the body 1 and the body 2, respectively, will have the following values of the projections $P_{11\,xp}$, $P_{11\,yp}$ and $P_{12\,xp}$, $P_{12\,yp}$ of momentums on the axis O_1x_1 and O_1y_1:

$$P_{11\,xp} = M_{\text{o}} \cdot \gamma_{v11\,x\text{p}} \cdot v_{11\,x\text{p}} \quad (47)$$

$$P_{12\,xp} = M_{\text{o}} \cdot \gamma_{v12\,x\text{p}} \cdot v_{12\,x\text{p}} \quad (48)$$

$$P_{11\,yp} = 0 \quad (49)$$

$$P_{12\,yp} = 0 \quad (50)$$

where: $\gamma_{v11\,xp}$ and $\gamma_{v12\,xp}$ - the coefficients of proportionality of the speed V, equal to $v_{11\,xp}$ and $v_{12\,xp}$ respectively.

As a second point in time we choose t_{1h} .

Under the terms of (32) and (36) in the mobile reference system $O_2x_2y_2z_2$ at time $t_{21h} = 0$ the body 1 will be located on the axis O_2x_2 , and in the stationary reference system $O_1x_1y_1z_1$ the body 1 will be located on the axis O_1x_1 at time t_{11} (t_{12}), equal t_{1h} and which corresponds to the time $t_{21\,h} = 0$ in the mobile reference system $O_2x_2y_2z_2$.

Moreover in the mobile reference system $O_2x_2y_2z_2$ according to equation (98), when the value of the coefficient of proportionality $\gamma_V \neq 1$, the body 2 can not be on the axis O_2x_2 at time t_{22h} , which corresponds to the time t_{1h} in the stationary reference system $O_1x_1y_1z_1$.

Ie the body 1 is located on the axis O_1x_1 in a the stationary reference system $O_1x_1y_1z_1$ at time t_{1h} , which corresponds to the time $t_{21h} = 0$ in the mobile reference system $O_2x_2y_2z_2$, and at the time t_{1h} the body 2 can not lie on the axis O_2x_2 (with a coefficient of proportionality $\gamma_V \neq 1$) .

As shown in Fig.5, in the mobile reference system $O_2x_2y_2z_2$ the body 1 at the time $t_{21\,h} = 0$ and the body 2 at the time t_{22h} respectively have projections $v_{21\,xh}$, $v_{21\,yh}$ and $v_{22\,xh}$, $v_{22\,yh}$ of speeds of his movement on the axis O_2x_2 and O_2y_2 , so that:

$$v_{21\,xh} = 0 \quad (51)$$

$$v_{21\,yh} = -\,v_R \quad (52)$$

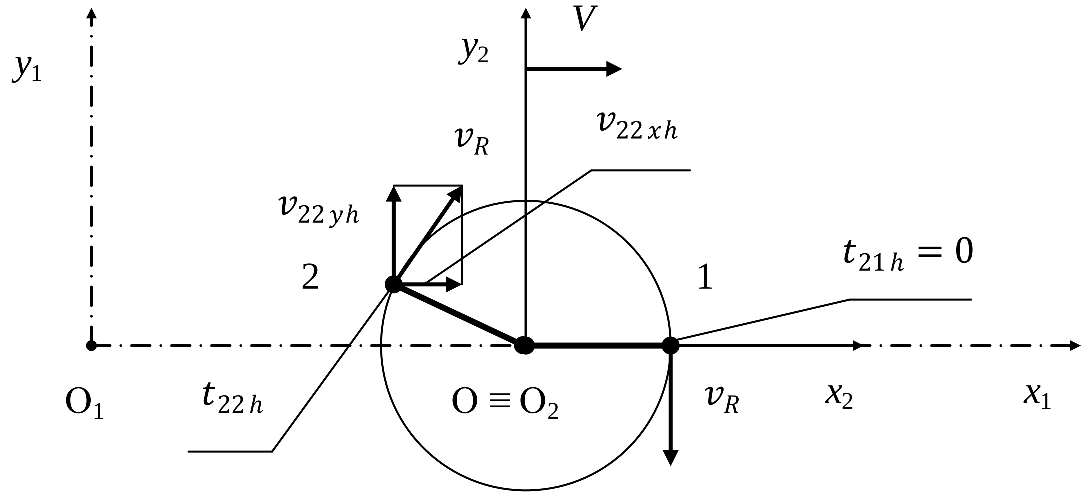

Fig.5

Then, on the basis of formulas (8), (10) and equations (51), (52), in the stationary reference system $O_1x_1y_1z_1$ at time t_{1h} the body 1 and the body 2, respectively, will have the values of the projections $v_{11\,xh}$, v_{11yh} and $v_{12\,xh}$, $v_{12\,yh}$ of speeds of his movement on the axis O_1x_1 and O_1y_1 :

$$v_{11\,xh} = V \tag{53}$$

$$v_{11\,yh} = -\frac{v_R}{\gamma_V} \tag{54}$$

$$v_{12\,xh} = \frac{V + v_{22\,xh}}{\frac{(\gamma_V^2 - 1) \cdot v_{22\,xh}}{\gamma_V^2 \cdot V} + 1} \tag{55}$$

$$v_{12\,yh} = \frac{v_{22\,yh}}{\frac{(\gamma_V^2 - 1) \cdot v_{22\,xh}}{\gamma_V \cdot V} + \gamma_V} \tag{56}$$

Given equation (38), we note that, with the coefficient of proportionality $\gamma_V > 1$ the time $t_{22h} > 0$, so the projection $v_{22\,yh}$ of the speed will be the direction of the axis O_2y_2 .

From equations (20) and (21) it follows that:

$$v_{22\,xh}{}^2 + v_{22\,yh}{}^2 = v_R{}^2 \tag{57}$$

Using formula (15), may be noted that in the stationary reference system $O_1x_1y_1z_1$ at time t_{1h} the body 1 and the body 2, respectively, will have the following values of the projections P_{11xh} , P_{11yh} and P_{12xh} , P_{12yh} of momentums on the axis O_1x_1 and O_1y_1 :

$$P_{11xh} = M_o \cdot \gamma_{v11h} \cdot v_{11xh} \qquad (58)$$

$$P_{12xh} = M_o \cdot \gamma_{v12h} \cdot v_{12xh} \qquad (59)$$

$$P_{11yh} = M_o \cdot \gamma_{v11h} \cdot v_{11yh} \qquad (60)$$

$$P_{12yh} = M_o \cdot \gamma_{v12h} \cdot v_{12yh} \qquad (61)$$

where: γ_{v11h} and γ_{v12h} - the coefficients of proportionality in the speed *V*, equal to v_{11h} and v_{12h} respectively, so that:

$$v_{11h}^2 = v_{11xh}^2 + v_{11yh}^2 \qquad (62)$$

$$v_{12h}^2 = v_{12xh}^2 + v_{12yh}^2 \qquad (63)$$

Due to the fact, that the mechanical system of the bodies 1 and 2 (and string 3) is closed, the law of conservation of momentum can write the following equations for the moments of times t_{1p} and t_{1h} :

$$P_{11xp} + P_{12xp} = P_{11xh} + P_{12xh}$$

$$P_{11yp} + P_{12yp} = P_{11yh} + P_{12yh}$$

or:

$$(M_o \cdot \gamma_{v11xp} \cdot v_{11xp}) + (M_o \cdot \gamma_{v12xp} \cdot v_{12xp}) =$$

$$= (M_o \cdot \gamma_{v11h} \cdot v_{11xh}) + (M_o \cdot \gamma_{v12h} \cdot v_{12xh}) \qquad (64)$$

$$0 = (M_o \cdot \gamma_{v11h} \cdot v_{11yh}) + (M_o \cdot \gamma_{v12h} \cdot v_{12yh}) \qquad (65)$$

Having obtained equation (64) and (65), can determine the conditions of implementation of the law of conservation of momentum for example 1 in the stationary reference system $O_1x_1y_1z_1$.

Equations (64) and (65) taking into account formula (5) take the form:

$$\frac{M_o \cdot v_{11xp}}{\sqrt{1 - \frac{v_{11xp}^2}{c_1^2}}} + \frac{M_o \cdot v_{12xp}}{\sqrt{1 - \frac{v_{12xp}^2}{c_1^2}}} = \frac{M_o \cdot v_{11xh}}{\sqrt{1 - \frac{v_{11xh}^2 + v_{11yh}^2}{c_1^2}}} + \frac{M_o \cdot v_{12xh}}{\sqrt{1 - \frac{v_{12xh}^2 + v_{12yh}^2}{c_1^2}}} \qquad (66)$$

$$0 = \frac{M_o \cdot v_{11yh}}{\sqrt{1 - \frac{v_{11xh}^2 + v_{11yh}^2}{c_1^2}}} + \frac{M_o \cdot v_{12yh}}{\sqrt{1 - \frac{v_{12xh}^2 + v_{12yh}^2}{c_1^2}}} \qquad (67)$$

Formulas (43) - (46) and (53) - (56) using the formula (53) can be written:

$$v_{11\,xp} = \frac{V - v_R}{1 - \frac{V \cdot v_R}{c^2}} \qquad (68)$$

$$v_{12\,xp} = \frac{V + v_R}{1 + \frac{V \cdot v_R}{c^2}} \qquad (69)$$

$$v_{11\,xh} = V \qquad (53)$$

$$v_{11\,yh} = -\left(v_R \cdot \sqrt{1 - \frac{V^2}{c^2}}\right) \qquad (70)$$

$$v_{12\,xh} = \frac{V + v_{22\,xh}}{1 + \frac{V \cdot v_{22\,xh}}{c^2}} \qquad (71)$$

$$v_{12\,yh} = \frac{v_{22\,yh} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 + \frac{V \cdot v_{22\,xh}}{c^2}} \qquad (72)$$

By inserting the projections $v_{11\,xp}$, $v_{12\,xp}$, $v_{11\,xh}$, $v_{11\,yh}$, $v_{12\,xh}$ and $v_{12\,yh}$ of speeds of formulas (53), (68) - (72) in equations (66) and (67) and using the formula (57), we obtain:

$$\frac{M_o \cdot (V - v_R)}{\sqrt{1 - \frac{{v_R}^2}{c^2}} \cdot \sqrt{1 - \frac{V^2}{c^2}}} + \frac{M_o \cdot (V + v_R)}{\sqrt{1 - \frac{{v_R}^2}{c^2}} \cdot \sqrt{1 - \frac{V^2}{c^2}}} =$$

$$= \frac{M_o \cdot V}{\sqrt{1 - \frac{{v_R}^2}{c^2}} \cdot \sqrt{1 - \frac{V^2}{c^2}}} + \frac{M_o \cdot (V + v_{22\,xh})}{\sqrt{1 - \frac{{v_R}^2}{c^2}} \cdot \sqrt{1 - \frac{V^2}{c^2}}} \qquad (73)$$

$$0 = -\frac{M_o \cdot v_R}{\sqrt{1 - \frac{{v_R}^2}{c^2}}} + \frac{M_o \cdot v_{22\,yh}}{\sqrt{1 - \frac{{v_R}^2}{c^2}}} \qquad (74)$$

or:

$$V - v_R + V + v_R = V + V + v_{22\,xh} \qquad (75)$$

$$0 = -v_R + v_{22\,yh} \qquad (76)$$

From equations (75) and (76) obtain the necessary conditions (the values of the projections $v_{22\,xh}$ and $v_{22\,yh}$ of speeds), which in the example 1 will be implemented by law of conservation of momentum in the stationary inertial reference system $O_1x_1y_1z_1$:

$$v_{22xh} = 0 \tag{77}$$

$$v_{22yh} = v_R \tag{78}$$

From (77) and (78) it follows, that the values of projections v_{22xh} and v_{22yh} of speeds do not depend on the magnitude of the speed V (and, consequently, do not depend on the magnitude of the coefficient of proportionality γ_V).

Substituting conditions (77) and (78) in equations (20) and (21), we obtain:

$$t_{22h} \;=\; t_{21h} \;= 0 \tag{79}$$

And substituting equation (79) in the formula (38):

$$\omega \cdot 0 \;= \left(1 - \frac{1}{\gamma_V^2}\right) \cdot \;[1 + \;1] \cdot \frac{v_R}{V} \tag{80}$$

will have another condition for the implementation of the law of conservation of momentum in the stationary inertial reference system $O_1x_1y_1z_1$ for example 1:

$$\gamma_V \;= 1 \tag{81}$$

Thus, we can conclude, that in a closed mechanical system of bodies, considered in example 1, for the values of the coefficient of proportionality $\gamma_V \;\neq 1$ the law of conservation of momentum is not satisfied.

The law of conservation of momentum will be carried out only, if the coefficient of proportionality γ_V equal to 1.

In the case of the obligation to fulfill the law of conservation of momentum of a closed mechanical system of bodies, considered in example 1, based on the formula (5), and given, that the coefficient of proportionality $\gamma_V \;= 1$, constant c will have the following meanings:

$$c = \;\pm \infty \tag{82}$$

4. Score quantities of momentums in example 2

Given the possible observation, that in example 1 the failure of the law of conservation of momentum can be attributed to the assumptions of infinitesimal mass of the string 3, consider the example 2.

Example 2 differs from example 1 in that in example 2 the mass of the string 3 is not infinitely small.

For example 2 will try to assess the impact of magnitude of the momentum of the string 3 on the magnitude of the momentum of bodies 1 and 2 and string 3.

Assume that there are two inertial reference systems, similar to those of reference systems, shown in Fig.1, stationary $O_1x_1y_1z_1$ and mobile $O_2x_2y_2z_2$, which moves with speed V parallel to the axis O_1x_1 relative to the system $O_1x_1y_1z_1$.

Suppose that there is a closed mechanical system of bodies, shown in Fig.2 and consisting of point bodies 1 and 2, with equal mass M_o at rest, and a string 3.

Bodies 1 and 2 are connected by a string 3, which has a mass of uniformly distributed along its length and equal to m_o at rest.

Bodies 1 and 2 rotate with angular speed ω around a common center of mass - the point O.

Distance from the point body 1 (body 2) to point O is equal to R.

Let's put a closed mechanical system of bodies 1 and 2 with a string 3 in the moving reference system $O_2x_2y_2z_2$ so, that the point O would be stationary in this reference system, and coincided with the origin O_2, and the rotation of bodies 1 and 2 around it would occur in a clockwise direction in the plane of $O_2x_2y_2$, as shown in Fig.3.

Also assume, that at the start of timing (t_2=0) in the reference system $O_2x_2y_2z_2$ bodies 1 and 2 were on the axis O_2x_2, with the body 1 had a positive coordinate, and the body 2 - negative.

In the mobile reference system $O_2x_2y_2z_2$ at any time t_2 bodies 1 and 2 will have the speeds υ_{21} and υ_{22} , equal v_R:

$$v_{21} = v_{22} = v_R = \omega \cdot R \quad (17)$$

In this case, the projections υ_{21x} and υ_{21y} of speed of the body 1 and the projections υ_{22x} and υ_{22y} of speed of body 2 on the axis O_2x_2 and O_2y_2 , respectively, for time t_2 will be equal to:

$$v_{21\,x} = -\,[v_R \cdot \sin(\omega \cdot t_2)] \tag{83}$$

$$v_{21\,y} = -\,[v_R \cdot \cos(\omega \cdot t_2)] \tag{84}$$

$$v_{22\,x} = v_R \cdot \sin(\omega \cdot t_2) \tag{85}$$

$$v_{22\,y} = v_R \cdot \cos(\omega \cdot t_2) \tag{86}$$

The relationship between the coordinates x_{21} and y_{21} of the body 1 and the relationship between the coordinates x_{22} and y_{22} body 2 depending on the time t_2 in the mobile reference system $O_2x_2y_2z_2$ can be written as:

$$x_{21} = R \cdot \cos(\omega \cdot t_2) \tag{87}$$

$$y_{21} = -\,[R \cdot \sin(\omega \cdot t_2)] \tag{88}$$

$$x_{22} = -\,[R \cdot \cos(\omega \cdot t_2)] \tag{89}$$

$$y_{22} = R \cdot \sin(\omega \cdot t_2) \tag{90}$$

Similarly, for the mobile reference system $O_2x_2y_2z_2$ you can get the dependencies:

- dependencies of the projections $\upsilon_{21x\rho i}$ and $\upsilon_{21y\rho i}$ of the speed of the i-point of the string 3, which is located at a distance ρ_i from point O on the segment from point O to the body 1, on the axis O_2x_2 and O_2y_2 on the time t_2 :

$$v_{21\,x\rho i} = -\left[v_R \cdot \frac{\rho_i}{R} \cdot \sin(\omega \cdot t_2)\right] \tag{91}$$

$$v_{21\,y\rho i} = -\left[v_R \cdot \frac{\rho_i}{R} \cdot \cos(\omega \cdot t_2)\right] \tag{92}$$

- dependencies of the projections $\upsilon_{22x\rho j}$ and $\upsilon_{22y\rho j}$ of the speed of the j-point of the string 3, which is located at a distance ρ_j from point O on the segment from point O to the body 2, on the axis O_2x_2 and O_2y_2 on the time t_2 :

$$v_{22\,x\rho j} = v_R \cdot \frac{\rho_j}{R} \cdot \sin(\omega \cdot t_2) \tag{93}$$

$$v_{22\,y\rho j} = v_R \cdot \frac{\rho_j}{R} \cdot \cos(\omega \cdot t_2) \tag{94}$$

- dependencies of the values of the coordinates $x_{21\rho i}$ and $y_{21\rho i}$ of i-point of the string 3 and the coordinates $x_{22\rho j}$ and $y_{22\rho j}$ of j-point of the string 3 on the time t_2 :

$$x_{21\rho i} = \rho_i \cdot \cos(\omega \cdot t_2) \quad (95)$$

$$y_{21\rho i} = -[\rho_i \cdot \sin(\omega \cdot t_2)] \quad (96)$$

$$x_{22\rho j} = -[\rho_j \cdot \cos(\omega \cdot t_2)] \quad (97)$$

$$y_{22\rho j} = \rho_j \cdot \sin(\omega \cdot t_2) \quad (98)$$

Now you can proceed to consider the movement of bodies 1 and 2 and string 3 in the stationary reference system $O_1x_1y_1z_1$.

Suppose that, as shown in Fig.6, the mobile inertial reference system $O_2x_2y_2z_2$ moves with speed V relative to the stationary reference system $O_1x_1y_1z_1$, where in the two systems as the origin of time (t_1=0 and t_2=0) is selected such a time, when origins O_1 and O_2 of these systems are the same (ie, when points O_1, O_2 and O are the same).

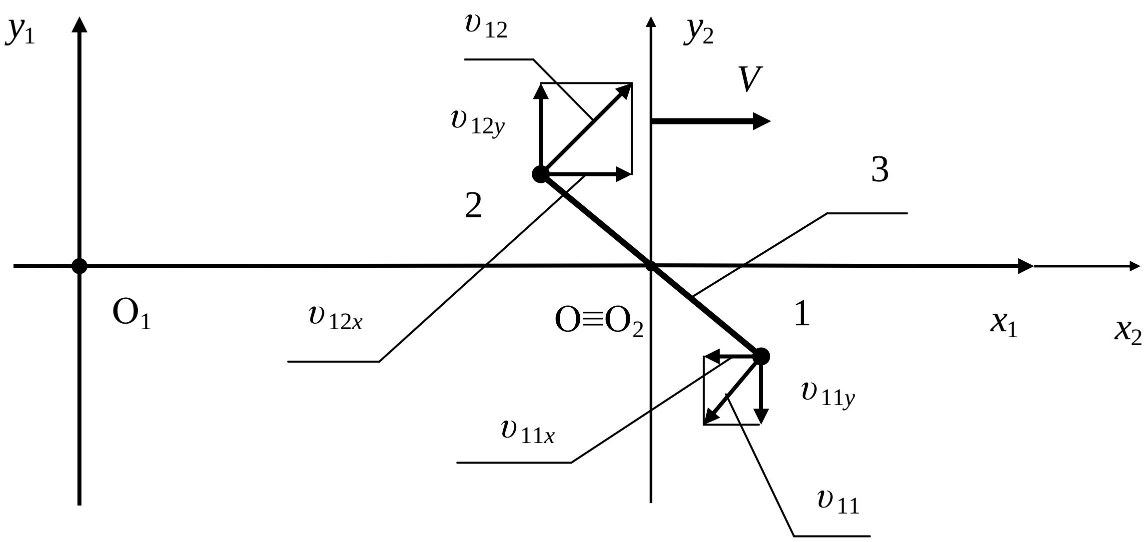

Fig.6

From equations (1) - (3), (6) - (8), (10), to consider the motion of the body 1, we can write the following:

- relationships between coordinates x_{11} and y_{11} of the body 1 at time t_1 in the stationary reference system $O_1x_1y_1z_1$ and coordinates x_{21} and y_{21} of the body 1 in the mobile reference system $O_2x_2y_2z_2$ at time t_2, which corresponds to the time t_1 in the stationary reference system $O_1x_1y_1z_1$:

$$x_{11} = \gamma_V \cdot [x_{21} + (V \cdot t_2)] \quad (99)$$

$$x_{21} = \gamma_V \cdot [x_{11} - (V \cdot t_1)] \quad (100)$$

$$y_{11} = y_{21} \tag{27}$$

- relationship between the values of times t_1 and t_2 in describing the motion of the body 1:

$$t_1 = \frac{(\gamma_V^2 - 1) \cdot x_{21}}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \tag{101}$$

$$t_2 = \frac{(1 - \gamma_V^2) \cdot x_{11}}{\gamma_V \cdot V} + (\gamma_V \cdot t_1) \tag{102}$$

while taking into account the equation (87) formula (101) becomes:

$$t_1 = \frac{(\gamma_V^2 - 1) \cdot R \cdot \cos(\omega \cdot t_2)}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \tag{103}$$

- relationships between the projections v_{x11} and v_{y11} of speed v_{11} of the body 1 at time t_1 in the stationary reference system $O_1x_1y_1z_1$ and similar projections v_{x21} and v_{y21} of speed v_{21} of the body 1 in the mobile reference system $O_2x_2y_2z_2$ at time t_2 , which corresponds to the time t_1 in the stationary reference system $O_1x_1y_1z_1$:

$$v_{x11} = \frac{v_{x21} + V}{\frac{(\gamma_V^2 - 1) \cdot v_{x21}}{\gamma_V^2 \cdot V} + 1} \tag{104}$$

$$v_{y11} = \frac{v_{y21}}{\frac{(\gamma_V^2 - 1) \cdot v_{x21}}{\gamma_V \cdot V} + \gamma_V} \tag{105}$$

Similarly, for the consideration of motion of the body 2 can be written:

- relationships between coordinates x_{12} and y_{12} of the body 2 at time t_1 in the stationary reference system $O_1x_1y_1z_1$ and coordinates x_{22} and y_{22} of the body 2 in the mobile reference system $O_2x_2y_2z_2$ at time t_2 , which corresponds to the time t_1 in the stationary reference system $O_1x_1y_1z_1$:

$$x_{12} = \gamma_V \cdot [x_{22} + (V \cdot t_2)] \tag{106}$$

$$x_{22} = \gamma_V \cdot [x_{12} - (V \cdot t_1)] \tag{107}$$

$$y_{12} = y_{22} \tag{29}$$

- relationship between the values of times t_1 and t_2 in describing the motion of the body 2:

$$t_1 = \frac{(\gamma_V^2 - 1) \cdot x_{22}}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \qquad (108)$$

$$t_2 = \frac{(1 - \gamma_V^2) \cdot x_{12}}{\gamma_V \cdot V} + (\gamma_V \cdot t_1) \qquad (109)$$

while taking into account the equation (89) formula (108) becomes:

$$t_1 = -\frac{(\gamma_V^2 - 1) \cdot R \cdot \cos(\omega \cdot t_2)}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \qquad (110)$$

- relationships between the projections v_{x12} and v_{y12} of speed v_{12} of the body 2 at time t_1 in the stationary reference system $O_1x_1y_1z_1$ and similar projections v_{x22} and v_{y22} of speed v_{22} of the body 2 in the mobile reference system $O_2x_2y_2z_2$ at time t_2 , which corresponds to the time t_1 in the stationary reference system $O_1x_1y_1z_1$:

$$v_{x12} = \frac{v_{x22} + V}{\frac{(\gamma_V^2 - 1) \cdot v_{x22}}{\gamma_V^2 \cdot V} + 1} \qquad (111)$$

$$v_{y12} = \frac{v_{y22}}{\frac{(\gamma_V^2 - 1) \cdot v_{x22}}{\gamma_V \cdot V} + \gamma_V} \qquad (112)$$

Also to consider the motion of *i*-the point of the string 3, which is located at a distance ρ_i from point O on the segment from point O to the body 1 in the mobile reference system $O_2x_2y_2z_2$, we can write the following:

- relationships between coordinates $x_{11\rho i}$ and $y_{11\rho i}$ of *i*-the point of the string 3 at time t_1 in the stationary reference system $O_1x_1y_1z_1$ and coordinates $x_{21\rho i}$ and $y_{21\rho i}$ of *i*-the point of the string 3 in the mobile reference system $O_2x_2y_2z_2$ at time t_2 , which corresponds to the time t_1 in the stationary reference system $O_1x_1y_1z_1$:

$$x_{11\rho i} = \gamma_V \cdot \left[x_{21\rho i} + (V \cdot t_2)\right] \qquad (113)$$

$$x_{21\rho i} = \gamma_V \cdot \left[x_{11\rho i} - (V \cdot t_1)\right] \qquad (114)$$

$$y_{11\rho i} = y_{21\rho i} \qquad (115)$$

- relationship between the values of times t_1 and t_2 in describing the motion of *i*-the point of the string 3:

$$t_1 = \frac{(\gamma_V^2 - 1) \cdot x_{21\rho i}}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \qquad (116)$$

$$t_2 = \frac{(1 - \gamma_V^2) \cdot x_{11\rho i}}{\gamma_V \cdot V} + (\gamma_V \cdot t_1) \qquad (117)$$

while taking into account the equation (95) formula (116) becomes:

$$t_1 = \frac{(\gamma_V^2 - 1) \cdot \rho_i \cdot \cos(\omega \cdot t_2)}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \qquad (118)$$

- relationships between the projections $v_{x11\rho i}$ and $v_{y11\rho i}$ of speed $v_{11\rho i}$ of *i*-the point of the string 3 at time t_1 in the stationary reference system $O_1x_1y_1z_1$ and similar projections $v_{x21\rho i}$ and $v_{y21\rho i}$ of speed $v_{21\rho i}$ of *i*-the point of the string 3 in the mobile reference system $O_2x_2y_2z_2$ at time t_2, which corresponds to the time t_1 in the stationary reference system $O_1x_1y_1z_1$:

$$v_{x11\rho i} = \frac{v_{x21\rho i} + V}{\frac{(\gamma_V^2 - 1) \cdot v_{x21\rho i}}{\gamma_V^2 \cdot V} + 1} \qquad (119)$$

$$v_{y11\rho i} = \frac{v_{y21\rho i}}{\frac{(\gamma_V^2 - 1) \cdot v_{x21\rho i}}{\gamma_V \cdot V} + \gamma_V} \qquad (120)$$

Also to consider the motion of *j*-the point of the string 3, which is located at a distance ρ_j from point O on the segment from point O to the body 2 in the mobile reference system $O_2x_2y_2z_2$, we can write the following:

- relationships between coordinates $x_{12\rho j}$ and $y_{12\rho j}$ of *j*-the point of the string 3 at time t_1 in the stationary reference system $O_1x_1y_1z_1$ and coordinates $x_{22\rho j}$ and $y_{22\rho j}$ of *j*-the point of the string 3 in the mobile reference system $O_2x_2y_2z_2$ at time t_2, which corresponds to the time t_1 in the stationary reference system $O_1x_1y_1z_1$:

$$x_{12\rho j} = \gamma_V \cdot [x_{22\rho j} + (V \cdot t_2)] \qquad (121)$$

$$x_{22\rho j} = \gamma_V \cdot [x_{12\rho j} - (V \cdot t_1)] \qquad (122)$$

$$y_{12\rho j} = y_{22\rho j} \qquad (123)$$

- relationship between the values of times t_1 and t_2 in describing the motion of *j*-the point of the string 3:

$$t_1 = \frac{(\gamma_V^2 - 1) \cdot x_{22\rho j}}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \quad (124)$$

$$t_2 = \frac{(1 - \gamma_V^2) \cdot x_{12\rho j}}{\gamma_V \cdot V} + (\gamma_V \cdot t_1) \quad (125)$$

while taking into account the equation (97) formula (124) becomes:

$$t_1 = - \frac{(\gamma_V^2 - 1) \cdot \rho_j \cdot \cos(\omega \cdot t_2)}{\gamma_V \cdot V} + (\gamma_V \cdot t_2) \quad (126)$$

- relationships between the projections $v_{x12\rho j}$ and $v_{y12\rho j}$ of speed $v_{12\rho j}$ of j-the point of the string 3 at time t_1 in the stationary reference system $O_1x_1y_1z_1$ and similar projections $v_{x22\rho j}$ and $v_{y22\rho j}$ of speed $v_{22\rho j}$ of j-the point of the string 3 in the mobile reference system $O_2x_2y_2z_2$ at time t_2, which corresponds to the time t_1 in the stationary reference system $O_1x_1y_1z_1$:

$$v_{x12\rho j} = \frac{v_{x22\rho j} + V}{\frac{(\gamma_V^2 - 1) \cdot v_{x22\rho j}}{\gamma_V^2 \cdot V} + 1} \quad (127)$$

$$v_{y12\rho j} = \frac{v_{y22\rho j}}{\frac{(\gamma_V^2 - 1) \cdot v_{x22\rho j}}{\gamma_V \cdot V} + \gamma_V} \quad (128)$$

In order to initiate testing of the law of conservation of momentum must select two points in time in the stationary inertial reference system $O_1x_1y_1z_1$.

First time - this is t_{1p} .

Suppose that in the stationary reference system $O_1x_1y_1z_1$ at time t_1 , equal to t_{1p} , the bodies 1 and 2 are on the line parallel to the axis O_1y_1 (or coinciding with it), ie where:

$$x_{11} = x_{12} \quad (129)$$

Condition (129) is possible only in the case, when in the mobile reference system $O_2x_2y_2z_2$ at the time t_2 , equal to t_{2p} , corresponding to the time t_{1p} in the stationary reference system $O_1x_1y_1z_1$, the following conditions:

$$x_{21} = x_{22} \quad (130)$$

$$\omega \cdot t_{2p} = \frac{\pi}{2} \quad (131)$$

As shown in Fig.4, according to equations (131), (83) - (86) in the mobile reference system $O_2x_2y_2z_2$ at time t_{2p} the bodies 1 and 2, respectively, have the following values of the projections $v_{21\,xp}$, $v_{21\,yp}$ and $v_{22\,xp}$, $v_{22\,yp}$ of speeds of his movement on the axis O_2x_2 and O_2y_2 :

$$v_{21\,xp} = -\,v_R \qquad (39)$$

$$v_{21\,yp} = 0 \qquad (40)$$

$$v_{22\,xp} = v_R \qquad (41)$$

$$v_{22\,yp} = 0 \qquad (42)$$

And in accordance with equations (131), (91)-(94) in the mobile reference system $O_2x_2y_2z_2$ at time t_{2p} the *i*-the point of the string 3, which is located at a distance ρ_i from point O on the segment from point O to the body 1, and the *j*-the point of the string 3, which is located at a distance ρ_j from point O on the segment from point O to the body 2, respectively, have the following values of the projections $v_{21x\rho ip}$, $v_{21y\rho ip}$ and $v_{22x\rho jp}$, $v_{22y\rho j\rho}$ of speeds of his movement on the axis O_2x_2 and O_2y_2 :

$$v_{21\,x\rho i\,\mathrm{p}} = -(v_R \cdot \frac{\rho_i}{R}) \qquad (132)$$

$$v_{21\,y\rho i\,\mathrm{p}} = 0 \qquad (133)$$

$$v_{22\,x\rho j\,\mathrm{p}} = v_R \cdot \frac{\rho_j}{R} \qquad (134)$$

$$v_{22\,y\rho j\,\mathrm{p}} = 0 \qquad (135)$$

A second point in time we choose t_{1h} .

Suppose that, as shown in Fig.5, in the stationary reference system $O_1x_1y_1z_1$ at time t_1 , equal to t_{1h} , the position of body 1 will be consistent the position of the body 1 at time t_2 , equal to t_{21h} :

$$t_{21\,h} = 0 \qquad (136)$$

in the mobile reference system $O_2x_2y_2z_2$, ie when the body 1 will be on the axis O_2x_2 .

The value of time t_{1h} can be determined from equation (103) on the basis of conditions (136):

$$t_{1h} = \frac{(\gamma_V^2 - 1) \cdot R}{\gamma_V \cdot V} \tag{137}$$

According to equations (136), (83), (84) in the mobile reference system $O_2x_2y_2z_2$ at time t_{21h} body 1 will have the following values of the projections v_{21xh} and v_{21yh} of the speed of his movement on the axis O_2x_2 and O_2y_2 :

$$v_{21xh} = 0 \tag{51}$$

$$v_{21yh} = -v_R \tag{52}$$

In the stationary reference system $O_1x_1y_1z_1$ at the time t_1, equal to t_{1h} , the position of body 2 will be consistent the position of the body 2 in the mobile reference system $O_2x_2y_2z_2$ at time t_2 , equal to t_{22h} , which can be determined on the basis of equations (110) and (137):

$$\frac{(\gamma_V^2 - 1) \cdot R}{\gamma_V \cdot V} = -\frac{(\gamma_V^2 - 1) \cdot R \cdot \cos(\omega \cdot t_{22h})}{\gamma_V \cdot V} + (\gamma_V \cdot t_{22h}) \tag{138}$$

or:

$$(\omega \cdot t_{22h}) = \frac{(\gamma_V^2 - 1) \cdot [1 + \cos(\omega \cdot t_{22h})] \cdot v_R}{\gamma_V^2 \cdot V} \tag{139}$$

Similar in the stationary reference system $O_1x_1y_1z_1$ at the time t_1, equal to t_{1h} , the position of the *i*-the point of the string 3 will be consistent the position of the *i*-the point of the string 3, which is located at a distance ρ_i from point O on the segment from point O to the body 1, in the mobile reference system $O_2x_2y_2z_2$ at time t_2 , equal to $t_{21\rho ih}$, which can be determined on the basis of equations (118) and (137):

$$\frac{(\gamma_V^2 - 1) \cdot R}{\gamma_V \cdot V} = \frac{(\gamma_V^2 - 1) \cdot \rho_i \cdot \cos(\omega \cdot t_{21\rho ih})}{\gamma_V \cdot V} + (\gamma_V \cdot t_{21\rho ih}) \tag{140}$$

or:

$$(\omega \cdot t_{21\rho ih}) = \frac{(\gamma_V^2 - 1) \cdot v_R}{\gamma_V \cdot V} \cdot \left\{1 - \left[\frac{\rho_i}{R} \cdot \cos(\omega \cdot t_{21\rho ih})\right]\right\} \tag{141}$$

Also in the stationary reference system $O_1x_1y_1z_1$ at the time t_1, equal to t_{1h} , the position of the *j*-the point of the string 3 will be consistent the position of the *j*-the point of the string 3, which is located at a distance ρ_j from point O on the segment from point O to the body 2, in the mobile reference system $O_2x_2y_2z_2$ at time t_2 , equal to $t_{22\rho jh}$, which can be determined on the basis of equations (126) and (137):

$$\frac{(\gamma_V^2 - 1)\cdot R}{\gamma_V \ \cdot V} \quad = - \ \frac{(\gamma_V^2 - 1)\cdot \rho_j \ \cdot \cos(\omega \cdot t_{22\rho jh})}{\gamma_V \ \cdot V} + (\gamma_V \ \cdot t_{22\rho jh}) \quad (142)$$

or:

$$(\omega \cdot t_{22\rho jh}) \quad = \quad \frac{(\gamma_V^2 - 1)\cdot \ v_R}{\gamma_V^2 \cdot \ V} \cdot \left\{1 + \left[\frac{\rho_j}{R} \cdot \cos(\omega \ \cdot \ t_{22\rho jh})\right]\right\} \quad (143)$$

To handle complex calculations in equations (139), (141) and (143), the values of momentums will try to determine by simple numerical examples.

For consideration in the mobile reference system $O_2x_2y_2z_2$ the string 3 conditionally divided by 17 equal parts (i = 0, 1, 2, 3, 4, 5, 6, 7, 8 and j = 1, 2, 3, 4, 5, 6, 7, 8) with accommodation in the center of each part the point of the body with rest mass m_{017} , equal to:

$$m_{017} \quad = \quad \frac{m_0}{17} \quad (144)$$

In this case, the distance ρ_i from point O to the i-the point of the string 3, located on the segment from point O to the body 1, will be equal to:

$$\rho_i \quad = \quad \frac{2 \ \cdot \ i}{17} \quad (145)$$

And the distance ρ_j from point O to the j-the point of the string 3, located on the segment from point O to the body 2, will be equal to:

$$\rho_j \quad = \quad \frac{2 \ \cdot \ j}{17} \quad (146)$$

Then as follows from formula (5) and (15), in any inertial reference system $Oxyz$ the projections P_x and P_y of the momentum of a material point, moving with the speed v and having a rest mass m_o , on the axis Ox and Oy , respectively, can be written:

$$P_x \quad = \quad \frac{m_o \ v_x}{\sqrt{1 - \frac{(v_x^2 \ + \ v_y^2)}{c^2}}} \quad (147)$$

$$P_y = \frac{m_o\, v_y}{\sqrt{1 - \frac{\left(v_x^2 + v_y^2\right)}{c^2}}} \qquad (148)$$

where: v_x and v_y - the projections of the speed v of a material point on the axis Ox and Oy , respectively.

Assume in the considered example 2 (shown in Fig.2 - Fig.6), that:

$$\frac{V}{c} = 0{,}9 \qquad (149)$$

$$\frac{v_R}{c} = 0{,}8 \qquad (150)$$

$$\frac{m_0}{M_0} = 0{,}1 \qquad (151)$$

To determine the values of the momentums of the system of bodies 1 and 2 and string 3 in the stationary reference system $O_1x_1y_1z_1$ at time t_{1p} will use equation (39) - (42), (147), (148), the raw data (144) - (146), (149) - (151) and the formulas, derived from the equations (104), (105), (111), (112), (119), (120), (127) and (128), taking into account equation (5) :

$$v_{x11} = \frac{v_{x21} + V}{1 + \frac{V \cdot v_{x21}}{c^2}} \qquad (152)$$

$$v_{y11} = \frac{v_{y21} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 + \frac{V \cdot v_{x21}}{c^2}} \qquad (153)$$

$$v_{x12} = \frac{v_{x22} + V}{1 + \frac{V \cdot v_{x22}}{c^2}} \qquad (154)$$

$$v_{y12} = \frac{v_{y22} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 + \frac{V \cdot v_{x22}}{c^2}} \qquad (155)$$

$$v_{x11\,\rho i} = \frac{v_{x21\,\rho i} + V}{1 + \frac{V \cdot v_{x21\,\rho i}}{c^2}} \qquad (156)$$

$$v_{y11\rho i} = \frac{v_{y21\rho i} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 + \frac{V \cdot v_{x21\rho i}}{c^2}} \qquad (157)$$

$$v_{x12\rho j} = \frac{v_{x22\rho j} + V}{1 + \frac{V \cdot v_{x22\rho j}}{c^2}} \qquad (158)$$

$$v_{y12\rho j} = \frac{v_{y22\rho j} \cdot \sqrt{1 - \frac{V^2}{c^2}}}{1 + \frac{V \cdot v_{x22\rho j}}{c^2}} \qquad (159)$$

The results of digital calculations presented in Tab.1.

Tab.1

Time t_{1p} .

Object	Mobile reference system $O_2x_2y_2z_2$		Stationary reference system $O_1x_1y_1z_1$			
	The projections of the velocity (the dimension c)		The projections of the velocity (the dimension c)		Projections of the momentum (the dimension c · M_0)	
	on the axis O_2x_2	on the axis O_2y_2	on the axis O_1x_1	on the axis O_1y_1	on the axis O_1x_1	on the axis O_1y_1
Body 1	-0,8	0	0,3571429	0	0,3823596	0
Body 2	0,8	0	0,9883721	0	6,5001125	0
Bodies 1 and 2					6,8824472	0
i = 0	0	0	0,9	0	0,0121455	0
i = 1	-0,09412	0	0,8804627	0	0,0109239	0
i = 2	-0,18824	0	0,8569405	0	0,0097801	0
i = 3	-0,28235	0	0,8280757	0	0,0086887	0
i = 4	-0,37647	0	0,7918149	0	0,0076261	0
i = 5	-0,47059	0	0,744898	0	0,0065676	0
i = 6	-0,56471	0	0,6818182	0	0,0054827	0
i = 7	-0,65882	0	0,5924855	0	0,0043263	0
i = 8	-0,75294	0	0,4562044	0	0,0030156	0
j= 1	0,094118	0	0,9164859	0	0,0134755	0
j= 2	0,188235	0	0,9305835	0	0,0149531	0
j= 3	0,282353	0	0,99427767	0	0,0166327	0
j= 4	0,376471	0	0,9534271	0	0,0185940	0
j= 5	0,470588	0	0,9628099	0	0,0209623	0
j= 6	0,564706	0	0,9711388	0	0,0239506	0
j= 7	0,658824	0	0,978582	0	0,0279629	0
j= 8	0,752941	0	0,9852735	0	0,0338959	0
String 3					0,2389836	0
Bodies 1 and 2 and string 3					7,1214557	0

To determine the values of the momentums of the system of bodies 1 and 2 and string 3 in the stationary reference system $O_1x_1y_1z_1$ at time t_{1h} will use equation (85)-(86), (91)-(94), (51)-(52), (147)-(148), (152)-(159), the raw data (149)-(151), (144)-(146) and the formulas, derived from the equations (139), (141) and (143), taking into account equation (5) :

$$(\omega \cdot t_{22h}) = \frac{V \cdot v_R \cdot [1 + \cos(\omega \cdot t_{22h})]}{c_1^2} \qquad (160)$$

$$(\omega \cdot t_{21\rho i h}) = \frac{V \cdot v_R}{c_1^2} \cdot \left\{1 - \left[\frac{\rho_i}{R} \cdot \cos(\omega \cdot t_{21\rho i h})\right]\right\} \qquad (161)$$

$$(\omega \cdot t_{22\rho j h}) = \frac{V \cdot v_R}{c_1^2} \cdot \left\{1 + \left[\frac{\rho_j}{R} \cdot \cos(\omega \cdot t_{22\rho j h})\right]\right\} \qquad (162)$$

The results of digital calculations presented in Tab.2.

Tab.2

Time t_{1h} .

Object	Mobile reference system $O_2x_2y_2z_2$		Stationary reference system $O_1x_1y_1z_1$			
	The projections of the velocity (the dimension c)		The projections of the velocity (the dimension c)		Projections of the momentum (the dimension $c \cdot M_0$)	
	on the axis O_2x_2	on the axis O_2y_2	on the axis O_1x_1	on the axis O_1y_1	on the axis O_1x_1	on the axis O_1y_1
Body 1	0	-0,8	0,9	-0,34871	3,441236	-1,333333
Body 2	0,700743	0,385953	0,9816482	0,103168	6,1205934	0,6432543
Bodies 1 and 2					9,5618294	-0,690079
$i = 0$	0	0	0,9	0	0,0121455	0
$i = 1$	-0,05716	-0,07477	0,8885503	-0,03436	0,0114249	-0,000442
$i = 2$	-0,10286	-0,15765	0,8784626	-0,07573	0,0109532	-0,000944
$i = 3$	-0,13452	-0,24825	0,8709212	-0,12311	0,0107684	-0,001522
$i = 4$	-0,14977	-0,3454	0,8671108	-0,17401	0,0109284	-0,002193
$i = 5$	-0,14699	-0,44704	0,8678151	-0,22457	0,0115169	-0,002980
$i = 6$	-0,12573	-0,55053	0,8730642	-0,27059	0,0126608	-0,003924
$i = 7$	-0,08687	-0,65307	0,8820957	-0,30881	0,0145863	-0,005106
$i = 8$	-0,03235	-0,75225	0,8936691	-0,33773	0,0177924	-0,006724
$j = 1$	0,066205	0,066896	0,9118716	0,027519	0,013097	0,000395
$j = 2$	0,139393	0,1265	0,9235324	0,048994	0,014282	0,000758
$j = 3$	0,217908	0,179553	0,934614	0,065433	0,0157261	0,001101
$j = 4$	0,300464	0,22683	0,9449365	0,077827	0,0174868	0,001440
$j = 5$	0,386083	0,269061	0,9544394	0,087037	0,0196698	0,001794
$j = 6$	0,474026	0,306907	0,9631315	0,093772	0,0224678	0,002187
$j = 7$	0,563739	0,34095	0,971058	0,098594	0,0262572	0,002666
$j = 8$	0,654805	0,371687	0,9782804	0,101939	0,0318835	0,003322
String 3					0,2736473	-0,010172
Bodies 1 and 2 and string 3					9,8354767	-0,700351

As a result of numerical calculation, it was found that, in the stationary reference system $O_1x_1y_1z_1$ at time t_{1p} the closed system of bodies 1 and 2 and string 3 has the projection of the momentum on the axis O_1x_1 , equal to $\mathbf{7{,}1214557 \cdot c_1 \cdot M_0}$, and the projection of the momentum on the axis O_1y_1 , equal to $\mathbf{0}$.

And in a stationary reference system $O_1x_1y_1z_1$ at time t_{1h} the closed system of bodies 1 and 2 and string 3 has the projection of the momentum on the axis O_1x_1 , equal to $\mathbf{9{,}8354767 \cdot c_1 \cdot M_0}$, and the projection of the momentum on the axis O_1y_1 , equal to $\mathbf{-0{,}700351 \cdot c_1 \cdot M_0}$.

As a result, we have a violation of the law of conservation of momentum for a closed mechanical system of bodies, because $7{,}1214557 \neq 9{,}8354767$ and $0 \neq -0{,}700351$.

Moreover, integration of mass of string 3 in calculating the momentum of the system of bodies 1 and 2 and string 3 leads to the aggravation of violating the law of conservation of momentum.

In the stationary reference system $O_1x_1y_1z_1$ in the case, when the coefficient of proportionality $\gamma_V \neq 1$ (and also $\gamma_v \neq 1$) , the momentum of a closed system of bodies 1 and 2 and string 3 is not constant, as is a function of time t_1 .

5. Conclusion

It can be concluded, that the use of the special theory of relativity in dealing with individual examples (examples 1 and 2) may lead to non-compliance with the law of conservation of momentum for a closed mechanical system in the inertial reference systems.

Given, that the law of conservation of momentum associated with the homogeneity of space, we can assume, that the failure of the law of conservation of momentum will lead to non-compliance with conditions of symmetry of space and time, on which is based the special theory of relativity.

The results obtained, when considering the examples 1 and 2 show that, if true to the law of conservation of momentum, it is necessary to finalize the special theory of relativity, or if it is true the special theory of relativity, then, consequently, incorrect law of conservation of momentum - possible to change the momentum of a closed system over time in the inertial reference systems.

The author expresses his gratitude to the professors: Hartwig W. Thim (Johannes Kepler University, Austria), Thalanayar S. Santhanam (Saint Louis University, USA), David A. Van Baak (Calvin College, USA), Sverker Fredriksson (Royal Institute of Technology, Sweden), Artru Xavier (Université Claude-Bernard, France), Dogan Demirhan (Ege University, Turkey), Murat Tanisli (Anadolu University, Turkey), A. K. Hariri (University of Aleppo, Syria), Eugenio Ley (Universidad Nacional Autónoma de México, Mexico), Jorge Zuluaga (Universidad de Antioquia, Colombia), and doctors: Hajime Takami (University of Tokyo, Japan), Emmanuel T. Rodulfo (De La Salle University, Philipines), Michael H. Brill (associate editor of «Physics Essays», USA) for their help and support.

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Author V.N. Cochetkov

Author - Cochetkov Victor Nikolayevich

E-mail: VNKochetkov@gmail.com .

E-mail: VNKochetkov@rambler.ru .

Website: http://www.matphysics.ru .