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MEANS OF THE RESTRICTIONS ELIMINATION OF THE SPACE-TIME APPARATUS IN RELATIVISTIC MECHANICS

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Summary. *The principle restrictions of the apparatus of relativistic mechanics by G. Minkovsky have been presented as well as the means of their elimination. Two connected between metric 4-space momentum and the interaction (events) positioning have been proposed. The properties of the mentioned 4-spaces are supplemented by the hypothesis of the reference direction existence, which divides them into three-dimensional observable and one-dimensional unobservable semispaces. It was proved that the laws of the momentum and energy conservation are not sufficient for the unambiguous description of the microparticle interaction results. The supplement of the dynamic laws of the material point by the law of the energy conservation made it possible to analyze the scattering of the latter in the external force fields.*

Key words: *relativistic mechanics; 4-momentum space; reference direction; dissipation of energy; microscopic irreversibility.*

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Introduction. For a century of application of the apparatus of relativistic mechanism by G.Minkovsky some contradictions have been revealed. Thus, astronomical observations proved [1] the existence of the absolute system of reference beyond the special theory of relativity [2 and the mentioned mechanics itself caused by the cosmic microwave background radiation. Being based on the general thinking P.Dirak has found the need of the linear dependence between the values of the particle momentum and its total energy (the main principle of mechanics) [3], which is impossible within the space-time. One of the attempts to overcome the mentioned problems was proposed in the [4]. Its main idea deals with the dynamics geometrizsation of the point mechanical objects in the homogeneous 4-space with the metric time.

The vector particles are the object of investigation in the presented paper, its objective being the mentioned particles mechanics apparatus abilities in the Euclidean 4-space. The notion of the reference direction of the absolute reference system has been introduced, the existence the three-and four-dimensional particles is shown. Special attention is paid to the investigation of the non-determined nature and the nodes interaction incomplanary. The proposed option of mechanics is not the improved one, the common signs for the specifying of particles in the 3-space being the same, its apparatus built on the main principle of mechanics (without references to the theory of relativity) within the equations of motion being of the same origin as those of classic and relativistic mechanics.

1. Particles 4-momentum space. Under the condition, that according to the Plank constant ($h \to 0$) can be ignored, the only mechanical characteristics of every discrete elementary object, which will be treated as a particle, are the 3-vector $\vec{p}$ of the momentum and the scalar E – [5].

1.1. Varieties of the 4-momentum particles. The existance of two varieties of the vector particles [5] has been proved experimentally. To describe the first, (e.g. photon), the 3-vector momentum is enough. According to the main principle of mechanics, the energy is in proportion to the momentum value: $E^2 = c^2 p^2$ [5]. Here, c – some constant (below it is shown, that it is precisely equal to the fundamental constant c – the light velocity in vacuum). For the second, (e.g. electrons), the value of the energy depends on the particle self-energy E_0 [5]:

$$E^2 = E_0^2 + c^2 p^2 . \tag{1}$$

For the (1) being in sequence with the main principle of mechanics let us introduce the scalar p_0 so, that $E_0^2 = c^2 p_0^2$, and broaden the dimension of the momentum space till four:

$$E^2 = c^2 p_0^2 + c^2 p^2 = c^2\left(p_0^2 + p^2\right). \tag{2}$$

Thus, energy $E > 0$ will be in proportion to the Euclidean value of some 4-vector,

$$\vec{P} = \begin{Vmatrix} p_0 \\ \vec{p} \end{Vmatrix}, \tag{3}$$

which will be called the 4-momentum. Its components are the 3-momentum $\vec{p}$ and the component p_0 along the additional (zero) dimension with the directed unit vector $\vec{\text{щ}} = \|1, 0, 0, 0\|^T$ being orthogonal to the rest three coordinates, the 4-vector $\vec{p}_0 = p_0\vec{\text{щ}}$ will be called the vector of the particle self-momentum.

1.2. Reference direction. Aberration angle. The zero dimension of the 4-momentum is a special one, as the value p_0 can be changed only in the discrete way. The problem of the direction sequence of different particles self-momentums (the axial isotropy of the 4-momentum space) will be solved taking advantage of the hypothesis of existance the external relatively the particles of the reference direction, which coincides with the vector $\vec{\text{щ}}$, to which all self-momentums are collinear. As the value p_0 is constant in mechanics [5],

$$\vec{p}_0 = p_0\vec{\text{щ}} \equiv const , \tag{4}$$

the reference direction $\vec{\text{щ}}$ will be called unobservable. At the same time the 3-dimentional subspace of the vectors $\vec{p}$ will be called observable. Having multiplied scalarly the vectors $\vec{P}$ and $\vec{\text{щ}}$, the value of the unobservable self-momentum can be found:

$$p_0 = (\vec{P}, \vec{\text{щ}}) = P(\vec{\tau}, \vec{\text{щ}}) = P\cos\alpha = const . \tag{5}$$

Here $\vec{\tau}$ – the unit vector of the 4-momentum direction $\vec{P} = P\vec{\tau}$, and α – the aberration angle, that is, the deflection vector of the 4-momentum from the reference direction $\vec{\text{щ}}$. The reference direction in the 4-space specifies clear criterion of the second variety particles distribution into two states according to the relative direction of the self-momentum vector: $(\vec{\tau}, \vec{\text{щ}}) > 0$ – substance, $(\vec{\tau}, \vec{\text{щ}}) < 0$ – anti-substances [4]. The momentum vector of the 3-dimentional particles of the first variety in the 4-space is orthogonal to the reference direction: $\left(\vec{\tau}, \vec{\text{щ}}\right) = 0$. In the Universe, where the observable (baryon) substance makes up less than 5% of the non-investigated dark substances and energy [1], it is too early to state the hypothesis on the nature of the reference direction.

2. Positioning space. The particles can interact between each other only being in mutual contacts (in the interaction nodes). To describe the result of the sequence interaction of many particles let us introduce the notion of the metric 4-space positioning of the interaction nodes, where all particles totality will be modelled by the interaction graph. The interaction graph itself consists of the rectilinear branches of any length, the directions of which will coincide with the directions of the corresponding 4-momentum vectors and the nodes, which specify the location of the interaction acts.

Let us spread the notion of the reference direction to the positioning space and similar to the 4-momentum space let us separate in it the unobservable and observable subspaces. The proof of the linearity, homogeneity and isotropy of the observable subspaces of the nodes positioning, which is similar to that classical 3-space one, is presented in the [1, 2]. Below it is shown, that the properties of its zero dimension do not differ from those three the rest.

2.1. Metric time. The light velocity value c in the vacuum [6] is stable. In the [4] the hypothesis was presented, that the mentioned characteristic is not only the peculiarity of photos, but is that of all particles in the 4-space positioning:

$$\vec{V} = c\vec{\tau} \,. \tag{6}$$

According to the definition of velocity let us introduce the notion of the time intervals Δt, which are connected linearly with the metric measure $\Delta\eta$ of every branch of the interactions graph:

$$\Delta\eta = c\Delta t \,. \tag{7}$$

The scalar Δt will be named metric (own) time of the branch. (The whole branch will be analyzed, as the particle can be found only in the interaction nodes).

2.2. Hybrid presentation of the 4-momentum. Let us spread the Eulerian type of the momentum presentation on the 4-space: $\vec{P} = m\vec{V}$ [2], where m is the particle mass. As, according to the [6], $\left|\vec{P}\right| = mc$, the mass m specifies the particle in the 4-momentum space, and $\vec{V}$ – in the positioning space. Such presentation of the 4-momentum will be called the hybrid. According to the hybrid presentation let us present the 4-momentum $\vec{P}$ by the blocks for the unobservable and observable subspaces

$$\vec{P} = m\vec{V} = m\left\|\begin{matrix} v_0 \\ \vec{v} \end{matrix}\right\|, \tag{8}$$

where v_0 – unobservable and $\vec{v}$ – observable (peculiar) velocities. As the left parts (8) and (3) are identical, the velocity $\vec{v}$ is similar to that calculated by the standard procedures of mechanics. From the (5) and (8) the connection of the velocity v with the aberration angle α will be obtained:

$$v = c\sin\alpha \,. \tag{9}$$

From the Einstein formula $E = mc^2$ [2] it is seen, that the proportionality factor between the energy and the value of the 4-momentum coincides with the fundamental constant c:

$$E = c \cdot cm = c\left|\vec{P}\right| . \tag{10}$$

Intermediate conclusion. It is known to consider [5], that in order to obtain the equations of motion, it is necessary to compare the momentum change rate with the vector of the outside forces vector. As the zero component of the 4-momentum is constant ($p_0 = const$), the 4-dimentional equation of motion can be divided into two independent ones – one-dimensional for the unobservable subspace and three-dimensional for the observable one. To test the identity of the equations of motion in the visible subspace with the similar equations of the relativistic mechanics by G. Minkovsky, it is enough to check the expressions similarity for their 3-momentum. For this, let us present the observable characteristics. Thus, according to the (2) and (10), $p_0 = cm_0$, where m_0 – the mass in rest (at the peculiar velocity $v = 0$). On the other hand, according to the (5), (9) and (10) $m_0 = m\cos\alpha = m\sqrt{1-(v/c)^2}$. As the expression for the 3-momentum vector in the observable subspace coincides totally with the similar one in the relativistic mechanics by G. Minkovsky, the results of calculations in the 3 spaces for both mechanics are identical: heredity of the proposed mechanics within the law of motion has been proved. To answer the question on the reasons of such a coincidence under totally different approaches, let us analyze the task on the correct application of the equation of motion $d\vec{p} = \vec{f}dt$ in mechanics (within the laws of conservation it is satisfied only in the Riemannian space [3]).

3. Peculiarities of the particles interaction nodes. The main experimental proofs of the Euclidean nature of the4-space momentum and positioning are the thoroughly checked laws of conservation, as the notion of the space homogeneity of the 4-momentum corresponds physically to the law of the momentum conservation, and the space homogeneity of the interaction nodes positioning – the law of the energy conservation (the Netter theorem) [3].

3.1. Non-planarity of the interaction nodes. Let us analyze the application of the conservation laws to the hypothesis case of the particles interaction with the 4-momentum $\vec{P}_1$ and $\vec{P}_2$, the result of which is the particle with the 4-momentum $\vec{P}_3$:

$$\vec{P}_3 = \vec{P}_1 + \vec{P}_2; \tag{11}$$

$$c\left|\vec{P}_3\right| = c\left|\vec{P}_1\right| + c\left|\vec{P}_2\right|. \tag{12}$$

Irrespectively on the values $\vec{P}_1$, $\vec{P}_2$ and $\vec{P}_3$ mutual satisfaction of the conservation laws (11) and (12) in the Euclidean space can be in the case, when all three vectors are collinear (that is, the node is not available. Because the branch self-division in some parts is not possible either. If the particles interact with the 4-momentum $\vec{P}_2 = -\vec{P}_1$, that is, the resultant momentum equals zero, then, according to the laws of conservation, at least two new branch-particles will be generated so, that the laws of conservation are to be satisfied.

Let us analyze 4-branch node, the graph of which is presented in Fig.1 on the example of the mechanical similarity of the A. Kompton effect [3]. Let the particle (electron) with the 4-momentum $\vec{P}_e = P_e \vec{щ}$ interacts with the photon carrying the 4-momentum $\vec{P}_\Phi = P_\Phi \vec{i}$, where $\vec{i}$ – the direction in the observable subspace (it is assumed, that $P_\Phi < P_e$). As the result of the interaction the photon is dissipated in the observable subspace along the cone generator with the expansion angle Θ relatively the axis $\vec{i}$, where $\cos\Theta = 1 - P_e(P_\Phi - P_\Phi^\vee)/(P_\Phi \cdot \vec{P}_\Phi^\vee)$ [4]. Here $\vec{P}_\Phi^\vee$ – the 4-momentum photon after the interaction. It is important to note, that the mutual satisfying the conservation laws is provided by means of implementation of the incomplanary node, that is, the generation of the orthogonal to the plane $\{\vec{P}_e, \vec{P}_\Phi\}$ additional opposite directed components of the resultant 4-momentum of the photon and the electron.

It was found experimentally [5], that, when $P_\Phi > P_e$, the mentioned above interaction node is often branched off into greater number of branches irradiating some photons, and at

$P_\Phi > 2P_e$ – initiating the pair electron – positron [3], that is, the particles with the 4-momentum components along the reference direction (which confirms directly the minus value of p_0 in the anti-particles).

It is important to note, that in order to meet the requirement of the conditions for conservation of the scalar and vector characteristics of the interacting particles system, the nature has chosen just the mechanism of the creation of the incomplanary node among the other possible ones. Thus, being based on the analysis of the properties of the presented interacting nodes, the following conclusions can be made:

– the branches are stable being branched off under the action of the external factors;
– the node net is formed at least by four branches:
– the branches forming the node are incomplanary:
– the elementary interactions are irrevesible.

The conclusion on the interaction nodes incomplanary of the discrete particles and the random nature of their result within the laws of conservation of the 4-momentum and the energy is fundamental (it can not be obtained within the space-time apparatus). The irreversibility has resulted from the obtained above conclusion on the non-determinated nature of the results of the particles interaction, which is wider than that the thermodynamic approach [7], which takes advantage of the static approach (the thermodynamic approach assumes, that the microscopic processes are absolutely reversible in time, the direction of time being the result of the microscopic irreversibility).

3.2. The node of the average-statistic interaction. It is shown in the [4], that the material point can be treated as the particle with the 4-momentum $\vec{P}$. Among the graph of the material point of interaction the continuous line of events positioning (LEP) is specified geometrically, that is, the linear nodes of the $d\eta = cdt$, where the material point obtains the growth of the 4-momentum $d\vec{P}$ (it is considered, that $\left|d\vec{P}\right| \ll \left|\vec{P}\right|$ – the material point as a rough object). To model the events the 5-branch node of the average-statistic interaction has been proposed in the [4], the graph of which is presented in Fig. 2. Here $\vec{P}$ – the 4-momentum of the material point at the beginning of the event, and $\vec{P} + d\vec{P}$ – when it is over. The averaging makes the 4-momentum $\vec{P}$, $d\vec{P}$ and $\vec{P} + d\vec{P}$ complanar, leaving the directions of the branches-particles with the 4-momentum $d\vec{P}_D$ and $-d\vec{P}_D$ random, which are responsible for the energy dissipation. The energy dissipation along two opposite branches $\pm d\vec{P}_D$ should not be treated word for word – every separate event is implemented by the 4-branch node with the random directions of the 4-momentum resultant vectors.

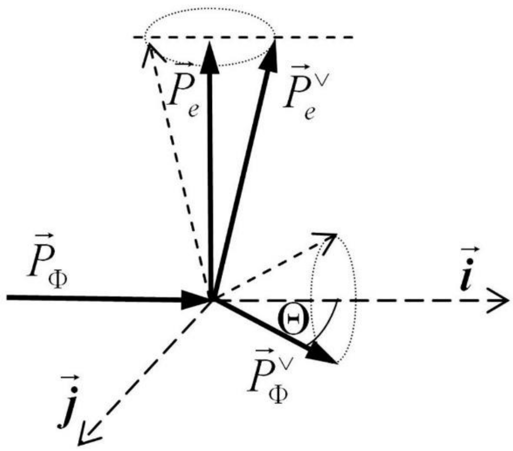

Figure 1. 4 – branch node scheme

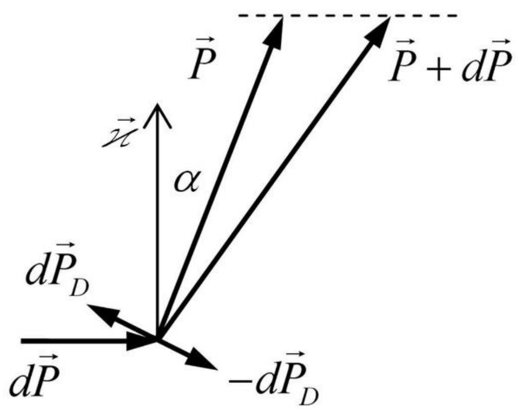

Figure 2. 5 – branch node scheme

During the event the redistribution of the energy will be $dE_H = cdP$. Thus, the change of energy of the material point itself will be equal to $dE_M = c \cdot abs(|\vec{P} + d\vec{P}| - |\vec{P}|)$. Taking into account, that $(\vec{P} + d\vec{P})^2 = (\vec{P})^2 + (d\vec{P})^2 + 2(\vec{P}, d\vec{P})$, in the first approximation we will obtain $dE_M \approx c\,dP|\sin\alpha|$. The maximum dissipation energy will be the difference of these energies:

$$dE_D = dE_H - dE_M \approx c\,dP(1 - |\sin\alpha|). \quad (13)$$

4. Equation of the material point dynamics in the 4-space. To take into account the external effects it is assumed, that in the positioning space there exist additionally the field flow of the first variety 4-momentum particles with the linear density $\vec{F}/c$. For example, when the 4-force $\vec{F}$ is created by the photons flow, then at small α their classic elastic scattering will be noticed (similar to the Thomson scattering [3]). The experiments, which testify the energy dissipation by the photons, when the relativistic particles are retarded, is described in the [8].

4.1. LEP curvature. While modeling every event by the average-statistic interaction node, the task on the behavior of the material point in the outside force field can be divided into two independent ones: in the first it is enough to use only the vector law of the 4-momentum conservation and in the second – only the scalar law of the energy conservation. In average within the event the material point obtains the growth of the 4-momentum:

$$d\vec{P} = \vec{F}dt. \quad (14)$$

Having specified the formula (14) for the hybrid presentation of the 4-momentum, we will obtain:

$$\vec{F} = \frac{d\vec{P}}{dt} = \frac{d}{dt}\left(m\vec{V}\right) = \frac{dm}{dt}\vec{V} + m\vec{A}. \quad (15)$$

The 4-acceleration $\vec{A}$ of the material point can be caused by the main curvature K LEP [3]

$$\vec{A} = \frac{d\vec{V}}{dt} = c\frac{d\vec{\tau}}{d\eta} = c^2\mathrm{K}\vec{n}, \quad (16)$$

where $\vec{n}$ – the directed unit 4-vector of the main normal to LEP. Having multiplied (15) and $\vec{V}$ scalarly, and taking into account the vectors $\vec{n}$ and $\vec{\tau}$ [3] orthogonality, we will obtain the formula for the calculation of the material point mass change rate

$$\frac{dm}{dt} = \frac{1}{c^2}\left(\vec{F}, \vec{V}\right) = \frac{1}{c}\left(\vec{F}, \vec{\tau}\right). \quad (17)$$

Together with the (16) the expression (17) will be easily interpreted for the curvature K LEP:

$$E\mathrm{K}\vec{n} = \vec{F} - (\vec{F}, \vec{\tau})\vec{\tau}. \quad (18)$$

For the rough objects the equation (18) is versatile – different mechanics differ only in the conditions for the 4-force. For example, to provide the unchangeable body mass in the classic mechanics, the condition $(\vec{F}, \vec{\tau}) = 0$ must be provided. On the contrary, in the relativistic one – the requirement (4) is $(\vec{F}, \vec{ш}) = 0$.

4.2. The G.Minkovsky's world. To provide the requirement (4) unobservable component of the 4-force $\vec{F}$ must be zero. Let the component forces in the observable 3-space be described by the vector $\vec{f}$ identical to the classic force. Then the (17) can be rewritten as the J.V. Poncelle formula [5] for the mechanic work $dE = (\vec{F}, \vec{V}dt) = (\vec{f}, d\vec{r})$, where $d\vec{r} = \vec{v}dt$ – displacement in the 3-space.

The equation (18) will be written by the independent blocks for the unobservable and observable subspaces using the mechanics variables m, $\vec{V}$ and $\vec{A}$:

$$ma_0 = -\frac{dm}{dt}v_0 = -\frac{1}{c^2}\left(\vec{f},\vec{v}\right)v_0; \tag{19}$$

$$m\vec{a} = \vec{f} - \frac{1}{c^2}\left(\vec{f},\vec{v}\right)\vec{v}. \tag{20}$$

The equation (19) provides the fulfillment of the requirement (4), and (20) are identical to the space part of the dynamic equations in the space-time – in fact, this is the Minkovsky's world [2].

As the construction of the multi-connected space-time was introduced by G.Minkovsky for the formal treatment of the obtained by G.A. Lorents acceptable transformations of the G.K. Maxwell's equations, that is, the first variety particles. To spread them to the second variety particles some additional investigations are needed. Let us show, that the elimination of the reference direction of the positioning space results in the space-time. Thus, presented due to the space positioning coordinates the square of the length $d\eta = cdt$ and random elementary LEP area will look like:

$$ds^2 + dr^2 = c^2dt^2, \tag{21}$$

where $ds = v_0dt$ – corresponding LEP changes along the reference direction. Having regrouped the variables, it is possible to come from the presentation of the dependence $d\eta$ in the homogeneous positioning 4-space with the coordinates $(s, \vec{r})$ to the presentation of the dependence ds in the non-homogeneous space-time with the coordinates $(ct, \vec{r})$ (in order the interval ds looking formally as $-ds^2 = c^2dt^2 + dr^2$, the time coordinate in the standard theory [2] being imaginable). As the requirement (4) makes the 4-space momentum that of the axial-isotropic one, the rotations are allowed only in the observable subspace. The latter do not disturb the aberration angle α, that is, the values v_0 and v are unchangeble. That is why ds is the invariant under the mentioned rotations. Having taken onto account the mentioned above and the great difference of the particles of the first and second variety, the transition of the G.A. Lorents transformation on the mechanics can be done with sufficient precautions.

Conclusion. The fundamental restrictions of the apparatus of relativistic mechanics by G. Minkovsky are revealed. To eliminate them it is proposed to use two interrelated metric 4 spaces – relativistic impulses and the positioning of nodes of interactions (events). The named 4 spaces are supplemented by the hypothesis of the existence of the reference direction, which divides them into 3 dimensional observable and one-dimensional unobservable ones. The only reason for such a division is the presence of two varieties of vector elementary particles – three- and four-dimensional, each with its own peculiarities of interaction. The effect of dissipation of energy under relativistic motions in power fields is investigated. The irreversibility in time of microscopic mechanical processes is proved. The equation of the motion of a material point in the Euclidean 4-space is obtained and conditions of their correct application are presented.

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ЗАСОБИ УСУНЕННЯ ОБМЕЖЕНЬ АПАРАТУ ПРОСТОРУ-ЧАСУ В РЕЛЯТИВІСТСЬКІЙ МЕХАНІЦІ

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Резюме. *Названо принципові обмеження апарату релятивістської механіки Г. Мінковського та вироблено засоби їхнього усунення, а саме: запропоновано використовувати два пов'язані між собою метричні 4-простори імпульсів та позиціювання вузлів взаємодій (подій). Властивості названих 4-просторів доповнено гіпотезою існування опорного напряму, що поділяє їх на 3-вимірний спостережуваний та одновимірний неспостережуваний підпростори. Доведено, що законів збереження імпульсу та енергії недостатньо для однозначного опису результатів взаємодії мікрочастинок. Пропонований варіант механіки побудований на її основному принципі, без посилань на теорію відносності. У межах рівнянь руху він зберігає спадковість з класичною та релятивістською механіками. Доповнення рівнянь динаміки матеріальної точки законом збереження енергії дало можливість розглянути розсіювання останньої у зовнішніх силових полях.*

Ключові слова*: релятивістська механіка, простір-час, простір 4-імпульсів, опорний напрям, дисипація енергії, мікроскопічна необоротність, основний принцип механіки.*

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