Dynamic Model of Elementary Particles and Fundamental Interactions

George P. Shpenkov and Leonid G. Kreidik
Institute of Mathematics & Physics, University of Technology & Agriculture
Al. Kaliskiego 7, Bydgoszcz 85-796, POLAND; e-mail: shpenkov@janmax.com

This paper describes a physical model of elementary particles based on the wave features of their behavior. Elementary particles are regarded as dynamical structures of the micro-world, interrelated with all levels of the Universe; *i.e.*, inseparable from the structure of the Universe as a whole. Between any elementary particles and the ambient field of matter-space-time, as well as between elementary particles themselves, there exists an interchange of matter-space-time occurring both in horizontal (within the same level) and vertical (between different levels) directions. This model reveals the nature of mass and charge of elementary particles, which in turn leads to the unified description of fundamental (electromagnetic, gravitational, and nuclear) interactions, and other important results considered concisely here. PACS Numbers: 01.58.+b, 11.90.+t, 12.90.+b

1. Introduction

Our understanding of fundamental interactions depends upon our knowledge about the nature, features, and behavior of the micro-objects of the Universe, called 'elementary particles' (although no one doubts that these particles too are complex). The elementary-particle model accepted in modern physics is the Standard Model (SM). It just attempts to describe behavior; *i.e.*, it focuses on answering questions of 'how'; but it encounters difficulties when questions of 'why' or 'what' arise. One unresolved mystery is the nature of mass and charge of elementary particles. Another is the relation between bare elementary particles and ambient space, *etc*. Following the as-yet unquestioned modern nuclear model of atoms, it is assumed that the dimensions of elementary particles do not exceed the size of atomic nuclei. But we do not know whether this is true.

Despite not knowing primordial features of matter, physicists created not only the abstract SM, but also an abstract quantum-mechanical model of atoms, and models of more complicated systems, including the whole Universe and its origin. In the course of time, many began to realize that some widely-accepted basic concepts were doubtful, and they noted that: "*…The ideas that were put in place by our intellectual ancestors in the early 1900's are insufficient to deal with the deep issues that are now being explored. The neat and tidy view of the 1970's has given way to confusing collections of paradoxes, puzzles, enigmas, and contradictions…* [1]". This comment refers, mostly, to the problems of elementary particles, gravity, and relativity. It is also widely recognized that the SM "*will not be the final theory*" and "*any efforts should be undertaken to finds hints for new physics*" [2].

Knowing that our ideas concerning the fundamentals of physics are poor, but not knowing better ways, the overwhelming majority of physicists continue research in a traditional way, creating more and more complicated, abstract theories based on sophisticated mathematics. But a new approach to the aforementioned problems is developed in works of the present authors [3]. According to our analysis of the fundamentals of physics, cognition of Nature is impossible without resolving the primordial problems of natural science mentioned above.

In the new approach developed in our works, atoms and elementary particles are regarded as structures of distinct levels of the Universe, which has many such levels (*e.g.*, molecular, atomic, subatomic, *etc.*). Perfect harmony and correlation inside and between all levels takes place in this Universe. From this viewpoint, the physical field-space of the Universe represents by itself an infinite series of spaces embedded in each other [recalling a set of nesting dolls, or an infinite functional series $f(x) = \sum_{k=1}^{\infty} u_k(x)$]. This series of spaces expresses the fundamental concept of natural philosophy concerning the infinite divisibility of matter. Every level of space is the *basis level* for the nearest above-situated level and, simultaneously, it is the *level of superstructure* for the nearest below-situated level. This means that above-situated field-spaces are formed on the basis of below-lying fields-spaces. Accordingly, there is no meaning to the concept of 'very last elementary particle' in the common classical sense of this phrase.

Therefore, it is clear; we should not consider atoms and elementary particles separately from the total structure of the Universe. This means that in a *consideration of the problem of structure of any material objects, one should begin from the precise definition of the principal axioms on the structure of the Universe on the whole*.

As follows from the first of the axioms of the general structure of the Universe [3] (see also the web site [4]), mutual transformations of fields with opposite properties cause the wave nature of the world (*e.g.*, transformations of the potential field into the kinetic field and *vice versa*). Waves appearing at one level generate other waves going deep into an infinite series of embedded field-spaces.

Based on these and other relevant axioms, the wave equation of matter-space-time was solved. As a result, we found the spatial distribution of characteristic points (called conditionally nodes) of wave fields, where the wave function of the wave equation reaches maximal and zero values. In particular, these solutions revealed the distribution of nucleons in atoms and, accordingly, the nature of Mendeleev's periodic law and symmetry [5] (including "forbidden to ordinary crystals" [6]).

According to the solutions obtained, nucleons in atoms are in the primary potential polar-azimuth nodes (maximum of two per a node) located along characteristic meridians and parallels of spherical shells, corresponding to radial solutions of the wave function (details are in [3] and partly in the web site [7]). This atomic model accounts for the known physical properties and phenomena already considered in [3]. It predicts and yields the structure and mass of all possible isotopes. In essence, it reveals the 'genetic code' of the structural variety in Nature.

Based on the solution of the wave equation, the new atomic model also allows an understanding of the physics of atomic reactions caused by an inelastic collision of high-energy particles with substance. Calculated binding energies and the proper energy of nucleons in the nodes conform to the experimental data of nuclear physics.

A deeper understanding of atomic properties and atomic structure cannot be achieved without understanding the nature of atomic components – 'elementary particles', *i.e.*, micro-objects of atomic and subatomic levels of the Universe: protons, electrons, neutrons, *etc*. In this way, the consideration of the wave nature of the particles led us to an understanding of the nature of their mass m and charge q.

Using the framework of our approach and the results obtained, a unified description of fundamental interactions (electromagnetic, gravitational, and nuclear) became possible [3], and is demonstrated here. The goal of this paper is to show all major stages of this research.

2. Model of Elementary Particles; Definitions

Let us imagine an elementary particle as a dynamic spherical formation of a complicated structure being in a dynamic equilibrium with environment through the wave process of the definite frequency ω. Longitudinal oscillations of its wave shell in the radial direction provide an interaction of the particle with other objects and the ambient field of matter-space-time (Fig. 2.1). In the approach presented, the logical triad, *matter-space-time*, expresses an indissoluble bond of matter, space, and time. The logical pair: *motion-rest* presents indissoluble bond of motion and rest, *etc*.

We assume that a spherical wave shell bounds the space of an elementary particle, separating it from the ambient wave field. We call this sphere the *characteristic sphere* of a micro-particle. The characteristic sphere restricts the *main part of the micro-particle* from its *field part* that merge gradually with the ambient field of matter-space-time.

The *main part* (core) is the *basis* of a micro-particle, whereas the *field part* represents its *superstructure*. Thus, the *basis space* of a micro-particle is restricted by the *characteristic sphere*, beyond which there is the space of its *superstructure*. Such a model interprets a micro-particle as a particular discrete physical point of an arbitrary level of matter-space-time, restricted by the characteristic sphere and being in rest in the field-space.

The ratio of mass dm and volume dV of elementary particles defines their *absolute-relative density* ε :

$$\varepsilon = dm / dV = \varepsilon_0 \varepsilon_r \tag{2.1}$$

where $\varepsilon_0 = 1\ g/cm^3$ is the *absolute unit density* and ε_r is the *relative density*.

The ratio of mass dm and time dt expresses the volumetric rate of mass exchange of the particles with environment, which we call the ***exchange charge***, or merely the charge

$$Q = dm / dt = S\upsilon\varepsilon \tag{2.2}$$

where S is the area of a closed surface separating the space of an elementary particle from the surrounding field of matter-space-time, υ is some speed of wave exchange (interaction) at the separating surface. It is natural to present the speed of wave exchange (interaction) in the form

$$\hat{\upsilon} = \upsilon(kr)e^{i\omega t} \tag{2.3}$$

where $k = 2\pi/\lambda = \omega/c$ is the wave number corresponding to the definite fundamental frequency ω of the exchange field (which is characteristic of the subatomic level of the Universe).

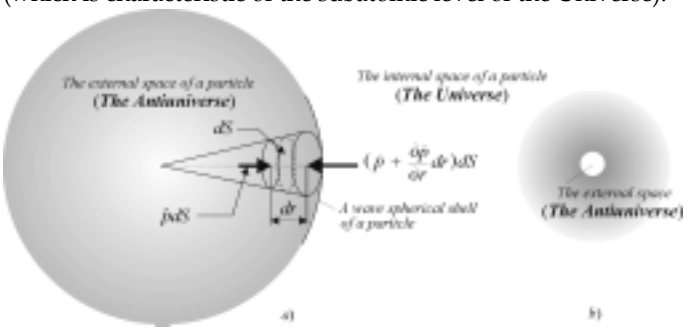

Figure 2.1. An element of the volume (a) of the wave shell in a spherical field of exchange: a particle –ambient field of matter-space-time; $\hat{p}dS$ and $[\hat{p} + (\partial\hat{p}/\partial r)dr]dS$ are powers of exchange of the field with the element of shell of the particle, $\hat{p}$ is the two-dimensional density of exchange, or the pressure of the field of exchange;. (b) the internal and external parts of an elementary particle.

Strictly speaking, the *exchange charge is the measure of the rate of exchange of matter-space-time*, or briefly the *power of mass exchange*. In this wider sense, the area of exchange S does not necessarily concern the closed surface. In a case of a micro-object of spherical structure, the measure of exchange charge (2.2) is

$$\hat{Q} = 4\pi a^2 \hat{\upsilon}\varepsilon_0\varepsilon_r \tag{2.4}$$

where a is the radius of the wave shell of the micro-object.

The Universe is an infinite series of material and ideal spaces. Between objects of the spaces, there occur complicated interactions that *represent the **exchange** of matter-space-motion-rest* (*matter-space-time* for brevity).

*The exchange of matter-space-time occurs simultaneously in many levels, which are represented by corresponding subspaces of matter of the Universe. These subspaces should be regarded as **embedded** into each other; they form the space of the Universe. The embedding is one of the aspects of the physical multi-dimensionality of fields of matter-space-time of the Universe.*

As a measure of exchange intensity in matter-space-time, it is possible to take any parameter of exchange. If it is momentum, then we deal with the rate of exchange of momentum, *etc*. In such a broad sense of the word, the expression $\mathbf{F} = d\mathbf{P}/dt$, known as Newton's second law, is a simple writing of the formula of the vector power of exchange of momentum. By virtue of this, we will also call the vector $\mathbf{F}$ the ***power of exchange of momentum***. Of course, this power of exchange $\mathbf{F}$ cannot be identified with the scalar power N of exchange of energy W: $N = dW/dt$. However, in spite of their difference, both N and $\mathbf{F}$ are ***powers of exchange, expressed by the language of the concrete measures of exchange, and nothing more***. This is why the same term the ***power of exchange*** is the rightful one as the ***measure of the rate of exchange***.

The dynamical model presented here uses terminology defined in [8]. The geometrical space (spherical volume) delimited by the spherical wave shell of an elementary particle is 'external' to the Universe. As the 'external world' of the Universe (Fig. 2.1b), this space inside the spherical volume can naturally be called the 'Anti-Universe'. In this sense, the World (Being and Non-Being) is presented here through the Universe and Anti-Universe. Obviously, the spaces of the Universe and Anti-Universe are closed on each other. Most probably, the main essence of life, its mystery, is hidden in the Anti-Universe.

Resting on the aforementioned definitions, we can start the consideration of wave exchange (interaction) of a particle with the ambient field of matter-space-time.

3. Derivation of Elementary Particle Mass

In a spherical field (Fig. 2.1), an equation of powers of exchange of momentum for an elementary volume of a characteristic spherical shell of a particle of area dS and thickness dr is defined by the equality

$$dm(d\hat{\upsilon}/dt) = d\hat{F} \tag{3.1}$$

where the speed $\hat{\upsilon}$ and the power of exchange $d\hat{F}$ are described by the field of binary numbers [9, 10], expressing the potential-kinetic character of exchange. The resulting action is

$$d\hat{F} = \hat{p}dS - [\hat{p} + (\partial\hat{p}/\partial r)dr]dS$$

Because $dm = \varepsilon_0\varepsilon_r drdS$, the equation of exchange (3.1) will take the following form

$$\varepsilon_0\varepsilon_r drdS\frac{d\hat{\upsilon}}{dt} = -\frac{\partial\hat{p}}{\partial r}drdS \quad \text{or} \quad \frac{d\hat{\upsilon}}{dt} = -\frac{1}{\varepsilon_0\varepsilon_r}\frac{\partial\hat{p}}{\partial r} \tag{3.2}$$

On the basis of Eq. (3.2) and because $d\hat{\upsilon}/dt = i\omega\hat{\upsilon}$ [see (2.3)], we arrive at

$$\hat{\upsilon} = -\frac{k}{\varepsilon_0\varepsilon_r i\omega}\frac{\partial\hat{p}}{\partial kr} \tag{3.3}$$

In a spherical field, the flow of oscillatory energy through an elementary cone is constant. Hence, the speed decreases inversely to a distance from the center of the spherical field. Consequently, a wave of exchange density has the form

$$\hat{p} = (p_m/kr)\exp[i(\omega t - kr)] \tag{3.4}$$

where p_m is the amplitude of the exchange density at the boundary of the wave zone defined by the condition $kr = 1$.

Joining the equalities (3.3) and (3.4), we have

$$\hat{\upsilon} = \frac{\hat{p}}{\varepsilon_0\varepsilon i\omega r}(1 + ikr) \tag{3.5}$$

On the basis of Eqs. (3.3) and (3.5), we find the power of exchange $\hat{F}_s$ with the ambient field at the boundary of the spherical shell of a particle with the area S and radius $r = a$:

$$\hat{F}_s = \hat{p}S = \frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2}(1 - ika)\hat{\upsilon}i\omega \tag{3.6}$$

or

$$\hat{F}_s = \left(\frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2} - \frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2}kai\right)\frac{d\hat{\upsilon}}{dt} \tag{3.7}$$

The expression in brackets can be regarded as a resulting mass of particle – environment exchange. It is an *associated field mass* of the particle

$$\hat{M} = \frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2} - \frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2}kai. \tag{3.8}$$

We can present the expression (3.7) in another form. Because $d\hat{\upsilon}/dt = i\omega\hat{\upsilon}$, the right part of this expression can be rewritten as

$$\hat{F}_s = \frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2}\frac{d\hat{\upsilon}}{dt} + \frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2}ka\omega\hat{\upsilon} \tag{3.9}$$

In such a case, the equation of radial exchange of a particle of mass m_0 through the spherical surface, within which the particle is localized, can be presented in the form of the following equation of exchange powers:

$$m_0(d\hat{\upsilon}/dt) = \hat{F} - \hat{F}_s \tag{3.10}$$

where $\hat{F}$ is the exchange power of the particle with an object in the ambient space, and the second term, $\hat{F}_s = \hat{p}S$, takes into account the exchange of the particle with the ambient field of matter-space-time.

Taking into account (3.9), the equation of exchange powers for the particle with the one radial degree of freedom can be presented as

$$\left(m_0 + \frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2}\right)\frac{d\hat{\upsilon}}{dt} + R\hat{\upsilon} = \hat{F} \tag{3.11}$$

where

$$R = \frac{4\pi a^3\varepsilon_0\varepsilon_r}{1 + k^2a^2}ka\omega \tag{3.12}$$

is the coefficient of resistance, or the dispersion of rest-motion at exchange.

The exchange-power equation (3.11) is presented in the classical form of Newton's second law, describing the motion in the field-space with resistance R. In such a description of motion-

rest, the expression in brackets represents the *effective mass* m of the particle:

$$m = m_0 + 4\pi a^3 \varepsilon_0 \varepsilon_r / (1 + k^2 a^2) \tag{3.13}$$

The second term is abbreviated as

$$m_a = 4\pi a^3 \varepsilon_0 \varepsilon_r / (1 + k^2 a^2) \tag{3.14}$$

called the *associated potential mass* of the particle, or merely the *associated mass of the particle*, or briefly the *mass of the particle*: This is the mass of the particle in longitudinal (central) exchange.

If the rest mass (own mass) of the particle m_0 is significantly less than the associated mass m_a, then the ***mass m of the particle** is **defined only by its associated mass m_a, and it is the field mass in the central exchange***. Obviously, the rest mass of the particle m_0 is the associated mass with respect to the deeper level of the field of matter-space-time. Therefore, we can assert that *all masses of micro-particles in the Universe have an associated field character, and that their own (proper, rest) masses do not exist*.

If situations are possible where exchanges of particles with the ambient field of matter-space-time of the subatomic level do not occur, then masses of particles with respect to this level are equal to zero, and no experiment will find such a world of micro-particles. Accordingly, this world will be unknowable to physics.

4. The Charge of Exchange

Equation (3.10) describes the exchange of motion, whereas the mass exchange is defined by charges (2.2). In this case, we present the field component of mass exchange in the form

$$\hat{p}S = (d\hat{m} / dt)\hat{\upsilon} = \hat{Q}\hat{\upsilon} \tag{4.1}$$

Assuming $m_0 = 0$ and taking into account the equality (3.10), we obtain the following equation of exchange powers:

$$\hat{Q}\hat{\upsilon} = \hat{F} \tag{4.2}$$

The exchange charge $\hat{Q}$ has an active-reactive character; it follows from Eqs. (3.6), (4.1) and (4.2) that

$$\hat{Q} = \frac{4\pi a^3 \varepsilon_0 \varepsilon_r}{1 + k^2 a^2} ka\omega + i \frac{4\pi a^3 \varepsilon_0 \varepsilon_r}{1 + k^2 a^2} \omega = Q_a + iQ_r \tag{4.3}$$

where

$$Q_a = \frac{4\pi a^3 \varepsilon_0 \varepsilon_r}{1 + k^2 a^2} ka\omega \tag{4.3a}$$

is the active charge, and

$$Q_r = Q_a / ka = m\omega = \frac{4\pi a^3 \varepsilon_0 \varepsilon_r}{1 + k^2 a^2} \omega \tag{4.3b}$$

is the reactive charge.

The active component Q_a defines the dispersion during exchange, which in a steady-state process of exchange is compensated by the inflow of motion and matter from the deeper levels of space. The reactive component of charge Q_r (further for brevity, the *charge of exchange* Q) *is connected with the associated mass* m *by the relation*

$$Q / m = \omega, \text{ or } Q = \omega m \tag{4.4}$$

Eq. (4.4) determines the **fundamental frequency of the field of exchange**, which is the distinctive 'time' frequency of exchange at the atomic and subatomic levels [3]. Using (4.4), the active charge can be presented as

$$Q_a = Qka \tag{4.4a}$$

The active mass of dispersion at exchange, corresponding to the active charge, is

$$m_a = Q_a / \omega = mka \tag{4.4b}$$

In such a case, the associated mass m should be regarded as the reactive mass.

5. Elementary Law of Central Exchange

The simplest potential of exchange speed in a spherical field has the following form

$$\hat{\Phi} = (A / r)\exp\{i[\omega t - k(r - a)]\} \tag{5.1}$$

Let the radial speed of exchange (at the wave spherical surface of a particle) follow the law $\upsilon_n = i\upsilon_0 e^{i\omega t}$. Then, taking into account the boundary conditions $\upsilon_n = -\partial\hat{\Phi} / \partial r = i\upsilon_0 e^{i\omega t}$, we obtain

$$A = i\upsilon_0 a^2 / (1 + ika)$$

On this basis, the potential of the spherical field of exchange can be presented as

$$\hat{\Phi} = \hat{\varphi}ka + i\hat{\varphi} \tag{5.2}$$

where $\hat{\varphi}ka$ is the active potential of dispersion, and $\hat{\varphi}$ is the reactive potential of exchange

$$\hat{\varphi} = \hat{Q} / 4\pi\varepsilon_0 \varepsilon_r r \tag{5.3}$$

The potential of radial exchange $\hat{\varphi}$ is determined by the charge wave of exchange

$$\hat{Q} = Q\exp\{i[\omega t - k(r - a)]\} \tag{5.4}$$

where Q is the amplitude of charge, determined by the expression (4.3b).

The potential (5.3) will not be changed if we will assume that at the field level $\varepsilon_r = 1$. Then, the amplitude (and also the mean value) of the potential will be determined by the equality

$$\varphi = Q / 4\pi\varepsilon_0 r \tag{5.5}$$

where

$$Q = m\omega = \frac{4\pi a^3 \varepsilon_0}{1 + k^2 a^2} \omega \tag{5.6}$$

is the amplitude (or mean value) of the charge.

The gradient of the exchange potential φ defines the intensity (or strength, or the rate, or the vector) of central exchange $\mathbf{E}$ (its amplitude and mean value):

$$\mathbf{E} = -\partial\varphi / \partial r = Q / 4\pi\varepsilon_0\varepsilon_r r^2 \tag{5.7}$$

The vector of central exchange $\mathbf{E}$ defines the dynamic vector $\mathbf{D}$, by definition equal to

$$\mathbf{D} = \varepsilon_0\varepsilon_r\mathbf{E} \quad \text{or} \quad \mathbf{E} = \mu_0\mu_r\mathbf{D} \tag{5.8}$$

This vector represents the density of exchange momentum of rest-motion.

In accord with (4.1), the following power of exchange F corresponds to the strength-rate of exchange E:

$$F = (dm / dt)E = Q^2 / 4\pi\varepsilon_0\varepsilon_r r^2 \tag{5.9}$$

where $\varepsilon_0 = 1\,\mathrm{g}/\mathrm{cm}^3$ is the absolute unit density. This expression represents the ***law of central exchange*** of the Coulomb kind. Its general form is

$$F = Q_1 Q_2 / 4\pi\varepsilon_0\varepsilon_r r^2 \tag{5.10}$$

The speed of exchange at the basis level is equal to c. In this case, the equation of the power of exchange (4.2) takes the form

$$\hat{Q}\hat{c} = \hat{F} \tag{5.11}$$

Hence, the (carrier) *energy of mass exchange* (interaction) on the basis level or, in other words, the *dynamic energy* of the subatomic level, will be equal to

$$W = \int Qc\,dl = \int (dm / dt)\,cc\,dt = \int c^2 dm \tag{5.12}$$

where $dl / dt = c$ and dl is the displacement of the wave front of exchange (at the separating surface of a particle, see Fig. 2.1). In the case of the differential exchange, we have

$$\Delta W = \Delta mc^2 \tag{5.12a}$$

We arrive at the so-called rest energy of particles, well known in the form $E = m_0c^2$, which appeared by chance in Einstein's manipulation with the fictitious mathematical empty spaces [3]. The sense (nature) of this energy is not (and cannot be) properly understood within the framework of generally accepted modern physical theories.

6. Fundamental Frequency and Wave Radius of the Electrostatic Field

The energy of exchange between a particle and the surrounding field, taking into account Eq. (5.5), is equal to

$$W = Q\varphi = Q^2 / 4\pi\varepsilon_0 r \tag{6.1}$$

In an electrostatic field theory, the Coulomb energy (in *CGSE* units) corresponds to the energy of exchange (6.1):

$$W_C = q_C^2 / r \tag{6.2}$$

where q_C is the Coulomb 'electric charge'.

Assuming, naturally, that $W = W_C$, we arrive at the formula of correspondence between exchange charge Q and Coulomb charge q_C:

$$Q = \sqrt{4\pi\varepsilon_0}\,q_C\,. \tag{6.3}$$

Hence, the *exchange reactive charge* of an electron at the level of the fundamental frequency is

$$e = e_C\sqrt{4\pi\varepsilon_0} = 1.70269248\times10^{-9}\ \mathrm{g/s} \tag{6.4}$$

where $e_C = 4.80320679\times10^{-10}\ CGSE_q$ is the (Coulomb) electron charge.

Thus, the physical quantity (6.4) is the *exchange charge of an electron* obtained on the basis of the experimental value of the electron's electric charge.

On the basis of (3.4), knowing the exchange charge of an electron (6.4), we find the ***fundamental frequency*** *of the wave field of exchange* (interaction) at the subatomic level (the 'frequency of electrostatic field')

$$\omega_e = e / m_e = 1.86916197\times10^{18}\ \mathrm{s}^{-1} \tag{6.5}$$

and the ***fundamental wave radius***, corresponding to this frequency,

$$\lambda\!\!\!^{-}_e = c / \omega_e = 1.603886998\times10^{-8}\,\mathrm{cm} \tag{6.6}$$

where $m_e = 9.1093897\times10^{-28}$ g is the mass of the electron.

The ***fundamental wave diameter*** $D = 2\lambda\!\!\!^{-}_e = 0.32\,\mathrm{nm}$ correlates with the average value of lattice parameters in crystals, defining an average discreteness of space at the subatomic level of exchange (interaction).

7. Unified Approach to Electromagnetic, Gravitational, and Nuclear Interactions

Taking into account the relation (4.4), $Q = \omega m$, between the charge of exchange Q and the associated mass m, the *law of central exchange* (5.10) can be presented as

$$F = \omega^2 m_1 m_2 / 4\pi\varepsilon_0 r^2\,. \tag{7.1}$$

This law lies at the foundation of Nature. Its particular case is the *law of universal gravitation*. Discovered by Newton in 1687, its original form is

$$F = Gm_1 m_2 / r^2 \tag{7.2}$$

Following the general form of the law of central exchange (interaction), (5.10) or (7.1), we should present the law of universal gravitation in its correct form. For this aim, obviously, the formula (7.2) must contain in the denominator the coefficient 4π, which expresses the spherical isotropic character of exchange, and the absolute unite density ε_0, which expresses the interrelation of matter and space (mass and volume, or contents and form [3]). Introducing these multipliers in numerator and denominator of (7.2), we arrive at

$$F = \gamma m_1 m_2 / 4\pi\varepsilon_0 r^2 \tag{7.2a}$$

where $\gamma = 4\pi\varepsilon_0 G$.

Comparing now the central exchange presented in the two forms, (7.1) and (7.2a), we arrive at the interrelation between the *fundamental frequency of the field of exchange at the gravitational level* ω_g with the gravitational constant G:

$$\omega_g = \sqrt{4\pi\varepsilon_0 G} \tag{7.3}$$

The important effects originating from this equality can be found in [11].

The *fundamental gravitational frequency*, obtained from the equality (7.3), is

$$\omega_g = \sqrt{4\pi\varepsilon_0 G} = 9.159248527 \times 10^{-4}\,\mathrm{s}^{-1} \tag{7.3a}$$

where $G = 6.6720 \times 10^{-8}\ \mathrm{cm}^3/\mathrm{g\,s}$. Knowing ω_g and assuming that the gravitational interaction relates to the subatomic level with the basis speed $c = 2.99792458 \times 10^{10}\,\mathrm{cm/s}$, we find the *wave gravitational radius of a particle*:

$$r_g = c/\omega_g = 3.273111949 \times 10^{13}\,\mathrm{cm} \approx 327.3\,\mathrm{Mkm} \tag{7.4}$$

This radius determines the wave gravitational sphere with the transient wave zone, which divides the spherical space-field of a particle into the near oscillatory domain (domain of basis) and the far wave domain (domain of superstructure).

If the particles form cosmic objects, for example stars, then the domain of the gravitational radius (as the transient zone, separating the basis and the superstructure of the field of the star) must be presented by a series of rings-shells. In the solar system, these are represented by the rings of asteroids of the Sun, adjoined to the shell of the gravitational radius. In this domain, big planets cannot exist because, in the process of formation of the Solar system, this transient domain was the place of the most intense motion.

It should be noted that the *existence of the gravitational frequency and the gravitational radius of elementary particles* shows the indissoluble bond of micro- and mega-objects of the Universe in the unit complex of the Infinitely Small and Infinitely Big, as the coexisting polar oppositions *Yes* and *No*. The gravitational spectrum of H-atomic wave shells, coinciding with the spectrum of planetary orbits, is presented in [3] (see there a Section "*The wave field of H-atom at the micro- and mega-levels*", pages 495 – 503).

The nucleon exchange charge defines, at the fundamental frequency ω_e, the high steadiness of atomic structures, *i.e.*, the interbond of nucleons ('nuclear forces') in an atom. According to the new atomic model [3, 8, 11, 12] mentioned in the Introduction, the amplitude energy of interchange [see (6.1)], in the case of two nucleons touching on their outer shells, is

$$W_m = q_p^2/4\pi\varepsilon_0(2r_p) = 45.93660967\,\mathrm{MeV} \tag{7.5}$$

where

$$q_p = \omega_e m_p = 1836.152701\ e = 3.1264034 \times 10^{-6}\,\mathrm{g/s} \tag{7.6}$$

is the exchange (associated) charge of a proton, $r_p = 5.284217526 \times 10^{-9}\,\mathrm{cm}$ is the radius of the proton's characteristic shell, defined from the expression (3.14) under the condition $kr << 1$ and $\varepsilon_r = 1$, $r_p = (m_p/4\pi\varepsilon_0)^{1/3}$. The average value of the energy in this case is $< W_m >= 22.96830484\,\mathrm{MeV}$. This value correlates with the height of the potential barrier of division $B_{\max}$ for a series of atoms [13].

8. Conclusion

Recognition of the wave nature of all phenomena in the Universe has required development of a physical (dynamical) model of elementary particles corresponding to such a wave nature, which has been carried out by the present authors. The existence and interactions of the particles are, in essence, a continuous process of wave *exchange* of matter-space and motion-rest, or, for brevity, *exchange of matter-space-time*. The wider (and, hence, truer) notion *exchange* is thus more correct because it reflects behavior of elementary particles in their dynamic equilibrium with the ambient field, at rest and motion, and interactions with other objects (and particles themselves). In other words, the notion *exchange* is more appropriate from the point of view of the physics of the complex behavior of elementary particles viewed as dynamic micro-objects belonging to one of the interrelated levels of the many-level Universe. (This notion was first introduced in [11].) It follows that the notion *rest mass* of elementary particles is, in principle, not valid for such a model. Accordingly, one could conclude that the rest mass of elementary particles does not exist. The *associated nature of mass*, as the field mass of the central wave exchange, naturally originates from this model. The *power of mass exchange*, *i.e.*, the rate of exchange of mass, defines the *exchange charge* or simply the charge of elementary particles, which in contemporary physics is called the '*electric* charge'.

The correctness of the dynamical model is reinforced by the fact that from this model it naturally (and logically) originates that:

1) The *fundamental law of central exchange* (5.10) (of the Coulomb kind), which ***unifies the fundamental interactions***, distinguished in contemporary physics as electromagnetic, gravitational and nuclear;

2) The formula of *dynamic energy of mass exchange* of the subatomic level $W = mc^2$ [see (5.12) or (5.12a)];

3) The *fundamental frequency of exchange* (6.5), *i.e.*, the frequency of the so-called 'electrostatic field', that reveals its essence, in particular, non-stationary nature;

4) The *fundamental wave radius* $\lambda\!\!\!^{-}_e$ [see (6.6)], defining the average atomic diameter and, hence, the average distance $2\lambda\!\!\!^{-}_e$ (lattice parameter) in ordered material structures (*e.g.*, crystals);

5) The *fundamental gravitational frequency* (7.3a) and the *wave gravitational radius* of elementary particles (7.4);

6) The *energy of interchange* in atoms ('nuclear forces'), *etc.*

Interested readers in can find details and other parameters, which have not been presented above, in other works [3, 8, 11]. The plentiful results obtained have universal meaning because they touch upon many fundamental interactions described on the basis of one theoretical concept. We believe that these data will stimulate corresponding theoretical research in all domains of physics, including High Energy and Elementary Particles Physics, *etc.*

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gshp@atr.bydgoszcz.pl