On the Nature of Dark Matter and Dark Energy

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Abstract

It is shown that some problems connected with dark matter and dark energy can be solved in the framework of the byuon theory.

1 Introduction

Some hard problems have appeared in astrophysics during the last dozens of years. Observations show that approximately 3 – 4\% of the cosmological energy density is accounted for by baryons, 25 – 27\% by the dark matter and the reminder by the dark energy (see, for example, [1-2]).

There are some evidences for the existence of dark matter (DM) and dark energy (DE).

Here we enumerate basic ones only.

1) In 1937 F.Zwicky measured velocities of galaxies in the Coma cluster and concluded that the total mass of this cluster must be much more than observable one to prevent the escaping of investigated galaxies from the cluster.

2) The summarized mass of the observed gas and galaxies in the number of clusters is not enough to keep them inside of the cluster.

3) The gravitational lensing by clusters of galaxies gives the mass of such lens much more than observable one.

4) The rotation curves of galaxies [3] show that the total mass of the individual galaxy is approximately one order higher than the mass of gas and all stars observed in this galaxy.

5) The observations of supernovae in distant galaxies (see, for example, [4]) show that our Universe expanses with an acceleration, and there is a source causing such type of expansion.
The nature of dark matter and dark energy is unknown up to now.

2 Dark matter

The DM is not observed as shining matter and must have very weak electromagnetic interactions. It must be approximately collisionless and non-relativistic.

The DM is not primarily baryonic. The calculated amount of deuterium should be much smaller than observed one if the average baryon density was an order of magnitude higher than the modern value ($\approx 0.3$ per cubic meter).

The mass interval for the possible candidates in DM is huge (from $10^{-22}$ eV to $10^6 M_\odot \approx 10^{72} eV$).

Let us discuss the most probable candidates in DM.

1) Axions, light pseudo-scalar bosons with mass $\mu eV \lesssim m \lesssim meV$. They could be detected by resonant axion-photon conversion in a magnetic field [7-8].

2) Neutrinos. Some laboratory experiments and cosmological restrictions give the mass interval for all kinds of neutrinos $50meV \lesssim \sum m_\nu \lesssim 0.7eV$, or $0.0005 < \Omega_\nu h^2 < 0.0076$,

where $\Omega_\nu = \rho_\nu/\rho_c$, $h = H_0/100km/sec/Mpc$, $\rho_c = 3H_0^2/(8\pi G)$ is the critical density of the Universe, $H_0$ is the Hubble constant.

Super-symmetric theories put bosons and fermions in common multiplets. They give some possible candidates in DM.

3) The super-partner of the graviton, gravitino with the spin 3/2 [9].

4) Neutralinos. These are the four spin 1/2 Majorana fermion superpartners of the neutral gauge and Higgs bosons ($\chi^0_{1-4}$) [10]. There are also two charged Dirac fermion super-partners of charge gauge and Higgs bosons, charginos ($\chi^{\pm}_{1-2}$).

5) Axinos, a spin 1/2 partner of the axion [11].

6) Non-topological solitons, Q-balls [12].

7) If our four-dimensional space-time is embedded in a higher dimensional space, the Kaluza – Klein excitations of Standard Model states along the orthogonal dimensions may be as DM candidates [13].
8) Objects of many dimensions (branes) are described in string theories. Their fluctuations have been considered as particles (branons) which could be DM candidates [14].

9) DM could be an ordinary matter in the mirror world where the only communication is gravitational. In this case our Universe and a mirror universe are two branes in a higher dimensional space [15].

10) At the last stages of inflation gravitational interactions can produce a lot of weakly interacting massive particles which for mass scales of $10^{13}$ GeV could account for DM [16].

11) Primordial black holes have been considered as candidates in DM as well [17].

So, as observations give, baryons provide approximately 4% of DM, neutrinos $\sim 0.3 - 3\%$ of it. The rest (20 – 25%) is a non-baryonic DM. The nature of this part of DM is unclear. There are many problems with theoretical foundations and experimental evidences of the existence of particles mentioned above and described in cited papers.

### 3 Dark energy

The nature of dark energy is much more unclear than that of DM. It is necessary for it to have the equation of state of the following form (see, for example, [18]):

$$P = w\rho$$ (1)

where $p$ is pressure and $\rho$ is the energy density. The most probable value of the parameter $w$ is approximately $-1$, as follows from the known observations. This implies that the energy density of such substance is constant and corresponds to the flat universe, i.e. the curvature $K$ of the spatial sections (slices at constant cosmic time) is equal to zero. DE causes the acceleration of the expansion of our Universe. Fig.1 shows the sum (solid line) of two potentials: The usual (negative) gravitational potential $\varphi_1$ (broken line) causing the attraction of two bodies and positive constant potential $\varphi_2$ giving the repulsion at large distances ($r > r^*$).

One of the possible sources of DE is quintessence [19], a scalar field $\Phi$ rolling slowly in a potential. Most quintessence models give for such scalar fields

$$m_\Phi c^2 \sim 10^{-33} \, eV$$ (2)
In quantum field theory light scalar fields are hard to understand. In any case these fields give rise to long-range forces which should be observable, and it is surprisingly why such quintessence field has not been detected up to now.

There are many problems with other models of DE (see, for example, [18]).

In this paper we shall try to explain DM and DE in the framework of the byuon theory. First of all we will describe briefly the foundations of this theory.

4 Basic axioms and hypotheses. Space, time, and physical vacuum in the light of the byuon theory

Any theory begins with axioms, that is, with basic postulates accepted without proofs.

Thus, let us assume that there are no space, no time, no world of elementary particles from which all physical bodies consist, but there is a mathematical object, a byuon $\Phi(i)$ [20-25], being unobservable in itself and characterized by discrete states (i.e. numbered by the series of natural numbers) having inherent vectorial property. The expression for $\Phi(i)$ is

$$\Phi(i) = \begin{cases} [A_g x(i)], \\ -\sqrt{-1}[A_g x(i)] \end{cases}$$

where $x(i)$ is length of the byuon, a real (positive or negative) value depending on the index $i = 0, 1, 2, \ldots k, \ldots$ Index $i$ is a quantum number for $\Phi(i)$.

The quantity $A_g$ is some internal potential being equal in magnitude to the cosmological vectorial potential $A_g$, a new fundamental vectorial constant introduced in Refs. [26-27] ($A_g \approx 1.95 \cdot 10^{11} Gs \cdot cm$).

Thus, $\Phi(i)$ can take both real and pure imaginary values.

The whole set $\Phi(i)$ forms a one-dimensional space $R_1$ in index $i$.

According to this conception, by the discrete time is meant, for the byuon, a discrete change in the index $i$ (its increase or decrease). In connection with the discrete time, a quantum of time $\tau_0$ and quantum of space are introduced in the one-dimensional discrete space $R_1$ formed by byuons.

\footnote{It should be explained that the vector $\Phi(i)$ is not an ordinary vector in some space but an object with "inner" vectorial properties that are manifesting themselves when the value $x(i)$ changes in the process of physical space formation.}
\( \tau_0 \approx 0.9 \cdot 10^{-43} \text{ s}, \bar{x}_0 \approx 2.8 \cdot 10^{-33} \text{ cm} \). The distance between byuons is defined therewith as a difference in their lengths \( x(i) \). The space \( R_1 \) is discrete by definition.

Since the space \( R_1 \) is discrete, one of methods of parametrization of \( x(i) \) is \( x(i) = \bar{x}_0 \cdot i \), or \( x(i) = -\bar{x}_0 \cdot i \).

**Statics.** In the set \( \{ \Phi(i) \} \), there are meant no static states with time \( t > \tau_0 \).

**Kinematics.** Depending on whether the length \( X(i) \) positive or negative, decreases or increases in magnitude, free byuons (i.e. not interacting one with another) can be only in one of the four so called vacuum states \((VS) II^+, I^+, I^-, II^- \).

Introduce the following definitions.

1. A free byuon is in the state \( II^+ \) if its positive length discretely, in a quantum of time \( \tau_0 \), increases by \( \bar{x}_0 \) with the speed of propagation (increase in length) \( c = \frac{\bar{x}_0 - 0}{\tau_0} = c_0 \) (\( c_0 \) is the light speed).

2. A free byuon is in the state \( I^+ \) if its positive length discretely, in a quantum of time \( \tau_0 \), decreases by \( \bar{x}_0 \). In this case \( c = \frac{0 - \bar{x}_0}{\tau_0} = -c_0 \).

3. A free byuon is in \( II^- \) if the modulus of its negative length increases by \( \bar{x}_0 \) in time \( \tau_0 \) with \( c = \frac{-\bar{x}_0 - 0}{\tau_0} = -c_0 \).

4. A free byuon is in \( I^- \) if the modulus of its negative length discretely, in time \( \tau_0 \), decreases by \( \bar{x}_0 \). In this case \( c = \frac{0 - (-\bar{x}_0)}{\tau_0} = c_0 \).

From the definition of byuons it is seen that they are in perpetual dynamics of generation and annihilation, extension and contraction. The collection of free (not interacting) byuons in \( VSs II^+, I^+, I^-, II^- \) forms physical vacuum of the one-dimensional space \( R_1 \) of index \( i \) (about properties of \( R_1 \) will be said below). Recall however that in this model of physical vacuum, time is a sequence of events of byuon generation (extension) and "collapse" (contraction). There corresponds to each byuon its own count of time measured by the natural number series. One of the two directions of the one-dimensional space \( R_1 \), coincident with that of a byuon with the maximum \( x(i) \) in \( VS II^+ \), is taken for the positive direction of the vector \( A_g \) and \( \Phi(i) \).

The average magnitudes for byuons being in the above described \( VSs \) at maximum \( i = k \), are determined from the following expressions (see (3),
and [20-22]):

\[
\begin{align*}
[A \cdot X]^{i+I}_{II-} &= A_g \left[ \frac{2i+1}{2} \cdot \frac{\text{const}_{1}}{k \cdot A_G} \right], & X > 0, \\
[A \cdot X]^{k-i}_{II-} &= \sqrt{-1} \cdot A_g \left[ \frac{2(k-i)-1}{2} \cdot \frac{\text{const}_{1}}{k \cdot A_G} \right], & X < 0, \\
[A \cdot X]^{k-i-1}_{I-} &= -A_g \left[ \frac{2(k-i)-1}{2} \cdot \frac{\text{const}_{1}}{k \cdot A_G} \right], & X < 0,
\end{align*}
\]

(4)

where \(\text{const}_{1} = \frac{\sqrt{\hbar c}}{4\sqrt{3}} \cdot \frac{\hbar c}{e_0^2}\) is some constant. As we will see later \(\hbar \) is equal to the Plank constant and \(e_0\) is the electron charge.

Assume that for the byuons with the length greater than \(\tilde{x}_0\), only contact interactions are realized, by which we will mean existence of at least two byuons at a quantum of space \(R_1\).

**Hypothesis 1.** Assume the observable three-dimensional space \(R_3\) to appear as a result of minimization of the potential energy (PE) of byuon interaction in the one-dimensional space \(R_1\) formed by them. We construct PE from the taking into consideration of dimensions. More precisely, the space \(R_3\) is fixed by us as the result of this byuon dynamics. In the space \(R_3\) therewith the dynamic processes for objects with the residual positive potential energy of byuon interactions originate, and in consequence, the wave properties of elementary particles arise.

The proposed hypothesis requires to develop a mathematical model basing on a new algebra of probabilistic events since the elementary events (a discrete decrease (\(\overline{D}\)) or increase (\(D\)) in the length of byuon) are assumed to be probabilistic in character. Hence for the byuons of the minimum length we may say about the existence, with certain probability, of the events (\(\overline{D} \cdot D \neq 0\). Note that in Ref. [9] an algebra of events is given, being a development of the Boolean algebra with the proviso that \(\overline{D} \cdot D = 1\). For the deterministic approach used in [28], the event \(\overline{D} \cdot D \neq 0\) is illogical by von Neumann, but in the probabilistic space of events the existence of \(\overline{D} \cdot D \neq 0\) is possible.

In this paper only the physical statement of the problem will be considered, and results of evaluations made in support of the hypothesis advanced, will be given.

The space \(R_1\) is formed from the set of byuons in such a manner that at its \(i\)-th point there exist all the byuons with the lengths smaller than \(X(i)\) or equal to \(X(i)\) for \(X(i) > 0\), and those with the absolute values smaller than \(X(k - i)\) for \(X(k - i) < 0\), where \(k\) is some period in \(i\).

The assumption that two neighboring byuons (the \(i\)-th and \((i + 1)\)-th; \((i + 1)\)th and \((i + 2)\)th etc.) being in vacuum states \(II^+\) will interact, is
unreasonable since in this case the definition of byuons for this \( VS \) would be violated at the point of interaction. Such interaction is possible only between the \( i \)-th and \((i-k)\)-th byuons in the state \( II^+ \) if they form a "loop" in the space \( R_1 \) (by the "loop", the periodicity of the process in \( i \) is implied), i.e. the two byuons \( II_i^+ \) and \( II_{i-k}^+ \) will be observed simultaneously at one point of the space \( R_1 \). The least possible value of \( k \) is \( k = 3 \). In Fig.2 shown is the interaction of byuons in the vacuum states \( II_i^+ \) and \( II_i^- \) (the smallest loop). The byuons in the state \( II^- \) interact likely.

The byuon states \( I^+ \) and \( I^- \) can occur only if the byuons have already been in \( VS II^+ \) and \( II^- \), respectively. The vacuum states \( I^+ \) and \( I^- \) as if "occupy" \( VSs II^+ \) and \( II^- \). At maximum positive potential energy of byuon interaction there exists a single variant of "occupancy" (Fig.3).

The probability of the minimum four-contact interaction of the neighboring in \( i \) byuons \( I^+II^+ \times I^-II^- \) ("\times" symbolizes interaction) with randomly appearing states \( I^+ \) and \( I^- \), is equal to \( 1/16 \) [20-22]. That is quite understandable when analyzing possible four-contact interactions (see Fig.4).

All other possible variants of the four-contact interaction are unobservable either because one cannot introduce them without violating the definition of byuons or in view of imaginary energy of such interaction.

Note once more that there exist only two directions in the one-dimensional world, the first of which corresponds to increasing \( i \) index for byuons with \( X > 0 \) (vacuum state \( II^+ \)), and the second corresponds to decrease in \( i \) for such byuons (vacuum state \( I^+ \)). These directions are coincident with those for byuons with \( X < 0 \): \( II^- \) with \( I^+ \), and \( I^- \) with \( II^+ \). It is clear from above definitions that the byuon with the maximum length \( X(i) \) in \( VS II^+ \) determines the positive direction, and directions of other byuons are correspondent with it.

The four-contact interaction of byuons is realized within a time \( \tau = \bar{\tau}_0 \) only at points \( D \) of the \( R_1 \)-space (Fig.3), i.e. at the points where introducing an interaction with \( PE > 0 \) is possible. In Fig.3 the arrows corresponding to byuons show directions of decrease or increase in their lengths relative to the origin of the coordinates introduced, for example, where \( i \to 0 \) (in its direction the absolute value of the byuon length is decreased (states \( I^+ \) and \( I^- \)), and it increases in the opposite directions (states \( II^+ \) and \( II^- \))). At the points \( A \) in Fig.3, the coordinate denoting place (time) of byuon interaction cannot be fixed because of violating, in such a case, the definitions of the byuon states (in one quantum of the \( R_1 \)-space within a time \( \tau_0 \), the byuons with \( II^+I^+I^-II^- \) should not be present). It is assumed that before the origin of \( VS II^+ \) with the minimum length \( (i = 1) \), the byuon vacuum states \( II^- \) and \( I^- \) with any possible lengths are already in existence.
Propagation of byuons in VSs $II^+ I^+$ and $I^- II^-$, the interaction between which occurs with imaginary energy (see below), presents two wave-like processes (see below) directed towards each other at $X(i) > 0$ and $X(i) < 0$, respectively. These processes are unobservable. A really observable signal can be transmitted by means of such processes only in the four-contact byuon interaction $II^+ I^+ \times I^- II^-$. 

Obtain an equation characterizing propagation of the four-contact interaction of byuons in $R_1$. Introduce functions of index $i$, characterizing the origin of such or another VS by byuons: $\Psi_{II^+}^{i+2}, \Psi_{II^-}^{k-i}$, determining the processes of byuon length magnitude origin and increase at positive and negative $X(i)$, respectively; $\Psi_{I^+}^i, \Psi_{I^-}^{k-i-2}$, determining the processes of byuon length magnitude cancellation and decrease at positive and negative $X(i)$, respectively.

The physical sense of the introduced functions consists in that their product determines the probability of two-contact interaction of byuons (for example, $\Psi_{II^+}^{i+2} \cdot \Psi_{II^+}^{i+2-k}$ determines the probability of interaction of byuons $[A \cdot X_{II^+}^{i+2}$ and $[A \cdot X_{II^+}^{i+2-k}]$, the product of four functions determines the probability of four-contact interaction, the product of eight functions gives the probability of eight-contact interaction. These products should be positive, and in this case only they can describe an observed event.

The probability of a single event is no greater than 1.

Depending on which range is $i$ in $(0 \leq i < k, k < i < Nk, Nk < i < NkP$ where $k, N, P$ are the assumed periods in $i$) various types of contact interactions between byuons may be introduced, and hence the normalization of the introduced functions should be dependent on $i$.

Let us normalize the introduced functions for the case $0 \leq i < k$ in the following manner

\[ \sum_{\xi=0}^{(NkP-k)/2} \sum_{j=1}^{j+2} \Psi_{II^+}^j \cdot \Psi_{II^-}^{NkP-j-2-2\xi} \cdot \Psi_{I^+}^{NkP-j-2-2\xi} = \frac{NP}{2}, \quad (5a) \]

\[ \sum_{\xi=1}^{NP-1} \sum_{j=0}^{j+2} \Psi_{II^-}^{NkP-j} \cdot \Psi_{II^-}^{NkP-j-2-\xi k} = P, \quad (5b) \]

\[ \sum_{\xi=0}^{(NkP-k)/2} \sum_{j=1}^{j+2} \Psi_{II^+}^j \cdot \Psi_{I^-}^{NkP-j-2-2\xi} = \frac{NP}{2}, \quad (5c) \]
When normalizing, it was taken into account that within a period in $i = k$, one four-contact interaction occurs with probability 1.

Obtain an equation in terms of $\Psi$-functions, describing the propagation of four-contact interaction of byuons. For that we may write the following relationships as to the origin of $VSs II^+(f_{I^+}), I^+(f_{I^+}), II^-(f_{I^-}), I^- (f_{I^-})$ depending on certain $VSs$ of the byuons neighbouring in the index $i$:

\[
\begin{align*}
\Psi_{I^+}^{i+2} &= f_{I^+}[\Psi_{I^+}^{i+1}, \Psi_{I^+}^{i+2}, \Psi_{NkP}^{NkP-i}, \Psi_{I^+}^{NkP-i-2}], \\
\Psi_{I^+}^i &= f_{I^+}[\Psi_{I^+}^{i+1}, \Psi_{I^+}^i, \Psi_{NkP}^{NkP-i}, \Psi_{I^+}^{NkP-i-2}], \\
\Psi_{NkP}^{NkP-i} &= f_{I^+}[\Psi_{NkP}^{NkP-i-1}, \Psi_{NkP}^{NkP-i-2}, \Psi_{I^+}^{i+2}, \Psi_{I^+}^i], \\
\Psi_{I^-}^{NkP-i-2} &= f_{I^-}[\Psi_{I^-}^{NkP-i-1}, \Psi_{I^-}^{NkP-i-2}, \Psi_{I^+}^{i+2}, \Psi_{I^+}^i].
\end{align*}
\]

Assuming only linear dependences in expressions (6) as well as equiprobability of $VSs$ of byuons neighbouring in $i$, we obtain the following equations for $\Psi$-functions of four-contact interactions of byuons:

\[
\begin{align*}
\Psi_{I^+}^{i+2} &= \Psi_{I^+}^{i+1} - \Psi_{I^+}^i - \Psi_{NkP}^{NkP-i} + \Psi_{I^+}^{NkP-i-2}, \\
\Psi_{I^+}^i &= \Psi_{I^+}^{i+1} - \Psi_{I^+}^i + \Psi_{NkP}^{NkP-i} - \Psi_{I^+}^{NkP-i-2}, \\
\Psi_{NkP}^{NkP-i} &= \Psi_{NkP}^{NkP-i-1} - \Psi_{NkP}^{NkP-i-2} - \Psi_{I^+}^{i+2} + \Psi_{I^+}^i, \\
\Psi_{I^-}^{NkP-i-2} &= \Psi_{I^-}^{NkP-i-1} - \Psi_{I^-}^{NkP-i-2} + \Psi_{I^+}^{i+2} - \Psi_{I^+}^i.
\end{align*}
\]

From the first and second pairs of Eqs.(7) it is easy to obtain, respectively, the following equations:

\[
\Delta[\Psi_{I^+}^{i+1} + \Psi_{I^+}^i] + \Psi_{I^+}^{i+1} + \Psi_{I^+}^i = 0, \\
\Delta[\Psi_{I^-}^{NkP-i-1} + \Psi_{I^-}^{NkP-i-1}] + \Psi_{I^-}^{NkP-i-1} + \Psi_{I^-}^{NkP-i-1} = 0,
\]

where $\Delta$ denote the second finite differences in index $i$.

It is seen from Eqs.(8) and (9) that the process in $i$ is of oscillatory character for the functions ($\Psi_{I^+}^{i+1} + \Psi_{I^+}^i$) and ($\Psi_{I^-}^{NkP-i-1} + \Psi_{I^-}^{NkP-i-1}$). These functions determine the A-type points in the space of index $i$ shown in Fig.3, i.e. the points at which we cannot introduce interaction of byuons. The A-type points in the space $R_1$ determine as if "ruptures" in $i$, between which there exist objects with energy $E > 0$.

For the case $i \leq k$, write an equation for an increment in potential energy of byuon interaction $\Delta E(i)$, corresponding to the occurrence of $VSs II_{I^+}^{i+2}$ and $I_+^i$. Minimization of $E(i)$ is assumed to be going at each step in $i$. 

9
\[ \Delta E(i) = \psi_{NkP-i-k} \psi_{NkP-i} E_{I+I-}^{NkP-i-k,NkP-i} \cos_{I+I-} + \]
\[ + \psi_{NkP-i-2k} \psi_{NkP-i} E_{I+I-}^{NkP-i-2k,NkP-i} \cos_{I+I-} + \]
\[ + \psi_{NkP-i-3k} \psi_{NkP-i} E_{I+I-}^{NkP-i-3k,NkP-i} \cos_{I+I-} + \ldots \]
\[ + \psi_{I+I-}^{NkP-i-2} \psi_{I+I-}^{NkP-i-2} \cos_{I+I-} + \]
\[ + \psi_{I+I-}^{NkP-i-3} \psi_{I+I-}^{NkP-i-3} \cos_{I+I-} + \ldots \]
\[ + \psi_{I+I+}^{NkP-i-2} \psi_{I+I-}^{NkP-i-2} \cos_{I+I-} + \]
\[ + \psi_{I+I+}^{NkP-i-3} \psi_{I+I-}^{NkP-i-3} \cos_{I+I-} + \ldots \]
\[ + \psi_{I+I+}^{NkP-i-2} \psi_{I+I-}^{NkP-i-2} \times \]
\[ \times \sqrt{E_{I+I-}^{I+I-} \cos_{I+I-} + E_{I+I-}^{I+I-} \cos_{I+I-} + \}
\[ + \psi_{I+I-}^{NkP-i-2} \times \]
\[ \times \sqrt{E_{I+I+}^{I+I+} \cos_{I+I-} + E_{I+I-}^{I+I-} \cos_{I+I-} + \}
\[ + \psi_{I+I+}^{NkP-i-2} \times \]
\[ \times \sqrt{E_{I+I+}^{I+I+} \cos_{I+I-} + E_{I+I-}^{I+I-} \cos_{I+I-} + \}
\[ + \psi_{I+I+}^{NkP-i-2} \times \]
\[ \times \sqrt{E_{I+I+}^{I+I+} \cos_{I+I-} + E_{I+I-}^{I+I-} \cos_{I+I-} + \ldots \}
\[ (10) \]

where \(E_{I+I-}^{NkP-i-k,NkP-i} \ldots \), are maximum values of potential energy of interaction of byuons with the lengths \(X(NkP-i-k) < 0\) and \(X(NkP-i) < 0\) in \(VS I^-\), as well as byuons with the lengths \(X(i)\) and \(X(i+2)\) in \(VS I^+\) and \(I^+\), respectively \(\cos_{I+I+}, \cos_{I-I-}\) etc. are functions minimizing the potential energy of interaction of byuons entering into the expressions for \(E_{I+I+}^{NkP-i-2}, E_{I+I-}^{NkP-i-2}\) etc. These functions are "responsible" for the appearance of a minimum plane object and introduction of the concept of spin (see below).

The difference in the average values of byuron lengths calculated basing upon the definition of byuons with the use of the rule of circular arrow (see Fig.5), is taken as a distance between the interacting byuons to find \(\Delta E(i) > 0\). The meaning of this rule is that the said distance is calculated as the difference in the length values of the subsequent and preceding byuons in the direction pointed by an arrow.
The lengths of byuons are:

\[
X^i_{I^1p} = \frac{2i+1}{2} \cdot \frac{\text{const}_1}{k_A G}, \quad X^k_{I^1-} = \frac{-2(k-i)-1}{2} \cdot \frac{\text{const}_1}{k_A G}, \quad \text{etc.}
\]

The distance between byuons does not depend on \(i\) and may take by magnitude only two values:

\[
X^{k-i,i}_{I^1-} = \frac{\text{const}_1}{A_G}, \quad X^{k+i+1-1}_{I^1-} = -\frac{\text{const}_1}{A_G};
\]

\[
X^{i,i+2}_{I^1-} = \frac{\text{const}_1}{k_A G}, \quad X^{k-i-2,k-i}_{I^1-} = -\frac{\text{const}_1}{k_A G},
\]
or multiples of them, for example,

\[
X^{Nk-i,i}_{I^1-} = \frac{\text{const}_1N}{A_G}.
\]

The expressions determining the maximum energy of byuon interaction are written as

\[
E^{k-i,i}_{I^1-} = \frac{[A_2]^{k-i}[A_2]_{i+1}}{X^{k-i,i}_{I^1-}} = \frac{\text{const}_1}{4k^2} A_G[2(k-i)-1](2i+1);
\]

\[
E^{i+1,k-i-1}_{I^1-} = \frac{[A_2]^{i+1}[A_2]_{k-i-2}}{X^{i+1,k-i-1}_{I^1-}} = \frac{\text{const}_1}{4k^2} A_G[2(k-i)-1](2i+1);
\]

\[
E^{i,i+2}_{I^1+} = \frac{\text{const}_1}{4k^2} A_G[2(k-i)-1](2i+3)(2i+1);
\]

\[
E^{k-i-2,k-i}_{I^1+} = \frac{\text{const}_1}{4k^2} A_G[2(k-i)-1][2(k-i)-3];
\]

\[
E^{NkP-i,k,NkP-i}_{I^1-1} = \frac{\text{const}_1}{4k^2} A_G[2(NkP-i-k)-1][2(NkP-i)-1]. \quad (11)
\]

The minimization of \(\Delta E(i)\) is achieved in the functional space of the following variables:

\[
\Psi^0_{I^1+}, \Psi^2_{I^1+}, \Psi^{NkP}_{I^1-}, \Psi^{NkP-2}_{I^1-}, \cos^{i+2}_{I^1+1}, \cos^{NkP-k-i}_{I^1-1}, k, N P. \quad (12)
\]

It is assumed therewith that the conditions of symmetry during the "closure of the loop" in \(i\) are fulfilled as well as symmetry of the world and antiworld, which conditions can be represented as:

\[
\cos^{i+2}_{I^1+1} = \cos^{NkP-i-2,NkP-i}_{NkP-i-2,nkP-i-2} = \cos^{NkP-i-2,NkP-i-2}_{I^1-1} = \cos^{NkP-i-2,NkP-i-2}_{I^1-2};
\]

\[
\cos^{NkP-i-2,k,NkP-i}_{NkP-i-2,k,NkP-i-2} = \cos^{NkP-i-2,k,NkP-i}_{I^1-2} = \cos^{NkP-i-2,k,NkP-i}_{I^1-2} = \ldots = \cos^{NkP-i-2,k,NkP-i}_{I^1-1} = \ldots
\]

The functions \(\cos_{I^1+1}, \cos_{I^1+1}\) are considered as equal to 1.
Initial conditions for \( \Psi \)-function are preset to be

\[
\begin{align*}
\Psi_{II^+}^0 &\approx 0, \quad \Psi_{I^+}^0 \approx 1, \quad \Psi_{NkP}^N \approx 1, \quad \Psi_{I^+}^N \approx 0, \quad \Psi_{I^-}^{NkP-2} = 0, \quad \Psi_{I^+}^{I^-+2} + \Psi_{I^-}^{I^-+1} = 0. \\
\end{align*}
\]

Using the solutions of the equations (8) and (9): \( \Psi_{I^+}^{i+1} + \Psi_{I^-}^{i+1} = A \cos \left( \frac{2\pi i}{N} \right) + B \sin \left( \frac{2\pi i}{N} \right) \) we contract the space of variables down to four: \( \cos \left( \frac{2\pi i}{N} \right), \cos \left( \frac{2\pi j}{N} \right), k, NP \).

Now, taking into account the normalizing expressions (5), seek for \( \min \Delta E(i) \) by the steepest descent method. When retaining only 14 terms of the series in (10) and (5a), \( \min \Delta E(i) \) will correspond to the following values:

\[
\begin{align*}
\Psi_{I^+}^{0} &= 0.999(6), \\
\Psi_{I^+}^{2} &= 1.00136 \times 10^{-4}, \\
\Psi_{I^+}^{NkP-2} &= 1.01043 \times 10^{-4}, \\
\Psi_{I^+}^{NkP-i+k} &= 1.20013 \times 10^{-5}, \\
\Psi_{I^+}^{NkP-i} &= 1.01887 \times 10^{-5}, \\
\Psi_{I^+}^{NkP} &= 3 \times 10^{60} \\
\end{align*}
\]

With increasing \( n \), as is seen from the solutions given and Fig. 6, \( k \) (the first period in \( i \)) approaches its value obtained in Refs. [25-26] on the base of physical considerations as an integer part of the ratio \( x_0/\bar{x}_0 = 3.2 \times 10^{15} \). Thus, we can now obtain, with the aid of the calculated \( k \), one of the fundamental dimensions in physics of elementary particles, \( x_0 \approx 10^{-17} cm \), with the only quantum of space \( \bar{x}_0 \) given. This mathematical result raises prospects that the advanced hypothesis is true. It reflects the nature of physical space and vacuum.

The minimum \( \Delta_1 E(i) \) was sought for a case when \( Nk < i \leq NkP \). In this case the normalizing expressions for the arising interactions of byuons have the form:

\[
\sum_{j=1}^{Nk} \sum_{\xi=0}^{NkP-2} \Psi_{j+1}^j + \Psi_{I^+}^{j+2} \Psi_{I^-}^{NkP-j-2} \Psi_{I^+}^{NkP-j-2} = iNP \frac{2k}{2k};
\]

\[
\sum_{\xi=1}^{NkP-1} \sum_{j=1}^{Nk} \Psi_{I^+}^{j-1} \Psi_{I^-}^{NkP-j-1} = iNP \frac{2k}{2k};
\]

\[
\sum_{\xi=0}^{NkP-2} \sum_{j=Nk}^{NkP-2} \Psi_{I^+}^{j+2} \Psi_{I^-}^{NkP-j-2} \Psi_{I^+}^{NkP-j-2} = iNP \frac{2k}{2k};
\]

The expression for \( \Delta_1 E(i) \) becomes more complicated:
It is interesting that at $i < k$ and even at $i \approx Nk$ (Table 1), a significant part in the magnitude of $\Delta E(i)$ is potential energy of the byyon interaction in $VS\Pi+\Pi-\Pi^-$, and at $i \rightarrow NkP$ the four-contact interaction of byyons in $VS\Pi+\Pi^+\Pi^-\Pi^-$ becomes determining.

Let us consider a simplified case when only the period in $i$, equal to $k$, is present in the antiworl. Then we have from the necessary condition of minimum $\Delta E(i)$ with respect to the function $\Psi_{II+}^{i+2}$ (i.e. from the equation $\frac{\partial \Delta E(i)}{\partial \Psi_{II+}^{i+2}} = 0$) we have

$$\cos_{II+} = - \frac{1}{\Psi_{II+}^{i+2} \Psi_{II+}^{k-i+2}} \cdot \frac{1}{k} \cdot \sqrt{[(k-i)-(2i+1)][(2i+3)(2k-i)+3]}.$$  

\[ (\Delta E(i) \text{ is taken from Eq.10), taking into account for multiplication over index } i \text{ as was shown above } (i + 2, i + 2 - k, i + 2 - 2k \text{ etc.).} \]

The search for $\min \Delta E(i)$ with the use of the chain of equations (7) in the space of similar variables with similar initial conditions (where $i = 0$ corresponds now to $i = Nk$), leads to practically the same results:

$$\Psi_{II+}^{Nk} = 0.9998, \Psi_{II+}^{Nk+2} = 1.006 \times 10^{-4}, \Psi_{II+}^{NkP} = 0.9999$$

$$\Psi_{II+}^{NkP^{-2}} = 1.101 \times 10^{-4}, \cos_{II+}^{i+2} = \cos_{II+}^{k-i+2} = 1.1019 \times 10^{-5}, \cos_{II+}^{NkP^{-i}} = 1.1203 \times 10^{-5}, k = 4.475 \times 10^{15}, NkP = 3.169 \times 10^{60}$$

It is interesting that at $i < k$ and even at $i \approx Nk$ (Table 1), a significant part in the magnitude of $\Delta E(i)$ is potential energy of the byyon interaction in $VS\Pi+\Pi-\Pi^-$, and at $i \rightarrow NkP$ the four-contact interaction of byyons in $VS\Pi+\Pi^+\Pi^-\Pi^-$ becomes determining.

| $E_{II+II^+}$ | 10$^{13}$ | 10$^{95}$ |
| $E_{II+I+II^-}$ | 10$^{10}$ | 10$^{11}$ |
| $E_{II-I-}$ | 10$^{45}$ | 10$^{13}$ |

\[ \text{Table 1:} \]
If \( i \ll k \), \( N = P = 1 \), and hence, according to Eq. (5) \( \sum_{j=0}^{k} \Psi_{I+}^{j} \cdot \Psi_{II-}^{k-j} \to 1 \), we obtain from Eq. (17) \( \cos_{II+I+} \approx 1/k \).

Thus, as show our numerical calculations and analytical estimations, the minimization of \( \Delta E(i) \) leads to values of functions \( \cos_{II+I+} \) etc. if not zero but extremely small.

Note that the functions \( \cos_{II+I+} \) for the case of \( NP \) "loops" in \( VSII^- \) and for the case when \( N = P = 1 \), differ by ten orders of magnitude. The physical meaning of these functions will be shown further.

Put a question, where disappears and into which transforms the potential energy of byuon interaction? An answer seems to be simple, of course, into the kinetic energy of rotation (since \( \cos_{II+I+} \ll 1 \), see (15), (17)). But the rotation of what and about what? And why do we assume the law of conservation of energy to be fulfilled here? After all, it makes no sense to say about uniformity in time for this statement in which the time is discrete!

Let us answer these questions.

As it was shown above, the optimum values of the functions \( \cos_{II+I+}^{i+2,i} \), \( \cos_{II-I-}^{NkP-I,NkP-i-2} \), etc., are much less than 1 but non-zero. The smallest values of \( \cos_{II+I+} \approx 1/k \) correspond to residual (finite) potential energies \( E_k \), from which, as we will further assume, the smallest part (associated with the formation of the own space of elementary particles) of the potential self-energy of elementary particles corresponding to the known Einstein’s relationship \( E_k = mc^2 \), is added together. Determine the minimum value of \( E_k \). It is seen from Eq. (10) that for the simplest objects with \( N \) and \( P \) approximately equal to 1, the minimum \( E_k \) is equal to the potential energy of the four-contact interaction of byuons with the minimum values \( \cos_{II+I+}, \cos_{II-I-} \).

In view of the normalization (5) we have for this case

\[
E_{k_{min}}^{(0)} = \sqrt{E_{I+II+}^{0,2} \cos_{I+II+} \cdot \cos_{I-I-}^{k-2,k} \cos_{I-I-}^{k-2,k}}.
\] (18)

From here, with the condition (13), and using Eqs. (11) and the equality \( \cos_{II+I+} \approx 1/k \), we obtain \( E_{k_{min}}^{(0)} \approx 33 \text{ eV} \).

Consider the process of energy transformation for the four-contact byuon interaction occurring within a time quantum \( \tau_0 \). Hence, the transformation must be discrete.

Any value of \( i \) can be re-denoted with another index, for example, with \( j, \gamma, \xi \), etc., which may be set equal to zero. At each point then, where \( j = \gamma = \xi = \ldots = 0 \), there will be always present an own system of account of the indices \( j, \gamma, \xi \), etc., as well as the minimum energy of four-contact
byuon interaction $E_{k_{\text{min}}^{(0)}} \approx 33\,\text{eV}$. Note that this minimum energy is limited in index $i$ by values $i = 0$ and $i = 2$ (point A in Fig.3).

Thus, we have in $R_1$ two sets of points $A(\{A\})$ and $D(\{D\})$, between which the dynamic process of renumeraton goes in connection with the properties of vacuum states of the discrete objects, the byuons $II^+, I^+, I^-, II^-$:

\[
\begin{align*}
\text{the time } & \tau_{i+1}^D \\
\{D\} &= i + 1, i - 1, \ldots \\
\{A\} &= i + 2, i, \ldots
\end{align*}
\]

\[
\begin{align*}
\text{the time } & \tau_{i+1}^D + \tau_0 \\
\{D\} &= i + 2, i, \ldots \\
\{A\} &= i + 3, i + 1, \ldots
\end{align*}
\]

The set $R_1$ may be represented, at some $i$-th point of time as the join of $\{A\}$ and $\{D\}$, i.e. $R_1 = \{A\}U\{D\}$ (Fig.7).

Hence the space $R_1$ segregates into the subspaces $R_D$ of $D$-points and $R_A$ of $A$-points. Thus, we may say about the motion of $D$-points relative to $A$-points. A new, second coordinate is appeared, symbolize it by $Y_{AD}$ (Fig.7). The minimum value of $Y_{AD}$ is $Y_{AD}^{\text{min}} = C_0 \tau_0 |(i + 1)A - iD| = \tilde{X}_0$. The minimum plane object appears. Assume that its appearance (new coordinate) corresponds to the minimum action $h$ (see [20-22], $h = ([A_g x_0]_{II^+} [A_g x_0]_{I^-})/c_0 x_0 /ct^* \approx 33\,\text{eV}$ and elementary electric charge $e_0^2 = 1/(4\sqrt{3}) A_g x_0^2(x_0) /ct^*)^3/2$. We may then introduce the concept of momentum for objects with the residual PE of byuon interaction by writing the relationship $P_{i+1}^D \times Y_{i,i+1}^{AD} = h$ where $P_{i+1}^D$ is the momentum of the point $D$ numbered $i + 1$ relative to the point $A$ with the number $i$. Similar relationship can be written in any point from $\{A\}$. The direction of the momentum vector $P_{i+1}^D$ corresponds to that towards the point $D^{i+3}$ of the subspace $R_D$. The direction of the coordinate corresponds to the vector directed from the point $A^i$ to the point $D^{i+1}$.

The appearance of the minimum plane object and realization of the minimum action are connected with the origin of the quantum spin number $\hat{S} = [\hat{P}_{i+1}^D \times \hat{Y}_{i,i+1}^{AD}]$ expressed numerically in minimum actions $h$.

The functions $\cos_{II^+I^+}$ etc. minimizing $\Delta E(i)$, will be further considered by us as cosines of the angles between the vector $P_{i+1}^D$ and $Y_{i,i+1}^{AD}$. I.e. before the byuon interaction, the space $R_1$ represents, at some time point $\tau$, a certain discrete straight line of points $\{D\}$ and $\{A\}$, and at the time point $\tau + \tau_0$ forms a line, broken at points $\{D\}$. That is the minimum interaction of byuons has occurred.

If an "observer" was able to perceive objects with $E > 0$ only every $\tau = k\tau_0$, he would simultaneously (within a time quantum $\tau_0$) fix all the planes arrived to the point of "observation", and "see" already the
three-dimensional world formed from the plane world in the result of its dynamics within the time $\tau = \tau_0$. Why the three-dimensional and not N-dimensional one? Because the set of two-contact interactions of byuons is divided, depending on reference point (Fig.2, $i = 0, 1, 2$), into three sub-
sets $M_0, M_1, M_2$ (the lower index denotes reference point), corresponded by three one-dimensional subspaces $R_{1,0}, R_{1,1}, R_{1,2}$ while introducing metric properties. Explain the above said.

As was indicated above, any value of index $i$ can be always redonoted by $j$ and then $j = 0, 1, 2$ corresponds to reference points. Redenoting $i + 1$ by $\xi$, $i + 2$ by $\gamma$ etc. leads, depending on reference points, to formation of three families of subspaces embedded in each other:

- reference point 0 $\Rightarrow R_{1,0}^i \supset R_{1,0}^j \supset R_{1,0}^\xi \supset R_{1,0}^\gamma$ etc.;
- reference point 1 $\Rightarrow R_{1,1}^i \supset R_{1,1}^j \supset R_{1,1}^\xi \supset R_{1,1}^\gamma$ etc.;
- reference point 2 $\Rightarrow R_{1,2}^i \supset R_{1,2}^j \supset R_{1,2}^\xi \supset R_{1,2}^\gamma$ etc., if $i > j > \xi > \gamma$ etc.

Thus, in connection with the existence of three independent reference points for the new pair interactions, the three independent coordinates should be given to fix a pair interaction with respect of the three reference points, i.e. $R_3$ can be represented as $R_3 = R_{1,0} \times R_{1,1} \times R_{1,2}$. Note that $R_{1,0}, R_{1,1}, R_{1,2}$ consist of the sets of points $\{A\}$ and $\{D\}$, i.e. at each subsequent point in time, renumeration of points $A$ and $D$ and "spinning" of objects with $E > 0$ in the subspaces $R_{1,0}, R_{1,1}, R_{1,2}$, occur. In this manner the concept of spin is introduced for objects with $E > 0$ in $R_3$. For objects of great size (as a result of described minimization of PE), the rotation will be always take place since the byuons are not closed in a volume of $R_3$ due to $\cos \gamma I + \gamma I \neq 0$. That is why, planets, stars and so on rotate, with the main part of potential energy of byuons being transformed into energy of rotation. The latter is because the functions $\cos \gamma I + \gamma I, \cos \gamma I + \gamma I$ etc. are very small.

Advance (without proving) the following theorem:

**If a system is closed, the amount of information in it is constant.**

That is, transformation of one information image into another is possible in the system, but the total amount of information does remain invariable.

Note that by information we mean here not informativity as in theory of information developed by Hartly and Shannon [29] on the basis of entropic approach, but the numbers of information bits (the values "0" and "1") in one or another information subsystems of the system of considered objects (the combinatoric approach [30]). By "1" we imply here accomplishing the minimal act (minimum action $\hbar/2$) in the system with formation of an object.
with \( E > 0 \) from byuons, and by "0" disappearing of the object with \( E > 0 \) is meant.

On the base of the theorem, write the following equality for informational units (bits) in the subspaces \( R_1 \) and \( R_3 \):

\[
2 \frac{\tau_0 E_1 S_1 k^2}{h} = 2^{S_3 N} \tag{19}
\]

where \( N \) is the number of information images in \( R_3 \) \((N = ct^*/x_0 - \) the second period in \( i \)); \( S_3 \) the complexity of the information image in \( R_3 \) (number of "loops" of length \( N \); \( S_3 = 1, 2, \ldots \)); \( E_1 \) potential energy of minimum four-contact interaction of byuons in \( R_1 \) if \( \cos I^+_I = \cos I^-_I = 1 \); \( \frac{\tau_0 E_1 S_1 k^2}{h} \) is a transformation factor of recounting the number of information images \((k)\) in \( R_1 \) into that in \( R_3 \) for \( i \geq kN \); \( S_1 \) is complexity of the information image in \( R_1 \) (number of "loops" of length \( k \), \( S_1 = 1, 2, \ldots \)).

By an information image in \( R_3 \), one means one or another quantum number of an elementary particle.

With Eq.(19), the expressions for lepton masses obtained in [20-22]( see Appendix 1) become more understandable (for example, \( m_e c^2 = E_0^0 \cdot N = 33 eV \cdot ct^*/x_0 = 2m_{\nu_e} c^2 \cdot ct^*/x_0 \)).

Taking \( k \) from the solution of the problem of searching minimum \( \Delta E \) and substituting \( S_3 = 1, S_1 = 1 \) into Eq.(19), we find \( N = 1.544 \times 10^4 = ct^*/x_0 \), and knowing \( N \) and \( NP \) from this same solution, determine \( P \approx 10^{42} \), and \( \tilde{x}_0 kN \approx 10^{-13} cm \).

Thus, we find all the periods of byon motion in \( i \), corresponding to the following scales of our World: \( 10^{-17} cm \) is a characteristic scale of weak interactions (for larger lengths our World is three-dimensional and almost orthogonal, for an empty space with the \( 10^{-15} \) precision); \( 10^{-13} cm \) is a characteristic size of proton and atomic nuclei), \( 10^{28} cm \) is the radius of our Meta-galaxy or the observable part of our Universe.

(See: Appendix 1 – The expressions for masses of ultimate particles; Appendix 2 - A qualitative distinction between the theory of byuons and previous physical theories. Appendix 3 - Force-free physics. A qualitative pattern of a common approach to unifying all interactions. A novel principle of relativity.)

It should be also noted that to calculate the fundamental constants \( h, e_0, c \); constants of known interactions, masses of main baryons, leptons, and mesons, only three numbers \( \tilde{x}_0, \tau_0, |A_g| \) should be given since the characteristic dimensions \( \tilde{x}_0 \approx 10^{-17} cm, ct^* \approx 10^{-13} cm \) and \( 10^{28} cm \) are found from the minimum PE of byuons and from the information theorem.
5 Dark Matter and Dark Energy in the byuon theory

Determine the average density of substance in the Universe while taking $i = NkP$ and, hence, its characteristic dimension $\tilde{x}_0NkP \approx 10^{28} \text{cm}$ (it coincides with the assumed radius of the Universe). The total energy in the Universe can be represented as $\frac{\hbar}{\tilde{x}_0}NkP$. Its value is $5.4 \times 10^{77} \text{erg}$, and the corresponding equivalent mass $\approx 6 \times 10^{56} \text{g}$. The uniformity of distribution of substance over the sphere with the radius $\tilde{x}_0NkP$ gives the density of substance in the Universe $\approx 10^{-29} \text{g} \cdot \text{cm}^{-3}$, which is measured in the known observations.

Through the set $\{A\}$, information exchange occurs between points of the set $\{D\}$, which is the main mechanism determining physical essence of Heisenberg uncertainty interval in the conception of physical space and physical vacuum. Without introducing the points $\{A\}$, the connection between $D$-points is realized in one direction only, in that of increasing index $i$ with the speed no greater than $c_0$.

According to the developed conception of physical vacuum structure, we can determine momentum and a coordinate of such a complex object as an elementary particle only with an accuracy of the momentum and coordinate entering into the relationship $P_D^{i+1}Y_{AD}^{i+1} = \hbar$ governing the momentum of $D$-points mapped into $R_3$ according to (19). That is, writing the uncertainty relation in $R_3$ for some elementary object $\gamma$ as $\Delta P \cdot \Delta X \leq \hbar/2$, we mean $\Delta P$ and $\Delta X$ to be caused by the process of $R_3$ formation from byuons, i.e. determined by quantities of $P_D$ and $Y_{AD}$ type.

Its momentum corresponding to the minimum momentum for elementary particles, can be given in general form as [20-22]

$$P = \Phi \cdot \mathcal{E}^{n}_{k_{\text{min}}}/c,$$

where $\Phi$ is probability of observing the object $4b$ in some region of space $R_3$.

If the objects $4b$ are free (that is, they create not an elementary particle but space free of them), then $\Phi = \frac{1}{16} \cdot \frac{\tilde{x}_0^3}{4\pi x_0^2\tilde{x}_0}$, where $\tilde{x}_0 \approx 10^{-33} \text{cm}$, and $x_0 \approx 10^{-17} \text{cm}$. In this case, if the scatter in values of momentum is $P$ for an elementary object $\Delta p$, then the uncertainty in coordinate in $R_3$ for the object $4b$ will be equal to $10^{28} \text{cm}$. This value $\Delta X$ has given us earlier the possibility to obtain the density of matter in the Universe, observed in experiment, by way of averaging it over the sphere $10^{28} \text{cm}$ in radius.
If the object $4b$ is not free (that is, it forms the internal geometry of an electron, for instance), then

$$
\Phi = \frac{1}{16} \cdot \frac{x_0^3}{4\pi (Nx_0)^2 x_0},
$$

and we can write the following expression for an assemblage of objects $4b$ forming an electron (for which $m_e c^2 = N \cdot E_{k_{\text{min}}}$):

$$
\Delta p = \frac{1}{16} \cdot \frac{x_0^3}{4\pi (Nx_0)^2 x_0} \cdot \frac{NE_{k_{\text{min}}}}{c} = \frac{1}{64\pi} \cdot \frac{NE_{k_{\text{min}}}}{Nc}.
$$

Using Eq.(21) we obtain the uncertainty in coordinate $\Delta x$ in $R_3$ on the order of $10 \text{ cm}$ for the assemblage of $N$ objects $4b$, that is, the electron, due to wave properties of $N$ objects $4b$, carries information on its properties not over distances of $10^{-8} \text{ cm}$ (characteristical dimension of de Broglie wave for electron at the temperature of 300K) as would be in the case of a pointwise particle but over distances of the order of $10 \text{ cm}$.

When considering not $N$ objects but one object $4b$ in the electron (that is, when Formula (20) is valid) then $\Delta x \approx 10^5 \text{ cm}$. Hence the less is amount of information on condition of internal spatial characteristics of electron, the larger is the scatter in coordinate.

In Appendix 3, qualitative pattern of a common approach to unifying all interactions is shown.

The byuon theory predicts a new anisotropic interaction of nature objects with physical vacuum.

Peculiar "taps" to gain new energy are elementary particles because their masses are proportional to the modulus of some summary potential $A_\Sigma$ that contains potentials of all known fields (Appendix 1). The value of $A_\Sigma$ cannot be larger than the modulus of $A_g$ [20-22]. In accordance with the experimental results shown in [22,31], this force ejects substance from the area of the weakened $A_\Sigma$ potential along cone’s formations with solution $100^\circ \pm 10^\circ$ formed around vector $A_\Sigma$ direction. This vector has the following coordinates in the second equatorial system of coordinates: right ascension $\alpha \approx 293^\circ \pm 10^\circ$ (19h 20m), declination $\delta \approx 36^\circ \pm 10^\circ$ [22,31]. The vector $A_\Sigma$ is parallel to the vector $A_g$ practically.

The new force is of nonlinear and non-local character as to variation of some summary potential $A_\Sigma$ and may be represented by some series in $\Delta A_\Sigma$ [20-22,32].

The expression for the new force takes the form:
\[ |\mathbf{F}| = -2N m_0 A_g \cdot c^2 \lambda(\Delta A) \cdot \frac{\partial \lambda(\Delta A)}{\partial \Delta A} \cdot \frac{\partial \Delta A}{\partial X_1}. \] (22)

where \( N \) is the number of stable elementary particles in the body, \( A_g = |A|_g \).

Note that expression for the new force (22) is local (we cannot deal with the nonlocal ones as yet), therefore, to account for the nonlocality of the phenomenon, we will take \( \Delta A \) equal to the difference in changes of the summary potential \( |A|_\Sigma \) at the location points of a test body and a sensor element \([20-22]\).

These changes being equal, the force will be absent. Depending on the relative position of the sensor and the test body, \( \Delta A \) can take as a positive, so a negative value.

To estimate a role of gravitational field in a change of \( |A|_\Sigma \) we put forward the maximal gravitational potential \( \varphi_{\text{max}} \), determined for proton by the following relationship:

\[ m_p \varphi_{\text{max}} = eA_g, \] (23a)

where \( m_p \) is the proton mass. Then the contribution of \( \varphi_{\text{max}} \) in the change of \( |A|_\Sigma \) is described by the following equality:

\[ \varphi_{\text{max}} \cos \alpha \cdot m_p = eAv/c, \] (23b)

where \( v \) is in this case the velocity of our Galaxy relative to the neighbouring galaxies, \( \cos \alpha = \cos^{N_{kP-i-I-I}}_{I-I} (15) \). It characterizes nonorthogonality of our World at the moment of the formation of the space of elementary particles. It is worth noting that potentials of physical fields have the physical meaning only for interacting byuons when elementary particles are generated with their masses and charge numbers. As for the vector potential of magnetic field it is gauged so that its value on the axis for example of the solenoid equals zero; \( x_1 \) is coordinate, directed from the point of the most decreased \( A_\Sigma \) on a winding to the vector \( A_g \).

The analysis of the specific experimental results with high field magnets (see \([20-22,32-35]\)) has led to the following expression for \( \lambda(\Delta A) \):

\[ \lambda(\Delta A) = \sum_{k=1}^{\infty} \lambda_k \exp \left\{ -\left[ \frac{\Delta A}{A_g} \cdot \frac{r}{\Delta y} \cdot \left( \frac{ct}{x_0} \right)^{3/2} \right]^k \right\} \cdot \Delta A^k, \] (24)

where \( r \) is the radius of the circle which the test body is located on; \( \Delta y \) is the difference in coordinates \( y \) of the sensor and the body \([20-22]\);


$(x_0/ct^*)^{3/2}$ is part of the energy $2m_\nu c^2 + 2m_0 |A_g|^2$, which can be acted upon by the electromagnetic field potentials.

Using the linear term only in the expansion of (22) by $\Delta A$, we obtain the following formula for the modulus of the new force:

$$F = 2N m_\nu c^2 \lambda_1^2 \cdot \Delta A_\Sigma (\Delta A_\Sigma/\Delta X).$$

(25)

It is worth noting that the experiments for the scanning the celestial sphere by the pulsed plasma generator [22,31] to detect some directions in space, where energy is more than the average value, are the final stage in the determination of the direction of the new force. This direction was determined before by the using the high field magnets [20-22,32-35], by the investigations of the rate of $\beta$-decay for a number of radioactive elements [20-22,24,25,36], by the investigations with high precision gravimeters [20-22,37], and by plasma generator of other types [20-22,38].

Experiments with high field magnets [20,21] showed that the new interaction has the most probably an isotropic component as well.

Let us discuss the nature of the dark energy in the framework of the byuon theory on the base of potentials of physical fields.

It is known that the gravitational potential $\varphi$ is negative, and therefore for any summation of potentials it decreases the modulus of $A_\Sigma$. Masses of elementary particles are proportional to this modulus. Hence the new force will push out any material body from the region of the decreased modulus of $A_\Sigma$, because a defect of energy $\Delta E = \Delta mc^2$ will appear and the corresponding force will act to the region with undisturbed value of $A_\Sigma$. Any material body decreases in its own region the modulus $A_\Sigma$ due to potentials of physical fields of all its elementary components, i.e. creates the gradient $\Delta A_\Sigma/\Delta X$. Gravitationally acting mass, for example, our Galaxy, creates around the gravitational potential $\varphi$. To estimate the action of one galaxy to another we put in the formula (25) the potential $\varphi_{\text{max}}$ from (23a) and $\Delta A_\Sigma$ from (23b) ($\Delta A_\Sigma = A$). Let us estimate the distance $R_{GG}$ where the new force $F$ from (25) will be higher than the gravitational force $F_g$ (cf. Fig.1):

$$R_{GG} \geq GM_g^2/(2N m_\nu c^2 \lambda_1^2 \cos^2 \alpha \varphi_{\text{max}}^2 (m_\nu c/ve)^2)$$

(26)

where $G$ is the gravitational constant.

Here $M_g$ is the mass of the one of interacting galaxies. We consider an interaction of two galaxies with $10^{10}$ stars, assume that the mass of each star is of order to the solar mass ($\sim 10^{33}$ g) and a relative velocity of each galaxy
v = 100 km/sec and 1000 km/sec. From our experiments \( \lambda_1 = 10^{-12} \) [20-22, 51]. As the result we obtain from (26) \( R_{GG} \geq 10^{26} \) cm for \( v = 100 \) km/sec and \( R_{GG} \geq 10^{28} \) cm for \( v = 1000 \) km/sec.

Thus we have estimated the magnitude of the distance between galaxies above which they scatter under the action of the new force. The estimate obtained seems as reasonable and indicates that the physics of byuons is perspective to explicate the nature of the dark energy and dark matter.

Appendix 1.

The masses of ultimate particles can be described by the following expressions [20-22]:

\[
\begin{align*}
    m_p c^2 &= \frac{\sqrt{hc}}{2}\left(\frac{4\sqrt{3}e^2_0}{hc}\right)^3 \left(1 - \frac{1}{6} \sqrt{\frac{3\mu_0}{c^2 t}}\right) \times \left[1 + \frac{1}{6\left(1 - \frac{1}{2} \sqrt{\frac{3\mu_0}{c^2 t}}\right)^2} + 1\right] |A| = 924 MeV, \\
    m_{\nu_0} c^2 &= \frac{\sqrt{hc}}{2}\left(\frac{4\sqrt{3}e^2_0}{hc}\right)^3 \left(1 - 2 \sqrt{\frac{3\mu_0}{c^2 t}}\right) \times \left[1 + \frac{1}{6\left(1 - 2 \sqrt{\frac{3\mu_0}{c^2 t}}\right)^2} - 1\right] |A| = 132 MeV,
\end{align*}
\]

(27)

Masses of all leptons:

\[
\begin{align*}
    2m_{\nu_0} c^2 &= \frac{\sqrt{hc}}{2k} \cdot \left(\frac{hc}{4\sqrt{3}e^2_0}\right)^{5.5} \cdot |A|, & m_e c^2 &= \frac{\sqrt{hc}}{2k} \cdot \left(\frac{hc}{4\sqrt{3}e^2_0}\right)^{3} \cdot |A|, \\
    2m_{\nu_0} c^2 &= 2 \cdot 3^{1/4} \sqrt{hc} \cdot \left(\frac{4\sqrt{3}e^2_0}{hc}\right)^{5.5} \cdot |A|, & m_\mu c^2 &= 3^{1/4} \sqrt{hc} \cdot \left(\frac{4\sqrt{3}e^2_0}{hc}\right)^{3.5} \cdot |A|, \\
    2m_{\nu_0} c^2 &= 3^{1/4} \cdot 96 \cdot \sqrt{2} \cdot \sqrt{hc} \cdot \left(\frac{4\sqrt{3}e^2_0}{hc}\right)^{5.5} \cdot |A|, & m_\tau c^2 &= 3^{1/4} \cdot 12 \cdot \sqrt{2} \cdot \sqrt{hc} \cdot \left(\frac{4\sqrt{3}e^2_0}{hc}\right)^{3.5} \cdot |A|.
\end{align*}
\]

(28)

Appendix 2.

It is known that any novel physical model of the Universe must meet the following criteria. First, all the discovered laws of nature as well as sufficiently well established models of one or another physical phenomena must follow from the new model as asymptotical approximations. Second, the new theory should have the capability for predictions. That is, it should guide an experimental way to the gain of new knowledge, as the theory itself gives
nothing but only points such a way. Criterion of truth is an accurately performed experiment independently confirmed by various authors. The theory of byuons [20-22] seems to meet the above criteria. That is a theory of "life" of special discrete objects from which the surrounding space and the world of elementary particles form. The intrinsic dynamics of byuons determines such fundamental phenomena as the course of time, rotation of planets and stars, spins of elementary particles, asf.

What is a qualitative distinction between the theory of byuons and previous physical theories?

First, the physical space was always given in all the science, in one way or another, and motion equations for a system of objects under study were written in that space. Space could be uniform continuum (Newton, Minkovsky) or discrete, one-dimensional or multidimensional, asf. In present-day cosmological models of the Universe origin (Gamov's Big Bang [39], Linde's model of bulging Universe [40], and so on), space is always given, too. But in the theory of byuons, the physical space (necessarily three-dimensional one, not ten- or more-dimensional as in some modern physical models) is a special quantized medium arising as the result of interaction of byuon's vacuum states (VSs). That is, space is not given but arises. Therewith the appearing three-dimensional space originated must have an insignificant global anisotropy, as distinct from all basic isotropic models with the same properties in various directions. The said anisotropy denotes the existence of some chosen direction caused by the existence, in nature, of a new fundamental vectorial constant, the cosmological vector-potential $A_g$ entering into the definition of the byuon. That new constant is associated with the prediction of a novel anisotropic interaction of natural objects between themselves and with the physical vacuum, a lowest energy state of physical fields.

It should be noted that in the literature spaces with local rather than global anisotropy are considered [41], for example, the Finsler's space-time [42], but the local anisotropy is given therein "by hand", as the saying goes. That is, an author himself directly introduces it into his model instead of obtaining from some general principle. For example, there are domain models of the Universe.

Secondly, the physical sense of time notion is not yet revealed in science in the present state of the art [43]. The general philosophic concept of time as a form of matter existence, which form expresses the order of change of objects and phenomena as a sequence of events, does not indicate a common nature of those events. As a rule, people tie their time to a particular periodic process: rotation of the Earth around its axis, Earth’s orbiting around the Sun, oscillations of a quartz system, asf, without becoming
aware of inner, profound sense of time. Standard physical time references, for example, quantum or, what is the same, atomic clock with instrument error on the level of $10^{-11}$ per year and moderate resolution on the order of $10^{-13}$ seconds, give us no possibility of approaching the knowledge of time essence. The byuon theory reveals physical essence of time as a discrete sequence of changes in the byuon’s ”length”, its quantum number. A possibility therewith arises, to synchronize clocks at great distances comparable with dimensions of our Metagalaxy, due to the quantum process of physical space formation from the byuon’s vacuum states (VSs). That possibility substantially distinguishes the theory of byuon’s from A. Einstein’s special theory of relativity (STR), in which clocks can be synchronized only when a signal has passed between them with speed of light $c$. It should be noted at once that in the byuon theory, material objects cannot move with a speed faster than the light speed (that is similar to the STR’s postulate on finite propagation velocity of interactions), but synchronization of clocks occurs by a quantum way without introducing the concept of speed. That is, some object originated in the course of interaction between byuon vacuum states and forming the physical space, is at a time in two spatial regions being very distant from each other in the three-dimensional space arising.

Third, an essential distinction of the byuon theory from modern models in the classical and quantum field theories [44] is that the potentials of physical fields (gravitational, electromagnetic, asf.) become, in the theory of byuons, exactly fixable, measurable values. Recall to the reader that ordinary methods of measurement are capable to measure solely a difference of potentials. Therefore, in the existing field theory, potentials are defined only with a precision of an arbitrary constant or the rate of change of the potentials in space or time (gauge models). But in the theory of byuons, field potentials become single-valued since there are formed, on the set of byuon VSs, field charge numbers which generate the fields themselves, as, for example, the electric charge of an electron generates an electric field. The physical sense of field as a special form of matter, loses its basic meaning because all the observable events can be described on the basis of the byuon theory without introducing the concept of force, and hence of field.

An important methodic distinction between the byuon model and all those existent in the theoretical physics of today, is that the latter use images with properties of real objects, - for example, strings in the physics of elementary particles [45], superstrings, membranes when creating a unified field theory [46], asf. The byuons but are unobservable objects having no analogues in the nature though all the natural objects appear in the result of interaction of byuon VSs.
The proposed pattern of formation of the observed space $R_3$ on the basis of dynamics of the finite set of byuons animates, fills with a sense, and supplements the physical results on properties of elementary particles, described in [34-35]. For example, if some elementary object appearing in byuon interaction has, with the probability near 1, the vacuum state $I^+$ of a byuon completing formation of its quantum numbers (the greatest period of byuon interaction of the order of $kN$), such an elementary object will be stable as well as its properties will, since quite a definite amount of information will be locked up by VS $I^+$. This relates, for example, to the electron.

Thus, as opposed to gauge models in which the level of symmetry constantly grows for more complete, all-embracing, and unified description of the surrounding world [23-28], and to obtain massive particles it is necessary to use "by hands" the Higgs mechanism (spontan violation of symmetry), in the present model there exists first a one-dimensional world (its direction, i.e. that of $A_g$, is determined by the byuon with the maximum $x(i)$), then its symmetrization takes place, and the space $R_3$, with the world of elementary particles originates. At that some insignificant ($\sim 1/k (\sim 10^{-15})$) asymmetry of "empty" $R_3$ remain as well as that of the $10^{-5}$ order inside the elementary particles.

It should be also noted that to calculate the fundamental constants $h$, $\epsilon_0$, $c$; constants of known interactions, masses of main baryons, leptons, and mesons according to formulae of the byuon theory, only three numbers $\tilde{x}_0$, $\tau_0$, $|A_g|$ should be given since the characteristic dimensions $\tilde{x}_0 \approx 10^{-17}$ cm, $c\tau^* \approx 10^{-13}$ cm and $10^{28}$ cm are found from the minimum PE of byuons and from the information theorem.

Notice that in [20-22, 24,25, 31-38], results of some fundamental experiments in support of the basic theoretical statements are shown.

Appendix 3. Force-free physics. A qualitative pattern of a common approach to unifying all interactions. A novel principle of relativity.

The byuon theory is presently in a stage of development but it is seen from already put milestones of the novel physical concept that the scope of this theory is much wider as compared to the unified field theory because the former gives physical interpretation of the observable space, reveals the nature of notions of time, mass, charge, and so forth. But what is the matter with a classical problem of physicists, - construction of a unified approach to all
interactions? The theory of byuon solves this problem in an unusual way, namely, by way of full abandoning the concept of force itself, that is, by way of construction of force-free physics. What usually sees an observer when investigating one or another interaction between objects? He sees the motion of objects which are either approaching each other, or moving farther apart, or revolving one around another at a common distance. For example, at a gravitational interaction of objects we see that they approach each other, but at an electrical interaction of two electron, for instance, they move away from each other. During rotary movements of natural objects, - for example, the Larmor rotation of electron in magnetic field, revolution of planets around the Sun, own rotations of objects asf., - the distances between the objects do not change. In terms of forces, the phenomenon in consideration may be described by the Newton’s law of gravitation, Coulomb’s law, Lorentz’s force, asf. But there is another approach at which all existent interactions of objects in nature (four known and the fifth novel ones) are explained by way of variation of fundamental scales $x_0$ and $c t^*$. Let us show it, but first recall how the concept of force is introduced in physics. At school we towed a weight by spring along an inclined plane and measured the magnitude of frictional force from tension of the spring. All the ordinary ”everyday” forces can be always reduced to the four known interaction mentioned above. For example, the forces of friction, gas or liquid pressure, forces in solid-state physics, - all are the electromagnetic forces.

In the field theory, the concepts of ”force” and ”field” are closely related. Let us give an extract from Ref. [47] on this subject:

"The interaction between particles is explicable by the notion of force field. Rather than say about the action of one particle onto another, we can say that the particle creates a field around itself, and any other particle being in that field, is subjected to the action of some force. In the classical mechanics, the field is only a means of describing the physical phenomenon of interaction between particles. But in the theory of relativity the situation substantially reverses because of a finite propagation velocity of interactions. Force acting upon a particle at an instant of time, do not determined by their arrangement at that same instant. A change in position of one particle reflects on other particles only after some time. That is, the field itself becomes physically real. We may not say that the particles being some distance apart, directly interact with each other. The interaction can occur at each time point only between neighbouring points in space (short-range interaction). Therefore we should speak about interaction of a particle with a field and subsequent interaction of the field with another particle.”

At our approach, the concept of ”field” is not necessary since the dy-
namics of observed objects can be explained by the dynamics of a finite set of VSs of a single object, the byuon. Let us show this qualitatively for the existent types of interactions.

**Weak interactions.** In papers cited we have touched on this subject when considered the leptons and indicated that the muon and tau-lepton decay under the action of weak interaction. In the framework of the byuon theory, this interaction can be explained in the following way. According to the basic hypothesis of said theory, the entire world has come into being in correspondence with the minimization of byuon VSs potential energy. Only those particles can be stable which are corresponded, when originating (i.e. forming their charge numbers), by minimum periods of interaction of byuon VSs in the process of minimization of potential energy, that is, the values $x_0$ and $ct^*$. For muon and tau-lepton, the process of their origin is extended over $2x_0$ and $8x_0$ in the observable space, therefore the nature tends, in accordance with minimization principle, to reduce all to the minimum, i.e. to the periods $x_0$ and $ct^*$. Constants of this interaction are exactly calculated in the theory of byuon. The vectorial constant $C_v$ characterizing local anisotropic properties of weak interaction, can be written as follows:

$$C_v = e_0A_g 2x_0^3$$

Firstly, draw the reader’s attention to the fact that no superfluous parameters are introduced to calculate $C_v$ and other properties of the surrounding world as well. All quantities in Eq. (A3) can be found from minimum potential energy when specifying quantum of space, quantum of time, and modulus of $A_g$. Substituting the above given values of parameters into Eq. (A3), we obtain $C_v = 1.35 \times 10^{-49} \text{erg} \cdot \text{cm}^3$. This value is very close to experimental results.

Explain the physical sense of Eq. (29). The quantity $e_0 A_g$ corresponds to the interaction of the electric charge of a particle, in the process of its origin, with the vector $A_g$ during extension of the volume in which the interaction takes place, up to $2x_0^3$. That is, the object 4b corresponding, for instance, to the muon, in the process of muon generation will be in the volume $2x_0^3$ with probability 1 (In the common physics such an object is corresponded by a pair “muon neutrino – muon antineutrino”). Earlier one of the authors (Yu.B.) in his books has also interpreted the weak interaction as the loss of independence of spatial from time coordinates in some generalized space, for example, in four-dimensional Minkovskian space [20-21].

**Strong interactions.** At present, the majority of physicists consider the theory of strong interaction as already developed. This discipline is
called Quantum Chromodynamics (QCD). Its basic statements substantially supplement earlier models advanced by Yukawa in 1934 and independently by Gell-Mann and Zweig in 1964. The former is based on the existent particles $\pi$-mesons being some interchange particles between protons and neutrons in the nucleus (these particles fasten the protons and neutrons into a single whole). The latter is a quark model. According to it, hypothetical quarks should have unusual properties: fractional charges (baryon charge $1/3$, electric $+2/3e_0$ and $-1/3e_0$). To experimentally detect the quarks assumed, immense financial means and intensive efforts of physicists were spent, but all was in vain despite the energy of particles colliding in accelerators reached enormous magnitudes of thousands billions electron-volts. Then the theorists proposed a string mechanism of interaction between quarks, so called QCD, that implies that the more are quarks stretched, the stronger is the interaction between them. That is, quarks in principle cannot leave the nucleus. This problem was denoted as “confinement”. In experiments, ”strings” longer than $10^{-13}$ cm, are not detected.

Now about what the byuon theory speaks on the subject. The existence of strong interactions is considered there as interaction between the pairs of byuon VSs $I^+$ and $I^-$. Such interpretation has an analogue in the classical electrodynamics and quantum mechanics where the interaction of two electric dipoles is considered. Their potential of interaction (Van der Waals forces) depends on distance as does the Yukawa’s potential, that is, it can ensure basic properties of nuclear forces. Therewith if charges of such dipoles will be one order of magnitude larger than the electric charge, the constant of these interactions will be about 1, as in the experiments [20-22].

In the theory of byuon, the interaction of pairs of byuon VSs $I^+$ and $I^-$ participant in formation of the baryon charge of proton and neutron, leads to a decrease in the period $ct^*$ of interaction of byuon VSs (around $10^{-13}$ cm), which is naturally manifested in attraction of nucleons (protons and neutrons). The fact that the hypothetic objects, the quarks, do not stretched into strings longer than $10^{-13}$ cm, now can be qualitatively explained. That is clear since the next (after $10^{-13}$ cm) period of interaction of byuons VSs is equal to $10^{28}$ cm. That is, there exist no stable quantum structures with dimensions between $10^{-13}$ cm and $10^{28}$ cm.

**Electromagnetic and gravitational interactions.** It should be noted that the most close to our method of attack the problem of searching unified pattern of interactions are works by H.Weyl [48-49] and P.Dirac [50]. Historically, Weyl’s geometry was proposed to explain by space curvature not only long-range gravitational field, as in the Einstein’s theory, but another long-range field, the electromagnetic field, too.
The gravitational field is well explained by Einstein’s theory that represents it in terms of space curvature. This has led to a thought that the electromagnetic field also may be explained by some property of space instead of an idea of its “immersion” into the given space. It was thus necessary to build up some more general space, as compared with Riemannian space forming the foundation of Einstein’s theory, which space would describe the existent gravitational and electromagnetic forces and lead to unifying long-range forces.

The space curvature required of Einstein’s theory, can be expressed in terms of parallel shift of a vector when moving it along a closed contour, which leads to a difference between the initial and final directions of the vector. Weyl’s generalization consisted in assuming that the finite vector has not only another direction but another length, too (and that is the most important). In Weyl’s geometry, there is no absolute means of comparing length elements at two different points if they are not infinitely close to each other. The comparison can be made only in relation to a line segment connecting both points, and different ways will give different results for the ratio of two length elements. To have a mathematical theory of lengths, we must arbitrarily specify standards of length at each point and then correlate any length at any point with a local standard for this point. Then we obtain some magnitude of vector length at any point, but this magnitude is changed when is changed the local standard of length.

Hence the Weyl’s geometry ensures just what is necessary for describing the gravitational and electromagnetic fields in geometric terms, that is, by changes in periods of byuon VSs interactions (fundamental scales). In the works [20,21,23] is shown that by way of changing fundamental scales, we can obtain Maxwell’s equations describing properties of the electromagnetic field. Let us show the gist of the matter on a qualitative level.

When assumed that there is composed a mathematical algorithm for transition of events from the one-dimensional space $R_1$ to three-dimensional $R_3$, the electromagnetic and gravitational interactions of objects can be achieved by changing periods of interaction of byuon VSs $k$, $N$ and, respectively, by changing scales $x_0$ and $ct^*$. The electrostatic field is caused by a change in $|A_\Sigma|$ due to some scalar $A^0$, the magnetic field is due to vectorial potential $\mathbf{A}$ but with complete return (without deviations) of the vector $\mathbf{A}$ to the initial point of space $R_3$ after circulation along some closed contour $\ell$ (in that case $\cos_{II^+I\ell^+} = \cos_{II^-I\ell^-} = 0$). It should be noted once more that the electromagnetic constant of interaction (constant of thin structure) $e^2/\hbar c$ will be the same in all reference systems.

Let us illustrate the above said by the example of static electric and
gravitational fields. For an electron in electrostatic field with potential $A^0$ we can write the following expression

$$m_e c^2 + eA^0 = m'_e c^2 = 2m_{\nu_e} N'. $$

Here we assume the electric field to be absent as such, but there are only changes in periods of byuon VSs interaction corresponding to the effect of presence of electric field at formation of this electron. That is, in fact only the own mass of electron is changed.

From the above relationship is seen that if $eA^0 > 0$ then $N' > N$ (starting value of the period before appearance of $A^0$), and $N' < N$ if $eA^0 < 0$. That is, the interaction of like charges leads to repulsion of them (increase in the period $N$), and unlike charges are attracted together (decrease in $N$).

For the electron in a static gravitational field with potential $\varphi$ an analogous relationship can be written: $m_e c^2 + m\varphi = m''_e c^2 = 2m_{\nu_e} N''$. 

(Here we also assume that there is no gravitational field as such but only the change in periods of interaction of byuons VSs correspondent with the effect of presence of gravitational field at formation of the electron). In this case we deal only with attraction since $\varphi < 0$, and hence $N'' < N$.

**New interaction.** We name this interaction as byuon interaction. That is principally distinct from the existent interactions since is connected with global anisotropy of space caused by the vector $A_g$ appearing in the definition of byuon $[A_g x(i)]$. The distinction is in that the functions $\cos II^+II^+, \cos II^-II^-, \cos II^+II^- \ldots$ do not precisely equal to zero, and there is going the process of extension of byuon in vacuum states $II^+$ and $II^-$, that is, space is coming into being. In terms of a simple geometric model, for any limited volume of $R_3$ always a vector of byuon $A_\Sigma$ can be found that enters the volume at some point of the surface embracing the volume, at the minimum angle of $\sim 1/10^{15}$, and another vector of byuon always comes out of the volume nearly at the same angle, creating global anisotropy of the Universe. Therewith the change of $A_\Sigma$ in $A_g$ direction due to the vector potential of a magnetic system also changes the period of byuons VSs interaction $k$, i.e. the scale $x_0$, and leads to rejection of an object out of the region of decreased $|A_\Sigma|$.

The new interaction, contrary to others, is of sharply anisotropic character and directed along generatrixes of above mentioned cone to the side of vector $A_g$, but that interaction is zeroth in the region of precise antiparallelism of the potential $A$ being generated, to the direction of $A_g$, since the derivative $\partial \Delta A / \partial x = 0$ exactly along the vector $A_g$.

**Unified pattern of all existent interactions** consists in the fact that
they are associated with one or another character of changes in fundamental
scales of physical space originated in the process of byuon VSSs interactions.
These scale changes are corresponded by one or another change of $\mathbf{A}_\Sigma$ that is
taken in the traditional physics for the action on a particle by one or other
field. Thus in terms of traditional physics, the byuon theory is a theory
of "addition" of potentials of all the existent fields with some fundamental
potential $\mathbf{A}_\Sigma$ that cannot be more than $|\mathbf{A}_g|$ in magnitude. This is just
the solution of the problem of unified field theory. When speaking about
the new interaction, we have separated in it only anisotropic properties, but
the quantity $\mathbf{A}_\Sigma$ contains potentials of all known fields, too. Therefore the
theory of single force is sure to be created in the nearest future on the basis of
the new interaction, and from that theory the expressions for all the known
forces in nature will be derived in one or another asymptotic approximation.

**Principle of relativity.**

The phenomenon in consideration, i.e. the new interaction, is nonlinear
and nonlocal. When getting to the root of its nature as well as nature of
other interactions associated with changes of fundamental scales, we come
to a force-free description of objects in the world as well as to necessity of
improvement of relativity principle.

According to the relativity principle of Galilei, all laws of nature are the
same in all inertial systems of coordinates or, if more exactly, the expressions
for these laws are invariant relative to transformation of coordinates and
time when going from one inertial coordinate system to another.

The full invariance of all inertial reference systems points to the absence
of any "absolute" system of coordinates. This is the essence of relativity of
phenomena.

In the mechanics of Galilei the interactions propagate instantly, and time
is absolute, that is, considered as independent of reference system.

Leaning upon the Michelson’s experiment (1881) demonstrated light
speed independence of direction of its propagation, A.Einstein developed
the principle of relativity having supplemented it with a postulate of finiteness
of velocity of propagating interactions. According to the relativity
principle, the value of this velocity is the same for all inertial reference sys-
tems and equal to the light speed $c_0$. The limitation on propagation velocity
of interactions led to the fact that time ceased to be absolute and became
dependent upon the reference system, and the laws of transition from one in-
ertial coordinate system to another acquired a non-Galileian form and were
embodied in Lorentz’s transformations.

What a new is introduced in relativity of events in $R_3$ by the new ap-
proach to formation of $R_3$ from VSSs of discrete object, the byuon, in ac-

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cordance with the Hypothesis 1. To answer the question, it should be once more reminded of what the coordinate system is at all in such an approach, and after that determine what we will call the inertial system of coordinates.

Since we have put a question of how the observed physical space is built, we already should not ”arithmetize emptiness” as that is made in the classic physics, quantum mechanics, and quantum field theory. We can only find coordinates of some observed physical objects relative to other objects.

For this reason alone the notion of coordinate system loses its uniqueness. Further, if we do determine arrangement of objects under observation relative each other with certain accuracy in the context of large scaled world, we can approach the notion of an inertial system of coordinates, too. By inertial systems of coordinates such systems are meant in which the periods \((k, N, P)\) of byuon interactions (or fundamental scales \(x_0, ct^*, \tilde{x}_0kNP\)) as well as functions of \(\cos I_{I+I+}, \cos I_{I-I-I-}\) type are the same. Of course, this statement is fulfilled always with some accuracy. Therein does lie basic idea of extension of the concept of relativity. In this connection it should be noted that all forces in nature as well as the new interaction will be zero in inertial coordinate systems (the earlier definition of relativity principle) as they all can be explained in terms of change of fundamental scales that do not altered in such systems. Therefore in the experiments on investigating the new force [20-22,32-35], the weight was always suspended on a cantilever, if only on the order of 1cm in length, since otherwise the new force is zeroth when the body and sensor are in regions of the same scale \(x_0\).

The force-free description of motion of objects gives an in-depth understanding of nature, but the stereotype of our mentality and a sufficient accuracy of description of motion of objects in the everyday life (by using the second Newton’s law) lead to the notion of the new force though physically that is only changes in fundamental scales.

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Figure 1: Scheme of two body interactions in our Universe.

Figure 2: Interaction of byuons in vacuum states $II_1^+$ and $II_4^+$ (the smallest loop).
Figure 3: Completion of vacuum states $II^+$ and $II^-$ by vacuum states $I^+$ and $I^-$, respectively, at the maximum potential energy of interaction.
Figure 4: The possible variants of four-contact interaction of byuons. The interaction being realized in nature is $II^+ - I^+ - II^- - I^-$. 

Figure 5: The rule of circular arrow for determining the distance between byuons.
Figure 6: \( k \) as a function of the number \( n \) of the terms of the series.

Figure 7: Representation of the set \( \{R_1\} \) as a union of sets of the points \( \{A\} \) and \( \{D\} \).