Content and Derivation of Newton's Law

By Khachatur Kirakosyan

Institute of Chemical Physics

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Abstract- Taking into account the peculiarities of interaction, the equations of motion are proposed, from which correspondences with the main parameters of both kinematics and dynamics are found. It is shown that it is the potential of interaction with the third-party partners that is the parameter, the presence, change, and redistribution of which the content of all three Newton's laws is interpreted.

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I. Introduction

Even though humanity has existed for hundreds of thousands of years, the beginning of the formation of conceptual scientific disciplines and the rapid penetration of scientific achievements into everyday life is largely associated with the emergence of Newton's work "The Mathematical Principles of Natural Philosophy" [1], with the discovery of the fundamental property "mass" in the modern sense. Subsequently, mass and related concepts (momentum, force, energy, et cetera) and laws became instruments for quantitative research not only in mechanics and physics in general but also in many other areas of natural science. Newton's laws are axioms, taken on faith, and always fulfilled in practice. Newton's first law states that if a body is at rest or moving at a constant speed in a straight line, it will remain at rest or keep moving in a straight line at constant speed unless it is acted upon by a force. The second law states that the acceleration of an object is dependent upon two variables – the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object.

$$\vec{a} = \frac{\vec{F}}{m} \tag{1}$$

Newton's Third Law. A force is a push or a pull that acts upon an object as a result of its interaction with another object. Formally stated, Newton's third law is: For every action, there is an equal and opposite reaction.

In modern formulations, Newton's laws were corrected by the introduction of the concept of a material point with infinitely small dimensions, the choice of inertial reference frames. In addition, based on the results of the special theory of relativity, a conclusion is made: the laws of mechanics are applicable for speeds that are significantly lower than the speed of light in a vacuum. Despite its colossal significance, the fundamental property of matter - the "mass" and related concepts and laws contain uncertainties[2-6].Analyzing the evolution of the concept of 'mass', the author of [2] concluded:' ... a modern physicist should be aware that the foundation of his impressive knowledge, the basic concepts of his science, such as the concept of mass, are shrouded in serious uncertainties that have not yet been determined ". Jammer's opinion was discussed in later publications [5,6].

In this work, based on the equations of motion of an approach called Structural Theory (ST) [7-10], the structural content of the basic concepts of mechanics is considered, taking into account the class of interactions in which physical bodies are involved, Newton's laws of motion are derived, it is shown that the momentum, or its change, a force, do not depend on the individual characteristics of the bodies under consideration.

In ST it is assumed that starting from a certain hierarchical level, all bodies have the same structural element, the laws of motion of which determine the laws of motion of physical bodies as a whole. Hence, the task of identifying the patterns of motion of physical bodies is reduced to modeling the above structural element and determining its motion.

Particles in ST are modeled in the following hierarchical sequence: a hypothesis is put forward about the existence of some particles of the conventionally smallest hierarchical level: ε-particles. From ε-particles, the Δ-particles, from pairs Δ-particles and three Δ-pairs the γ-particles for various purposes are modulated, which are the basis of known elementary particles: electrons (e⁻), positrons (e⁺), muons, pions, proton (p⁺), antiproton (p⁺), including γ_{0i}-particles, the regularities of motion of which determine the regularities of motion of physical bodies. The main attribute of ε-particles is their ability to interact in pairs. An elementary act of interaction between ε-particles (ε-act) occurs with a strictly defined duration at a strictly defined distance, while, as a result of the interaction, ε-particles move strictly at the same distance. Specific directions of displacement are determined by the type of interacting particlesю Three types of Δ-elements Δ_i, Δ_j, and Δ_k are modeled from ε-particles, which oscillate in three mutually perpendicular directions, the indices at the - symbols indicate the directions of the corresponding unit vectors: $\vec{e}_i, \vec{e}_j$, and $\vec{e}_k$ Compositions and rules of interactions between ε-particles and Δ-elements are selected in such a way that Δ_i, Δ_j, and are always

Author: Institute of Chemical Physics, National Academy of Sciences, Yerevan, Armenia. e-mail: khkirakosyan@gmail.com

mutually recognizable. The γ_{0i}-particles are characterized by the general Δ-composition $2\Delta_i 2\Delta_j 2\Delta_k$ or, simply 2i2j2k, where only their indices are used to designate the type of Δ-elements.

The trajectory of motion of the reduced composition of γ_{0i}-particles are formed by the addition of oscillations in three mutually perpendicular directions, which are further considered as the coordinate axes [9].

Because both the smallest path and time intervals are associated with the same ε-act, by counting ε-acts, we will determine both the path and time of motion and if the final path is determined by adding the displacements in three mutually perpendicular directions, time is determined by the number of successively implemented ε-acts in all directions of motion. Thus, γ_{0i}-particles are used both as coordinate systems and as a single tool for determining the path and time, that is the γ_{0i}-particle itself is used as a frame of reference.

For a dimensional description of space and time, the following dimensions are assigned to a strictly constant interval of the ε-act: ξ_d cm for path and ξ_t sec for time. Due to the constancy of the ε-interval, ξ_d and ξ_t are also constants. Multiplying the number of ε-intervals by ξ_d and ξ_t, we obtain the dimensional values of the path and time, in connection with which ξ_d and ξ_t are called the coefficients of the dimensions of the path and time. In addition to the direction, the Δ-particles are characterized by the amplitude of the oscillation H_Δ, the Δ-pair α_0, and multiple repetitions of the amplitude $H_c = H_\Delta^2$, that is, characterized by

$$H_{oe} = \alpha_o H_\Delta^2 = \alpha_o H_c \qquad (2)$$

ε-acts, where

$$\alpha_0 = \sum_{n=1}^{7} \sum_{l=0}^{n-1} (2l+1) = 140 \qquad (3)$$

n and l play the role of the principal and azimuthal quantum numbers for the considered hierarchical level [9]. Taking into account the geometric features of the formation of the trajectory of γ_{0i}-numbers [8,9], equation (2) is transformed into

$$H_0 = \frac{\alpha_o H_c}{\chi_c} \qquad (4)$$

where indicated

$$\alpha_c = \frac{\alpha_0}{\chi_c} \qquad (5)$$

It should be noted that the introduction of constant χ_c is associated with the transition from

actually formed spatial trajectories of motion to simplified linear trajectories [10].

The trajectories of motion of γ_{0i}-particles, because of their Δ-composition, always represent a three-dimensional figure, the volume of which is called a trajectorial. Thus, the trajectory formed by the addition of three mutually perpendicular oscillations is a torus, the volume of which is calculated using integrals related by an equation formally resembling the equation Stokes

$$\oint_L S dl = \oint_{S_j} curl S dS_j \qquad (6)$$

The left side of the above equation is the volume of the torus is calculated by the circulation of the oriented surface S (axial vector) along a curvilinear closed path L, with the help of the right side the same volume is calculated as the result of the mixed product of three vectors, one of which is $curl S$.

The integration of equation (6) is carried out taking into account the class of interactions in which the γ_{0i}-particles participate. In addition to the gravitational one, the ST considers the following types of interactions:

– with the participation of only its constituent particles;

– with the participation of the constituent particles of their own and their partner;

– with the participation of component particles of third-party partners.

Sequential participation of γ_{0i}-particles in all types of interactions is allowed. Taking into account the interaction class from equation (6), after some simplifications, the following equations of motion are derived [9]:

$$\alpha_c 2\pi r_c \left[\alpha_c^2 H_c^2 \right] = \alpha_c H_c \left[\pi H_0^2 \right] \xi_d \qquad (7)$$

$$\alpha_c 2\pi r \left[H_i^2 \right] = \alpha_c H_c \left[\pi H_o^2 \right] \xi_d \qquad (8)$$

$$\lambda [H_i^2] = H_i \left[\pi H_0^2 \right] \xi_d \qquad (9)$$

$$\left(\alpha_c 2\pi r + \lambda \right) \left[H_i^2 \right] = \left(H_0 + H_i \right) \left[\pi H_0^2 \right] \xi_d \qquad (10)$$

In equation (7), the subscript "c" at r and H indicates the constancy of the intrinsic interaction: $r_c = H_c \xi_d / 2, S_j = \pi H_0^2, L_c = \alpha_o 2\pi r_c$. The oriented surfaces S and S_j are taken in square brackets. The trajectory of the intrinsic interaction is a torus with equal radii. In interactions with its partner, only the constituent particles of interaction partners participate. This class includes

electrostatic and gravitational interactions, while in certain cases planetary trajectories are formed. When interactions at a distance, a certain number of ε-acts is spent on removing particles - carriers of interaction, from their bases, in this connection, the amplitude of oscillation of the leading Δ-pairs of γ_{0i}-particles H_i is less than H_c. The motion of γ_{0i}-particles in the case of interaction with their partner is described by equation (8), where the circulation path $L = \alpha_c 2\pi r$, $S = [H_i^2]$, r is a larger circulation radius. The oscillation amplitudes H_c, H_i, and also the value $H_0 = \alpha_c H_c$ is called interaction potentials. Any variants of interactions with the participation of third-party partners are reduced to the introduction into the system under consideration of a coupled pair of γ_{0i}-particles called β_ε-pairs and born as a result of chemical, nuclear, thermal, and many other processes [7-10]. β_ε-pairs can be introduced into the systems under consideration by supplying heat, radiation, mechanical shock, etc. Depending on the mechanism of interaction of b-pairs with particles of the medium, there is a change in thermal, electrical, and other properties of physical bodies, including their movement as an integral unit [7,8]. In this work, we will consider those cases when from the outside introduced β_ε-pairs cause the motion of physical bodies as integral units. In the free state of the β_ε-pair, it is photons that are in a state of constant motion in a given direction in space. The motion of β_ε-pairs, both in the free and in the bound state, is described by equation (9), where H_i is the interaction potential, λ is the minimum transverse path of manifestation of the integrity of the γ_{0i}-particle.

Two photons with the opposite directions of motion and Δ-composition are formed during the annihilation of slow $e^- e^+$-pairs.

$$ f_k = \frac{2j2\bar{i}2k}{2\bar{j}2i2k} \text{ and } f_{\bar{k}} = \frac{2\bar{j}2\bar{i}2\bar{k}}{2j2i2\bar{k}} \qquad (11) $$

where f is the symbol of photons, indexes k and $\bar{k}$ at f indicate the direction of motion, the dashes above the symbols of the Δ-elements indicate that the particles are moving in the opposite direction.

Photons with orts of motion y e_j and $\bar{e}_j$ are represented by Δ-compositions

$$ f_j = \frac{2j2\bar{i}2k}{2j2i2\bar{k}}, f_{\bar{j}} = \frac{2\bar{j}2\bar{i}2\bar{k}}{2\bar{j}2i2k} \qquad (12) $$

Note that the directions of motion of photons and β_ε-pairs are determined by the directions of motion of leading Δ-pairs: $2k/2k$ for f_k, $2\bar{k}/2\bar{k}$ for $f_{\bar{k}}$, $2j/2j$ and $2\bar{j}/2\bar{j}$ for f_j and $f_{\bar{j}}$, respectively. It is convenient to represent the union of γ_{0i}-pairs in photons and β_ε-pairs in complexes by the formula j_{ef}/j_{pf}, where the numerator shows the Δ-pairs of the world e^- with a $2\bar{i}$-pair, in the denominator of the Δ-pairs of the world e^+ with $2i$ pairs. The specificity of the bound state between γ_{ef} and γ_{pf} is such that periodically, upon reaching the phase π, there is an exchange of $2j$- and $2k$-pairs between the worlds e^- and e^+, while the Δ-pairs that have exchanged these pares, change the direction of their motion. Because the Δ-pairs perform an oscillatory motion, their direction of motion is reversed also when the phase π is reached. Hence, due to the simultaneous double change in the direction of movement of the leading Δ-pairs, their final direction of motion remains unchanged. Hence, the parametric equation describing the motion of the leading Δ-pair becomes linear. The β_ε-pairs introduced into the composition of various physical bodies are characterized by a similar system of parametric equations.

Thus, the motion of the photon, as well as the β_ε-pairs, are characterized by two periodic and one linear parametric equations, in relation with which the photon is in constant motion in the direction of the leading Δ-pairs.

As a rule, the γ_{0i}-particles of physical bodies with rest mass in a state of interaction are characterized by compositions of the type $2j2\bar{i}2\bar{k}/2\bar{j}2i2k$ or $2j\bar{2}i2k/2\bar{j}2i2\bar{k}$, that is the Δ-pairs in the numerator and denominator have opposite directions [7,8]. It is easy to verify that the reduced γ_{0i}-pairs, exchanging with γ_{0i}-particles of β_ε-pairs, with compositions similar to photons (11, 12), are transformed into β_ε-pairs with Δ-pairs of the same direction of motion. As a result of the periodic exchange of γ_{0i}-particles, the entire complex passes into a state of periodic motion in the direction of the leading Δ-pairs.

The β_ε-pairs, both in the free and in the bound state, are characterized by the potential H_i, respectively, and the equation of motion above the considered complex is represented by equation (10).

From the equations of motion of the ST (6) – (10), it follows that the final trajectory of motion of γ_{0i}-particles are formed by two components: transverse, always with a closed curvilinear trajectory with the weaving perpendicular to the surface of $[H_i^2]$ and longitudinal with the weaving of the perpendicular surface of $[\pi H_0^2]$. Now, let us reveal the

correspondence between the given characteristics of the ST motion and the generally accepted kinematic and dynamic characteristics of physical bodies. In kinematics, a material point with infinitely small dimensions is considered as a physical body, its velocity v is defined as $v = \lim\limits_{\Delta t \to 0} \dfrac{\Delta l}{\Delta t}$, that is, the ratio of an infinitely small path interval to a time interval tending to zero. Thus, three uncertainties are put forward, associated with infinitely small intervals of the path, time, and sizes of the investigated bodies. Formally, the use of such small values means penetration into the microcosm, while the absence of clear limits of space and time gives rise to new uncertainties regarding the hierarchical level of the world under consideration.

According to the foregoing, the laws of motion of physical bodies are determined by the laws of motion of γ_{0i}-particles, hence, γ_{0i}-particles are promoted to the role of the specified material point. In this case, we do not reduce the dimensions of the physical body to infinitesimal values but penetrate deep into the structure of matter to such a hierarchical level, with which the mechanism of motion of physical bodies is associated. Because we choose the γ_{0i}-particle as the smallest organization associated with the mechanism of motion, the essence of the periodic process of restructuring the organization under consideration in a given direction [9], then it is quite natural to use the duration and the distance traveled during this period as the characteristic smallest kinematic intervals associated with the manifestation of γ_{0i}- particles as integral units. In equations (6), (8), (9), and (10), the main variable is the potential H_i, therefore, the manifestation of the integrity of γ_{0i}-particles are associated with the intervals of longitudinal and corresponding transverse paths

$$l_o = H_o \xi_d, l_i = H_i \xi_d, l_{0i} = (H_o + H_i)\xi_d \qquad (13)$$

$$\lambda_0 = \frac{\pi H_0^2 \xi_d}{H_0}, \lambda = \frac{\pi H_0^2 \xi_d}{H_i}, \lambda_{0i} = \frac{(H_0 + H_i)\pi H_0^2 \xi_d}{H_i^2} \qquad (14)$$

The given longitudinal and transverse paths are overcome in the same time intervals:

$$t_i = H_i \pi H_0^2 \xi_t, t_0 = H_0 \pi H_0^2 \xi_t, t_{0i} = (H_0 + H_i)\pi H_0^2 \xi_t \quad (15)$$

where it is taken into account that the longitudinal motion is realized by weaving a perpendicular surface πH_0^2, that is, a certain amount ε-acts is also spent on weaving this surface.

Introducing a new dimension factor for time

$$\pi H_0^2 \xi_t = \xi_\tau \qquad (16)$$

the time intervals for the manifestation of integrity (15) are represented by the series

$$\tau_i = H_i \xi_\tau, \tau_0 = H_0 \xi_\tau, \tau_{oi} = (H_0 + H_i)\xi_\tau \qquad (17)$$

By the ratio of the reduced minimum intervals of the longitudinal path (13) and the corresponding times (17), we obtain the velocities

$$c = \frac{H_0 \xi_d}{H_0 \xi_\tau}, c = \frac{H_i \xi_d}{H_i \xi_\tau}, v = \frac{H_i \xi_d}{(H_0 + H_i)\xi_\tau} = \frac{H_i c}{H_0 + H_i}, \qquad (18)$$

where indicated

$$c = \frac{\xi_d}{\xi_\tau} \qquad (19)$$

and when determining v, it was taken into account that the final path with its own interaction is zero.

In [8, 9] it was shown that the quantity c (19) is numerically equal to the speed of light in a vacuum. From the first two formulas of the series (18) it follows that we have the symmetric flow of path and time, while, in the case of its interaction, for each time interval $H_0 \xi_\tau$, the particle is in the same place in space, as if being at rest. Hence, those bases involved only in their interaction will be called γ_o-particles. From the third formula of the series (18), it follows that the maximum speed of longitudinal motion $H_i \square H_0$ tends to the speed of photons c (19). From series (14) and (17) it follows that the speed of the transverse motion of photons and complexes of b β_ε-pairs with γ_{0i}-particles exceeds the speed of light.

Within the framework of classical mechanics, as a rule, longitudinal motion is considered, and, as a rule, for $H_i \square H_0$, thus, based on the third formula of the series (18), the velocity of γ_{0i}-particles

$$v = \frac{H_i}{H_0} c \qquad (20)$$

We represent the equations of motion (7-10) in the form

$$\frac{H_0^2}{H_0 \pi H_0^2} = \frac{\xi_d}{\alpha_c 2\pi r_c}; \frac{H_i^2}{H_0 \pi H_0^2} = \frac{\xi_d}{\alpha_c 2\pi r}; \frac{H_i^2}{\pi H_0^2} = \frac{\xi_d}{\lambda}; \frac{H_i^2}{(H_0 + H_i)\pi H_0^2} = \frac{\xi_d}{L} \qquad (21)$$

where are designated

$$\lambda = \frac{\pi H_0^2 \xi_d}{H_i}, L = \alpha_c 2\pi r + \lambda \tag{22}$$

Multiplying both sides of the reduced series (21) of formulas by a strictly constant scalar quantity ξ_m with the dimension of mass, we obtain two series

$$m_0 = \frac{\xi_d \xi_m}{\alpha_c 2\pi r_c}; m_{i0} = \frac{\xi_d \xi_m}{\alpha_c 2\pi r}; m_i = \frac{\xi_d \xi_m}{\lambda}; m_{i\Sigma} = \frac{\xi_d \xi_m}{L}, \tag{23}$$

$$m_0 = \frac{\xi_m H_0^2}{H_0 \pi H_0^2} = \frac{\xi_m}{\pi H_0}; m_{i0} = \frac{\xi_m H_i^2}{H_0 \pi H_0^2}; m_i = \frac{\xi_m H_i}{\pi H_0^2}; m_{i\Sigma} = \frac{\xi_m H_i^2}{(H_0+H_i)\pi H_0^2} \tag{24}$$

where the definitions of masses are given: own interaction or rest m_0, interactions with an own partner m_{i0}, and the mass of the general interaction $m_{i\Sigma}$.

We can conclude that the fundamental properties of matter - "mass", are determined by the ratio of the perpendicular surface of the transverse path to the corresponding trajectory volume, as well as the reciprocal of the length of the transverse path for a given type of interaction.

With the help of the constants ξ_d, ξ_m, and ξ_τ, we combine the new constants with the dimensions of momentum ξ_p and energy ξ_ε

$$\xi_p = \frac{\xi_m \xi_d}{\xi_\tau} = \xi_m c; \xi_\varepsilon = \frac{\xi_m \xi_d^2}{\xi_\tau^2} = \xi_m c^2. \tag{25}$$

Multiplying both sides of the formulas of series (22), first by ξ_p and then by ξ_ε, we obtain formulas for determining the moment a and energies depending on the interaction class

$$m_0 c = \frac{h}{\alpha_c 2\pi r_0}; m_{i0} c = \frac{h}{\alpha_c 2\pi r}; m_i c = \frac{h}{\lambda}, m_{i\Sigma} c = \frac{h}{L} \tag{26}$$

$$m_0 c = \frac{\xi_p H_0^2}{H_0 \pi H_0^2} = \frac{\xi_p}{\pi H_0}; m_{i0} c = \frac{\xi_p H_i^2}{H_0 \pi H_0^2}; m_i c = \frac{\xi_p H_i}{\pi H_0^2}; m_{i\Sigma} c = \frac{\xi_p H_i^2}{(H_0+H_i)\pi H_0^2}$$

$$m_0 c^2 = \frac{ch}{\alpha_c 2\pi r_0}; m_{i0} c^2 = \frac{ch}{\alpha_c 2\pi r}; m_i c^2 = \frac{ch}{\lambda}, m_{i\Sigma} c^2 = \frac{ch}{L} \tag{27}$$

$$m_0 c^2 = \frac{\xi_e H_0^2}{H_0 \pi H_0^2} = \frac{\xi_p}{\pi H_0}; m_{i0} c^2 = \frac{\xi_e H_i^2}{H_0 \pi H_0^2}; m_i c^2 = \frac{\xi_e H_i}{\pi H_0^2}; m_{i\Sigma} c^2 = \frac{\xi_e H_i^2}{(H_0+H_i)\pi H_0^2}$$

where the constant h is a combination

$$h = \frac{\xi_m \xi_d^2}{\xi_\tau} \tag{28}$$

The constants ξ_m, ξ_p, and ξ_ε, by analogy with ξ_d and ξ_τ, are called the coefficients of the dimensions of mass, momentum, and energy.

It was shown in [8] that the constant h is numerically equal to Planck's constant.

Summing up the masses m_0 and m_i, we obtain the mass of the complex of γ_{0i}-particles with a β_ε-pair

$$m = \frac{\xi_m (H_0 + H_i)}{\pi H_0^2} = m_0 + m_i \tag{29}$$

the total energy, proceeding from series (27), is represented by the formula

$$mc^2 = m_0 c^2 + m_i c^2 \qquad (30)$$

$$\xi_m (H_0 + H_i) / \pi H_0^2 \qquad (29).$$

Comparing the formulas for determining the mass (23), (24), and energy (27), we can unambiguously conclude that the unity (or equivalence) of mass and energy is determined by the unity of their scalar dimensionless components for each class of interactions.

The laws of motion formulated by Newton are the result of generalizations of experimental observations based on the proposed property of matter - mass and the parameters of momentum and force associated with it.

These laws are passed on faith without answering questions of causality. Nevertheless, the question related to the First Law may turn out to be very informative: what is the reason for the finding of the considered body (test body) in a state of motion? The answer to this question was the beginning of the disclosure of the content of the formulations of Newton's laws.

The motion of physical bodies is caused by the presence in them of bound β-pairs with the potential of γ_{0i}-particles H_i. In this case:

o at $H_i = 0$, the body is at rest, at $H_i = const$, the body moves at a constant speed

o with a change H_i, the speed of motion also changes

o in the collision of two bodies, a redistribution of β_ε-pairs occurs, while the total potential of the pair remains unchanged.

Then a natural question arises: what is the quantitative relationship between the characteristics of the supplied β_ε-pairs and the observed patterns of motion of test bodies? That is, the problem arises of representing the laws of motion in the framework of a causal relationship.

When a β_ε-pair is introduced into a test body, a complex is formed with the participation of γ_0-particles of test bodies, thereby changing the structural frame of reference for describing β_ε-pairs, that is, the way of calculating the path and time. According to (18), the speed of free β_ε-pairs is set by the relation $c = H_i \xi_d / H_i \xi_\tau$ in the state of a complex with the γ_0-particle, the final path remains $H_i \xi_d$, while the flow of time changes, instead of $H_i \xi_\tau$, the motion is realized in the time interval $\xi_{0i} = (H_0 + H_i)\xi_\tau$ (17). From series (24) it follows that the mass of γ_0-particles is given by the ratio $H_0 / \pi H_0^2$ and the mass of γ_{0i}-particles from β_ε pairs is given by the ratio $H_i / \pi H_0^2$.

In passing to the complex under consideration, the mass is determined by the ratio

Hence, to pass to the characteristics of the complex under consideration, it is necessary to multiply and divide the impulse of β_ε-pairs by the sum $(H_0 + H_i)$

$$m_i c = \frac{\xi_m H_i}{\pi H_0^2} \frac{(H_o + H_i)}{(H_o + H_i)} = \frac{\xi_m (H_o + H_i)}{\pi H_0^2} \frac{H_i}{H_o + H_i} c = mv \qquad (31)$$

that is, as a result of the rearrangement carried out, from the mass $\xi_m H_i / \pi H_0^2$ we go over to the mass $\xi_m (H_0 + H_i) / \pi H_0^2$ and from the velocity $c = H_i \xi_d / H_i \xi_\tau$ to the velocity $v = H_i \xi_d / (H_0 + H_i)\xi_\tau$.

A similar procedure can be used to establish connections between other characteristics of β_ε-pairs and test bodies. So, for the total energy of interaction energy (27), we obtain:

$$m_i c^2 = \frac{\xi_m H_i^2 (H_0 + H_i)}{(H_0 + H_i)^2 \pi H_0^2} = \frac{\xi_m (H_0 + H_i)}{\pi H_0^2} \frac{H_i^2}{(H_0 + H_i)^2} c^2 = mv^2 \qquad (32)$$

The equality $m_i c = mv$ (31) is a connecting basis between the characteristics of β_ε-pairs and test bodies, rather, it is the basic law of mechanics, on its basis, Newton's laws can be represented as a consequence of the following formulations:

− for $m_i c = 0, v = 0$ the body is at rest, with $m_i c = const, v = const$ that is, a body with a given mass moves at a constant speed;

− change of momentum

$$cdm_i / dt = d(mv) / dt = F \qquad (33)$$

is a force;

− when two bodies collide, a redistribution of b β_ε-pairs occurs, while the total impulse of the colliding pair remains unchanged:

$$cdm_{i1} / dt + cdm_{i2} / dt = d(mv)_1 / dt + d(mv)_2 / dt = F_1 + F_2, = 0 \qquad (34)$$

where the indices "1" and "2" indicate the participants in the collisions. From formulas (31) and (33) it follows that the greater the mass of the test body, the lower its velocity or the less it accelerates, that is, the value of the mass is a criterion of inertia to motion. In addition, it follows from (31) and (33) that neither the momentum cm_i or the force $F = cdm_i / dt$ depends on the characteristics of the test body. Based on series (26), (27), and equality (31), we impart relativistic momenta and energy to a complex of γ_{0i}-particles with a β_ε-pair

6

$$m^2 c^2 = m_0^2 c^2 + m_i^2 c^2 = m_0^2 c^2 + m^2 v^2 \qquad (35)$$

$$m^2 c^4 = m_0^2 c^4 + m_i^2 c^4 = m_0^2 c^4 + m^2 v^2 c^2 \qquad (36)$$

where the condition $m_0 c \perp m_i c$ is taken into account by $H_i \perp H_0$ [9].

Multiplying both sides of equality (3) by the transverse path λ (22), we obtain the de Broglie equation for photons and particles with rest mass

$$m_i c \lambda = h; m v \lambda = h \qquad (37)$$

– The similarity of formulas (37) with de Broglie's formulas does not at all mean that the nature of matter is dual, the transverse path λ is not at all conjugate with the particle wavelength, while formulas (37) simply combine the characteristics of the transverse (λ) and longitudinal motion c and v. The result of unification: the fundamental property of matter is mass

$$c \lambda = h m_i^{-1}; v \lambda = h m^{-1} \qquad (38)$$

Planck's constant in this case is a proportionality coefficient with a complex dimension: the dimensionless parts $c\lambda$ and m_i^{-1}, $v\lambda$ and m^{-1} are equal, just historically they were assigned different dimensions, hence the role of Planck's constant λ.

In formulas (23), (24), and (29) the masses are calculated per one γ_{0i}-particle. The same formulas can be used to calculate the masses of elementary particles with relatively simple structures [10], in particular, the mass e^-, which in the state of its interaction consists of two γ_{0i} r-particles:

$$m_e = \frac{2\xi_m H_0}{\pi H_0^2} = \frac{2\xi_m}{\pi H_0}, \qquad (39)$$

where m_e is the rest mass of the electron.

In the case of particles with a more complex structure, it is necessary to know their γ_{0i}-composition, taking into account the fact that, depending on the distance of interaction, the masses of the γ_{0i}-particles can differ significantly from each other [10].

For practical calculations, two potentials are introduced, H_p and H_1, to isolate the rest masses $p^+ (m_p)$ m atomic unit m_1 which is constants:

$$m_p = \frac{\xi_m H_p}{\pi H_0^2}; m_1 = \frac{\xi_m H_1}{\pi H_0^2} \qquad (40)$$

In the state of interaction, the mass p^+, m_{pi} and one atomic unit m m_1 is calculated by the formulas

$$m_{pi} = \frac{\xi_m (H_p + H_i)}{\pi H_0^2}, m_{1i} = \frac{\xi_m (H_1 + H_i)}{\pi H_0^2} \qquad (41)$$

correspondingly, and the speed of their movement is represented by the relations

$$v_p = \frac{H_i}{H_p + H_i} c \text{ and } v_1 = \frac{H_i}{H_1 + H_i} c \qquad (42)$$

where H_i is the interaction potential for one p^+ and one atomic unit, for $H_i \square H_p$ and $H_i \square H_1$

$$v_p = \frac{H_i}{H_p} c; v_1 = \frac{H_i}{H_1} c \qquad (43)$$

If a physical body consists of N_{m1} atomic units, we represent its mass by the formula

$$M_{1i} = \frac{N_{m1} \xi_m H_1 + N_{mi} \xi_m H_i}{\pi H_0^2} = M_1 + M_i \qquad (44)$$

where

$$M_i = \frac{N_{mi} \xi_m H_i}{\pi H_0^2} \qquad (45)$$

the total mass of interaction with the participation of N_{mi} third-party partners.

From equations (40) and (41) it follows that at $H_i \square H_1$ we obtain the mass

$$M_{1i} \approx M_1 = N_{m1} m_1 \qquad (46)$$

in this case, if $N_{m1} \beta_\varepsilon$-particles with the potential H_i are brought to this body, then for one atomic unit we obtain the potential

$$H_{i1} = \frac{N_{mi} H_i}{N_{m1}}, \qquad (47)$$

respectively, the velocity and momentum are given by the formulas

$$v = \frac{N_{mi} H_i}{N_{m1} H_c} c, M_1 v = M_i c \qquad (48)$$

where the designation for the total interaction mass (45) is used.

Thus, replacing the constant H_0 by H_1 or H_p in the previously given formulas, we obtain formulas for describing the motion from N_{m1} atomic units or N_{mp} protons.

In physics, as a rule, one operates with two types of mass, already considered inert and gravitational M_G, which characterizes a body as a source of gravitational interaction. According to [7], the gravitational interaction at a distance is realized with the participation of particles generated by p^+ and performing a shuttle motion relative to p^+. In this case, we represent the gravitational mass of a physical body with H protons by the formula

$$M_G \quad \frac{\xi_m N_{mp} H_p}{\pi H_0^2} \tag{49}$$

Because the masses m_1 and m_p differ insignificantly and practically always $N_{m1} = N_{mp}$ HH, it is possible to accept the equality of inertial and gravitational masses with an acceptable accuracy

$$M_{in} \approx M_G \tag{50}$$

although they also have different physical manifestations.

From the given definition of gravitational mass, we can conclude that many elementary particles (e, muons, pions, etc.) can participate in gravitational interaction, not being sources of particle generation, with the participation of which gravitational interaction is realized.

What is the way to preliminarily determine the potential H_i? Let us consider electrostatic interaction, which belongs to the class of interactions with its partner and is characterized by the equation of motion (8). In this case, the carriers of the interaction are γ_E-particles that shuttle relative to their bases [8]. Interacting with the partner's base, each γ_E-particle turns into an γ_{0i}-particle, the potential of which is determined by the degree of remoteness from its base [8]. If one of the participants in the electrostatic interaction emits N_{q1} carriers of the interaction γ_E, the other N_{q2}, the equation of motion (8) can be represented in the form

$$\frac{N_{q1} N_{q2} H_i^2}{H_1 \pi H_0^2} = \frac{N_{q1} N_{q2} \xi_d}{\alpha_c 2 \pi r} \tag{51}$$

where a test body with N_{m1} atomic units with potential H_1 is considered.

Multiplying both sides of the above equation by the coefficient of the dimension of energy, then multiplying and dividing the left side by $N_{m1} H_1$, and the right side by the square of the dimension of the charge ξ_q^2, we obtain

$$M_1 v^2 = \frac{N_{q1} N_{q2} \xi_q^2}{r} = M_{i\Sigma} c^2 \tag{52}$$

where indicated

$$v^2 = \frac{N_{q1} N_{q2} H_i^2}{N_{m1} H_1^2} c^2 \tag{53}$$

and formulas (32), (41), (43), and (46) were taken into account, while the numerical value ξ_q^2 was selected in such a way that the following condition be met

$$\frac{ch}{\alpha_c 2 \pi \xi_q^2} = 1, \text{ or } c\hbar = \alpha_c \xi_q^2 \tag{54}$$

Based on the equation of motion of the proper interaction (7), as applied to the e^- ($N_q = 1$), taking into account formulas (39) and (54), we obtain

$$m_e c^2 = \frac{\xi_q^2}{r_e} \tag{55}$$

where $r_e = H_c \xi_d / 4$, is the classical electron radius.

Comparing the results obtained with the known formulas $m_e c^2 = e^2 / r_e$ and $e^2 = \alpha c \hbar$, one can conclude that $\xi_q = e$ and $\alpha_c = \alpha^{-1}$, that is, the constant α_c obtained by designation (5), is the reciprocal of one of the most important constants of physics, the fine structure constant α [13, 14]. From the equality of the dimension coefficient ξ_q to the elementary charge e it follows that the property of matter –the charge, is caused by the presence of r γ_E-particles in physical bodies, the number of which, emitted during the τ_{oi}-interval, determines the value of the charge

$$q = N_q \xi_q, q_1 = N_{q1} \xi_{q1}, q_2 = N_{q2} \xi_{q2}. \tag{56}$$

Combining the above designations with equality (52), we obtain the energy of the electrostatic Coulomb interaction

$$E_q = M_{i\Sigma} c^2 = \frac{q_1 q_2}{r} = M v^2. \tag{57}$$

According to the above, it is the general interaction energy formula (27), independent of the mass of the participants, that became the basis for the

derivation of the Coulomb formula, respectively, and the energy determined using the Coulomb formula should not depend on the mass of the interaction participants. Thus, to calculate the potential H_i, or derivatives on its basis mm introduced a new property of matter – charge ($m_i c, m_{i0} c, m_{i\Sigma} c, \varepsilon_i, \varepsilon_{i0}, \varepsilon_{i\Sigma}, etc$).

Similarly, in thermodynamics, the formula is used to determine the energy of thermal motion of gas particles $E = 3kT/2$, also independent of the mass of gas particles (it was shown in papers [7,8] that $T \square H_i^2$), further, within the framework of the kinetic theory of gases, the relationship was established $mv^2 = 3kT$.

Thus, historically, information about H_i and its derivatives was obtained by introducing new properties

of matter with characteristic dimensions. In general, the potentials of electric and magnetic fields themselves can serve as the basis for calculating the interaction potentials, like variants, proposed in [8].

Now let us define the order of quantities used in ST to describe the content of concepts and laws of classical mechanics. In [7,8], it was shown that not only constants c (19) and h (28) are combinations of ξ_d, ξ_τ and ξ_m, but also Newton's gravity constant G is a combination of the coefficients of dimensions:

$$G = \frac{\xi_d^3}{2\pi \xi_m \xi_\tau^2} \qquad (58)$$

Combining the world constants c, h and G, we obtain:

$$\xi_d = \left(\frac{2\pi G h}{c^3}\right)^{1/2} \approx 1.015 \cdot 10^{-34} m; \xi_\tau = \left(\frac{2\pi G h}{c^5}\right)^{1/2} \approx 3.38 \cdot 10^{-43} s; \xi_m = \left(\frac{ch}{2\pi G}\right)^{1/2} \approx 2.176 \cdot 10^{-8} kg \qquad (59)$$

It follows from the above formulas that ξ_d and ξ_τ differs numerically from the Planck units of length l_p and time t_p, however, this difference is of significant importance in describing the phenomena of the physical world 15.

Based on the formula for determining the mass e^- (39) and the bonds (4) and (5), we calculate constants H_0 and H_c:

$$H_0 = \frac{2\xi_m}{m_e} \approx 4.777 \cdot 10^{22} \qquad (60)$$

$$H_c = \frac{H_0}{\alpha_c} = 3.46 \cdot 10^{20} \qquad (61)$$

Using the formula (20), we determine the value of the potential H_i at a speed of 2000 km/h:

$$H_i = \frac{v}{c} H_0 \approx 1,667 \cdot 10^{15} \qquad (62)$$

II.   CONCLUSION

The regularities of the movement of physical bodies are considered at the hierarchical level of the manifestation of the mechanism of their movement. In this case, we are not talking about an endless decrease in the size of physical bodies to the level of a material point, but in deepening into the structure of matter to such a smallest organization, called γ_{0i}-particles, the

laws of motion of which determine the laws of motion of physical bodies as a whole. The mechanism of motion of γ_{0i}-particles is composed of two components: transverse, always with a closed curvilinear trajectory with a weaving of a perpendicular surface relative to the direction movement and longitudinal, also with weaving of a perpendicular surface. The final trajectory of the γ_{0i}-particles is formed in the form of a three-dimensional figure, the volume of which is calculated using integrals related by an equation that is formally similar to the Stokes equations. For transverse motion, the volume of the formed trajectory is calculated by circulation along a closed path of a weaving perpendicular surface (axial vector). Using the second integral, the same result is calculated as a mixed product of three vectors. Integration is performed taking into account the interaction class. Depending on the nature of the participants, three types of interaction are classified, when the interactions are involved:

–   own constituent particles;

–   own and constituent particles of its partner;

–   particles, carriers of momentum, and energy of third-party origin - β_ε-pairs.

In the same system, the sequential participation of γ_{0i}- particles in all classes of interaction is allowed. Each type of interaction corresponds to its equation of motion, in which the main constants are H_c and α_0 of structural origin, π, and χ_c- of geometric origin, associated with the transition from real to measurable linear trajectories. These constants are related by the relations: $\alpha_c = \alpha_0/\chi_c$, $H_0 = \alpha_c H_c$.

The main dimensionless variable in the equations of motion is the interaction potential H_i,

which is used to determine the characteristic parameters of both kinematics and dynamics. When some bound γ_{0i}-pair (β_ε-particle) interacts with potential H_i or interaction mass $m_i = \xi_m H_i / \pi H_0^2$ (per one γ_{0i}-particle) with a particle of proper interaction with rest mass $m_0 = \xi_m H_0 / \pi H_0^2$, a complex is formed with mass $m = m_0 + m_i$ and velocity of motion $v = H_i c / (H_0 + H_i)$, where ξ_m and c, respectively, are the coefficients of the dimensions of mass and velocity. Numerically, c is equal to the speed of light in a vacuum, ξ_m is equal to the Planck mass unit. Because the particle of its own interaction ultimately remains at rest, the state of motion of the entire complex is due to the presence of a β_ε-pair, respectively, and the speed and momentum mv of the complex under consideration is caused by and equal to the momentum of the γ_{0i}-particle from the β_ε-pair $m_i c = \xi_p H_i / \pi H_0^2$, $= mv$, where ξ_p is the coefficient of the impulse dimensionality, $\xi_p = \xi_m c$.

The equality $m_i c = mv$ can be considered the basic equation of mechanics, in particular, all formulations of Newton's laws follow from this equality:

– At $m_i = 0$ or $m_i = const$, the body is at rest or in a motion at a constant speed;

– $c\, dm_i / dt = F = d(mv)/dt$ is the definition of force;

– During the collision of physical bodies, a redistribution of β_ε-pairs occur between the participants of the collisions with the preservation of the total momentum: $c\sum_n m_i = const$, or $\sum_n F_n = cd\sum_n m_{in} / dt = 0$, where n is the number of colliding pairs.

Thus, the basis of Newtonian formulations of the laws of motion of physical bodies is the presence, change, and redistribution of β_ε-pairs.

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