On The Fine-Structure Constant Physical Meaning

George P. Shpenkov

Institute of Mathematics & Physics, UTA, Kaliskiego 7, 85-796 Bydgoszcz, Poland; shpenkov@janmax.com

Abstract

The fine-structure constant α, formed from the four basic physical constants (e, $\hbar$, c, and ε_0), is regarded in modern physics as a convenient measure of the strength of the electromagnetic interaction. The unknown earlier meaning of α, originated mainly from the uncovered true values and dimensionalities of its two constituents, the electric constant ε_0 and electron charge e, is elucidated in this paper. It is shown that α reflects the scale correlation of threshold states of conjugate oscillatory-wave processes inherent in wave motion.

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1. Introduction

The fine-structure constant α is a dimensionless quantity formed from the four basic physical constants $e, \hbar, c,$ and ε_0:

$$\alpha = e^2 / 4\pi\varepsilon_0\hbar c = 7.297352533\cdot 10^{-3} \qquad \text{(SI)} \qquad (1.1)$$

where $e = 1.602176462\cdot 10^{-19}\ C$ is the electron charge, $\hbar = 1.054571596\cdot 10^{-34}\ J\cdot s$ is the Planck constant h divided by 2π, $c = 2.99792458\cdot 10^{8}\ m\cdot s^{-1}$ is the speed of light, $\varepsilon_0 = 8.854187817...\cdot 10^{-12}\ F\cdot m^{-1}$ is the so-called "*permittivity of free space*" (or "*electric constant*") [1-3]. The fine-structure constant is considered in modern physics as a convenient measure of the strength of the electromagnetic interaction. In other words, α is the "coupling constant" or measure of the strength of the electromagnetic force that governs how electrically charged elementary particles (*e.g.*, electron, muon) and light (photons) interact.

The inverse quantity of α is

$$\alpha^{-1} = 137.03599976\,. \qquad (1.2)$$

The constant α was introduced by Arnold Sommerfeld (1916) during his studies on the Balmer series in the framework of the Bohr Theory [4] (before the introduction of wave mechanics), first as the quantity

$$\alpha = \upsilon_0 / c\,, \qquad (1.3)$$

where $\upsilon_0 = 2.187691251\cdot 10^{8}\ cm\cdot s^{-1}$ is the speed of the electron on the Bohr first orbit in the hydrogen atom. Then, after some simple transformations, Sommerfeld reduced this ratio to $e^2/\hbar c$ (in the CGSE system). Thus Sommerfeld introduced the value

$$\alpha = \upsilon_0 / c = e^2 / \hbar c \qquad \text{(CGSE)} \qquad (1.4)$$

expressed in the SI units as

$$\alpha = \upsilon_0 / c = e^2 / 4\pi\varepsilon_0\hbar c \qquad \text{(SI)} \qquad (1.4a)$$

He called α the *fine-structure constant* because the combination of three fundamental constants in it (in the right part of the equality (1.4)) enters in the formula of spectral terms, defining the amount of the fine structure splitting.

From the expression (1.4) it follows that α has a double meaning. The first of them, expressed by the ratio of speeds υ_0 and c, has *never been discussed*. The second one *states only the fact* that α is the combination of the specific universal physical constants, which characterize, respectively: the discrete nature of electric charges (e), quantum theory ($\hbar$), and relativity theory (c). The fine-structure constant α enters in the so-called "relativistic correction" in the same formula of spectral terms (derived earlier by Sommerfeld), obtained when the hydrogen atom is calculated by Dirac's relativistic wave mechanics.

Thus, we should recognize that the principal question about the true physical meaning of both ratios in (1.4a) remains open. What do they express?

From our point of view, the reason of such a gap in our knowledge on this matter is the absence in contemporary physics of a concept on the *nature of mass and charge of elementary particles*, and in particular, of electron mass and electron charge.

In this paper, based on the *dynamic model of elementary particles* (DM), put forward first in the last decade [5], and on the other new data presented in [6], we answer to the above question and elucidate the physical meaning of the α-constant. The DM uncovers the true dimensionality of electric charges, and hence, the true meaning of the electron charge e that is the principal key for resolution of the fine-structure constant problem posted here. The collective nature of wave processes, taken into account in the present work, is the second such key.

From the equalities (1.1) and (1.3) it follows that the electron charge can be presented in the following form:

$$e = \sqrt{4\pi\varepsilon_0\hbar\upsilon_0}\,. \qquad (1.5)$$

The constant $\hbar = h/2\pi$, entered in the above formulas, is in essence the *orbital moment of momentum* of the electron on the Bohr first orbit (of the radius r_0); it has the form

$$\hbar = P_{orb} = m_e\upsilon_0 r_0\,. \qquad (1.6)$$

where $m_e = 9.10938188\cdot10^{-28}\ g$ is the electron mass, $r_0 = 0.5291772083\cdot10^{-8}\ cm$ is the Bohr radius.

The Planck constant h is the quantity the value of which is equal to the *orbital action of the electron* on the Bohr first orbit in the hydrogen atom, namely to its *orbital moment of momentum* P_{orb} multiplied by 2π:

$$h = 2\pi P_{orb} = 2\pi m_e \upsilon_0 r_0, \tag{1.7}$$

Putting (1.6) in (1.5), we arrive at the formula of electron charge expressed through electron mass m_e and the two characteristic parameters, υ_0 and $r_{0,}$ of the steady-state circular motion of the electron around a proton in the hydrogen atom:

$$e = \sqrt{4\pi\varepsilon_0 m_e \upsilon_0^2 r_0}\ . \tag{1.8}$$

Hence, the dimensionality of the electron charge is

$$[e] = F^{1/2} \cdot kg^{1/2} \cdot m \cdot s^{-1}. \tag{1.9}$$

Or, because

$$1F \approx 9 \cdot 10^9\ m, \tag{1.10}$$

$$[e] = kg^{1/2} \cdot m^{3/2} \cdot s^{-1} \tag{1.11}$$

The same dimensionality of electric charges (based on the units of matter, *kg*, space, *m*, and time, *t*) originates also from the Coulomb's law in the SI units. In the CGSE system, the dimensionality is $g^{1/2} \cdot cm^{3/2} \cdot s^{-1}$.

It is impossible to reveal the nature (a sense) of electric charges of such a strange (rather senseless) dimensionality formed on the basis of *fractional powers* of reference units. Obviously, the dimensionality problem is hidden in Coulomb's law $F = kq_1q_2/r^2$. To be exact, it is in the coefficient of proportionality k between the resulting Coulomb force F and interacting electric charges q_1 and q_2.

The coefficient k was first accepted (in the CGSE system) to be equal to the *dimensionless* unit, $k = 1$ (resulted in $[e] = g^{1/2} \cdot cm^{3/2} \cdot s^{-1}$). Later on, in the SI units, it gained the form $k = 1/4\pi\varepsilon_0\ m \cdot F^{-1}$, which led to the dimensionality $[e] = C$, the coulomb. Applying (1.10) to the latter form, we find that k is in essence the *dimensionless* quantity, as the *"electric" constant* ε_0 (the constituent of k), which is equal actually to $1/4\pi$ [6, 7]. We will analyze it below in detail. Thus, we have as before $k = 1$, and $[e] = kg^{1/2} \cdot m^{3/2} \cdot s^{-1}$.

We proceed now to consider just this question, which is the principal matter for understanding the nature of electric charges, the fine-structure constant, *etc*., and hence for electrodynamics (and physics) entirely.

2. An explicit value and dimensionality of the "electric constant" ε_0

The aim of the present section is to perform a dimensional analysis of the constant ε_0, entered in (1.1), which reveals its true value of dimensionality. Why is this so important?

Beginning from the Coulomb's time, nothing changed in uncovering of the true nature of electric charges. This *status quo* strengthened for long after an introduction of the SI units (Système International d'Unités) given birth to the "*electric constant*" ε_0. The latter imposed its imprint on all further development of physics.

A functional dependence between two interacting, at the distance *r*, point charges q_1 and q_2, discovered first by Coulomb, is

$$F = kq_1q_2 / r^2, \tag{2.1}$$

where *k* is the unknown at that time coefficient of proportionality between the resulting force *F* and the observed functional dependence. At $k = 1$ (that was accepted in the *CGSE* system), the Coulomb law reduces to the following form (in vacuum)

$$F_{CGSE} = q_1q_2 / r^2. \tag{2.2}$$

Hence, the dimensionality of the electric charge in the *CGSE* system is

$$[q] = g^{1/2} cm^{3/2} s^{-1}. \tag{2.3}$$

In order to get rid of the fractional powers of the above dimensionality, the unit of electric current ***ampère*** was introduced in physics as the *base* (reference) *unit*, additionally to the triad of truly base units of *matter-space-time*: the units of *mass, length*, and *time*. This was made contrary to the fact that actually the ampère is the *derived unit* defined from Ampère's law for interacting currents. The dimensionality of the ampere contains the fractional powers of the two base units (of length and mass), namely $1A = \frac{c_r}{10} CGSE_I = \frac{c_r}{10} g^{1/2} cm^{3/2} s^{-2}$. As a result, the coefficient of proportionality k in Eq. (2.1) in the *SI* units was turned out to be equal to

$$k = 1/4\pi\varepsilon_0 . \qquad (2.4)$$

The constant ε_0 entering in k was called the *electric constant*; its value and dimensionality are presented as

$$\varepsilon_0 = \frac{10^{11}}{4\pi c_r^2} F \cdot m^{-1} \approx 8.854187817 \cdot 10^{-12} \ F \cdot m^{-1} . \qquad (2.5)$$

Thus, caused by an introduction of the ampere and based on the tangled manipulations during the conducted "rationalization" of dimensionalities into the SI units, the new "physical" constant ε_0 was introduced as a result.

Coulomb's law ((2.1) in SI units) took the following form:

$$F_{SI} = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2} . \qquad (2.6)$$

It is easy to show that ε_0 is actually the dimensionless magnitude. Indeed, the unit of capacity the ***farad*** *F* (in the SI units) is $1F = \frac{c_r^2}{10^{11}} m \approx 9 \cdot 10^9 \ m$, where $c_r = 2.99792458 \cdot 10^{10}$ ($c_r = c / c_e$, $c = 2.99792458 \cdot 10^{10} \ cm \cdot s^{-1}$ and $c_e = 1 \, cm \cdot s^{-1}$) is the relative speed of light; hence, from Eq. (2.5) it follows that

$$\varepsilon_0 = \frac{10^{11}}{4\pi c_r^2} \cdot \frac{c_r^2}{10^{11}} = \frac{1}{4\pi} , \qquad (2.7)$$

and we arrive finally at

$$F_{SI} = \frac{Q_1 Q_2}{4\pi(1/4\pi) r^2} \quad \text{or} \quad F_{SI} = \frac{Q_1 Q_2}{r^2} . \qquad (2.8)$$

i.e., at the same situation that took place more than 300 years ago at the Coulomb time (see (2.2)). This means that actually the coefficient of proportionality in Coulomb's law, in SI units just like in the CGSE system, remains unknown both in value and dimensionality, and, as before, it is equal to the dimensionless unit, $k = 1$.

Thus, the question about the true value and dimensionality of k in Coulomb's law (2.1) still remains open. The actual dimensionality of the charge in the *SI* units is expressed through the triad of base units (of length, mass, and time), two of which have the fractional powers

$$[Q] = kg^{1/2} m^{3/2} s^{-1}, \qquad (2.9)$$

as in the *CGSE* system (see (2.3)). Therefore, it is no wonder that the same dimensionality originates also from the expression (1.8).

The derived SI unit of the electric charge, the ***coulomb***, does not contain the fractional powers in the accepted dimensionality, because in this case $1C = 1A \cdot 1s$ and $[Q] = A \cdot s$. However, expressed with use of the two reference units of *mass* and *length* (*matter* and *space*), the coulomb contains the fractional powers of the units (like the ampere):

$$1C = \frac{c_r}{10} CGSE_q = \frac{c_r}{10} g^{1/2} cm^{3/2} s^{-1} \quad \text{(CGSE)} \qquad (2.10)$$

$$1C = \frac{c_r}{10} \cdot \frac{1}{\sqrt{10^9}} kg^{1/2} m^{3/2} s^{-1} \quad \text{(SI)} \qquad (2.11)$$

The erroneous value of k in Coulomb's law (2.6) gave rise to a phenomenological system of notions with measures having fractional powers of base units that are really meaningless. Cognition of the nature of electric charges has become impossible.

It is obvious that without solving the k-constant problem (in (2.1)), physics of electromagnetic phenomena (and related fields) will make no headway. Let us take a look at the law of universal gravitation, which is similar in form to Coulomb's law:

$$F = Gm_1 m_2 / r^2. \qquad (2.12)$$

The value of the coefficient of proportionality G (the gravitational constant) in the law is known, and its dimensionality has the definite non-contradictory physical meaning, $G = 6.6720 \cdot 10^{-8}\ g^{-1} \cdot cm^3 \cdot s^{-1}$, expressed by integer powers of reference units. The similar situation should be clarified for the coefficient of proportionality *k* in Coulomb's law (2.1).

Since the erroneous system of measures of the electromagnetic field involves all physical formulae, *experiments* based on these formulae are *unable to detect the accumulated errors*. Thus, everything is formally "correct" and "consistent", although the electron charge is defined incorrectly, qualitatively and also quantitatively (we show it below). This situation has given rise to numerous additional atomic constants, complicating cognition of the Universe on the atomic level yet more.

Wrong measures may unfortunately give rise to false theories, within the framework of which formally correct results are possible only on the basis of new errors in full agreement with the dialectical law of double negation: $No_1 \cdot No_2 = Yes$, where No_1 is the initial lie, No_2 is a new lie, and *Yes* is the formal truth. The result of this course of events can only be an impasse.

However, not all is so hopeless now. The matter is that the *k*-constant problem and the problem of the dimensionality of electric charges have been recently solved in the framework of the DM [5-7]. As it turned out, the coefficient of proportionality *k* in the Coulomb law (2.1) is equal to

$$k = 1/4\pi\rho_0\,, \tag{2.13}$$

where $\rho_0 = 1\, g \cdot cm^{-3}$ is the *absolute unit density of matter*, so that its dimensionality is

$$[k] = g^{-1} \cdot cm^3\ . \tag{2.14}$$

In such a case the dimensionality of the electric charge *q* is

$$[q] = g \cdot s^{-1}. \qquad (2.15).$$

The latter means that ***electric charge is the rate of mass exchange*** (interaction), or briefly the *power of mass exchange*. And the electron charge *e* is the *elementary quantum of the rate of mass exchange* or, simply, the *elementary quantum of exchange*. Thus, the electric charge gains at last the definite physical meaning.

If we now introduce the symbol ε_0 for the absolute unit density, instead of ρ_0, and pass to Coulomb's law (2.1) by putting (2.13), we obtain

$$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}. \tag{2.16}$$

In this case Coulomb's law does not differ *in form* from the commonly used presentation of the law (2.6). However, it essentially differs from the latter *in contents* of its constituents. The law (2.16) is based on the true value of the constant proportionality *k*, where $\varepsilon_0 = 1\ g \cdot cm^{-3}$ is the *absolute unit density of matter*. Whereas (2.6) is based on the "*electric constant*" of the meaningless (as was shown above) value and "dimensionality", (2.5) or (2.7), artificially attributed to Nature by creators of the SI units.

We show below the main expressions (details are in [5-7]), which led to the uncovering of the true dimensionality and meaning of the electric charge. The electron charge is indissoluble related with the electron mass. Therefore, both aforementioned parameters are considered in the next section in their interrelation.

3. The nature of electron mass and electron charge

In accordance with the dynamic model (DM) [5, 8], an elementary particle presents by itself a dynamic spherical formation of a complicated structure being in a dynamic equilibrium with environment through the wave process of the definite frequency ω. The wave shell of a particles represents by itself a characteristic sphere of the radius $r = a$, which restricts the main part of the particle from its field part merging gradually with the ambient field of matter-space-time. Longitudinal oscillations of the wave shell of a particle in the radial direction provide an exchange (interaction) of the particle with other objects and the ambient field of matter-space-time. The *oscillatory speed* of wave exchange at the separating surface (characteristic sphere) of the particle is presented in the form

$$\hat{\upsilon} = \upsilon(kr)\exp(i\omega t), \tag{3.1}$$

where $k = 2\pi/\lambda = \omega/c$ is the wave number corresponding to the fundamental frequency ω of the field of exchange at the subatomic level, and *c* is the wave speed of exchange at this level equal to the speed of light.

The notion *exchange* (instead of *interaction*) is wider and more correct for the DM developed in [5, 6] 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, as the dynamic formations, belonging to one of the interrelated levels of the Universe.

All masses of dynamic formations (micro-particles) in the Universe, according to the DM, have an *associated field character* with respect to the deeper level of the field of matter-space-time; therefore, their own (proper, rest) masses do not exist.

An equation of the power of exchange, at the *exchange of motion*, for a particle with one radial degree of freedom takes in the DM the form

$$m\frac{d\hat{\upsilon}}{dt}+R\hat{\upsilon}=\hat{F}\,, \tag{3.2}$$

where R is the *coefficient of resistance*, or the dispersion of rest-motion at exchange,

$$R=\frac{4\pi a^3\varepsilon_0\varepsilon_r}{1+k^2a^2}ka\omega\,; \tag{3.3}$$

m is the *associated mass* of the particle, or briefly the *mass of the particle*,

$$m=\frac{4\pi a^3\varepsilon_0\varepsilon_r}{1+k^2a^2}\,. \tag{3.4}$$

Here and further $\varepsilon_0=1\,g/cm^3$ is the *absolute unit density*, and ε_r is the *relative density*. The symbol “^” expresses the contradictory (or complex) potential-kinetic character of physical space-fields [9, 10]. The details of the derivation of the above and below presented expressions are in Ref. [5, 6, 8].

The equation of exchange powers, at the *mass exchange*, has the form

$$\frac{d\hat{m}}{dt}\hat{\upsilon}=\hat{F}\,, \tag{3.5}$$

where dm/dt is the *volumetric rate of mass exchange* of the particles with environment, which we call the ***exchange charge***, or merely the charge

$$\hat{Q} = d\hat{m}/dt\,. \tag{3.6}$$

The charge of exchange $\hat{Q}$, obtained from some necessary transformations, has the active-reactive character

$$\hat{Q} = \frac{4\pi a^3 \varepsilon_0 \varepsilon_r}{1+k^2a^2} ka\omega + i\frac{4\pi a^3 \varepsilon_0 \varepsilon_r}{1+k^2a^2}\omega = Q_a + iQ_r\,, \tag{3.7}$$

where

$$Q_a = \frac{4\pi a^3 \varepsilon_0 \varepsilon_r}{1+k^2a^2} ka\omega \tag{3.8}$$

is the *active charge*, and

$$Q_r = \frac{4\pi a^3 \varepsilon_0 \varepsilon_r}{1+k^2a^2}\omega \tag{3.9}$$

is the *reactive charge*.

The active component Q_a (equal to R, see (3.3)) 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, called in contemporary physics the "*electric*" charge (further for brevity, the *charge of exchange* Q) is connected with the associated mass m (3.4) by the relation

$$Q = m\omega\,. \tag{3.10}$$

The *dimensionality* of the exchange charge is $g \cdot s^{-1}$. Thus, the DM reveals the true physical meaning of the electric charge, which is one of the fundamental notions of physics. The exchange ("electric") charge is the measure of the *rate of exchange* of matter-space-time, or briefly the power of mass exchange.

Equation (3.10) determines the ***fundamental frequency of the field of exchange***, which is the distinctive "time" frequency of exchange at the atomic and subatomic levels.

The derivation carried out first in [11] (details can be found in [8], accessible in Internet) leads to the following formula of correspondence between exchange charge Q and Coulomb charge q_C:

$$Q = q_C\sqrt{4\pi\varepsilon_0} \tag{3.11}$$

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

$$e = e_C \sqrt{4\pi\varepsilon_0} = 1.702691555 \cdot 10^{-9} \ g \cdot s^{-1}, \qquad (3.12)$$

where $e_C = 4.803204197 \cdot 10^{-10} \ CGSE_q$ is the Coulomb charge of an electron of the dimensionality $g^{1/2} \cdot cm^{3/2} \cdot s^{-1}$. The exchange charge of the value (3.12) (electron charge) represents an *elementary quantum of the rate of mass exchange*.

On the basis of (3.10) and (3.12), knowing the mass of the electron m_e we find the *fundamental frequency of the wave field of exchange* at the *subatomic level* (the frequency of "*electrostatic*" field)

$$\omega_e = e / m_e = 1.86916256 \cdot 10^{18} \ s^{-1}. \qquad (3.13)$$

The corresponding speed of exchange at the boundary sphere of an electron of the radius r_e is determined by the relation

$$\upsilon_e = r_e \omega_e. \qquad (3.14)$$

We have thus presented the basic concepts and formalism, according to which the problem posed can be treated. We will consider the above data and solutions in their application for elucidation of the equality (1.4). But before to make this, we will explain first the *binary character* of wave motion, directly related to the problem in question.

4. A correlation of basis and superstructure in wave processes

A wave process is a contradictory complex of *basis-superstructure*. In a wave field of exchange of the *basis*, the composite oscillating movement of discrete micro-, macro-, and megaobjects occurs. This motion forms together with the objects the *superstructure* of the wave field.

Thus, the *basis* is the continuous side of the wave process, whereas the *superstructure* represents its discrete side. In turn, the superstructure is a contradictory discrete-continuous complex where the discrete side is represented by an object with a mass *m*, and the continuous side is represented by the oscillatory rest-motion of the object. *Mutatis mutandis*, the basis is characterized by its own internal continuous and discrete sides at the subatomic level.

In other words, a *wave motion* is the *mass process* having the binary character. It means that the wave process of any subspace of the Universe runs simultaneously at the two levels: the level of *basis* and the level of *superstructure*. The *basis level* embraces an interaction of particles between themselves in a subspace. This interaction gives rise to its own *superstructure* – the wave motion – the dynamic collective interaction of particles with the subspace. Here, the *basis* is the *cause* and *superstructure* is the *effec*t. Thus, any wave process is a contradictory complex of *basis* and *superstructure*, of *cause* and *effect*.

At the same time the wave motion is a contradictory process of *rest-motion*. The latter is characterized by strength vectors of rest E and motion B, at the level of the basis, and, respectively, by potential V_p and kinetic V_k speeds [9, 10], at the level of the superstructure.

Let us turn to an example. An interaction of atoms between themselves in a string (fixed from both ends) is a process occurring at the level of *basis* of the string. A disturbance of the equilibrium interaction (caused by an external influence) leads to the expansion of this disturbance along a string, which has the wave character. With this the *oscillatory* speed υ of every atom of the mass m of the string (in the wave of the expansion) and the *wavelength* itself λ_υ represent the collective parameters of the wave motion related to the level of *superstructure*.

The energy of the wave quantum of *superstructure*

$$E = h(\upsilon / \lambda_\upsilon) \tag{4.1}$$

generates, at the level of basis, the equal energy of the wave quantum of *basis*

$$E = h(c/\lambda)\,, \tag{4.2}$$

where c is the *basis* speed.

For instance, the wave motion of a string with the frequency of the fundamental tone ν_1 and wavelength λ_1 generates in a surrounding air an acoustic wave of the same frequency, but with the basis (sound) speed in air c and the wavelength λ_a different from λ_1:

$$\nu_1 = 1/T_1 = \upsilon/\lambda_1 = c/\lambda_a\,. \tag{4.3}$$

The similar situation takes place under disturbance of the hydrogen atom, where υ is the orbital (oscillatory) speed of the electron – superstructure of the H-atom, and c is the wave speed of radiation of the excess energy at the transition of the exited H-atom into the equilibrium state.

The speed c, equal to the speed of light in the last example, is the basis speed of exchange of matter-space-time of the longitudinal (radial) wave field of the proton with the transversal (cylindrical) wave field of the orbiting electron at the *fundamental frequency of exchange* inherent in the subatomic and atomic levels ω_e.

During the motion in a *transient process*, the electron in the hydrogen atom causes the wave perturbation. The myriad of particles of the subelectronic level is involved in this process. They have nothing in common with the mathematical points-photons of zero rest mass and zero rest energy. They represent a huge world of particles-satellites of electrons. For them, Earth is in the highest degree the "rarefied" spherical space. These particles pierce the Earth just freely as asteroids pierce the space of the solar system and galaxies. Just their directed motion, fluxes, called "magnetic field", surrounds a conductor with a current, a bar magnet, our Earth and fills up interplanetary, interstellar, and intergalactic spaces. It is the cylindrical field-space of the subelectronic level.

In a wave process, the associated mass m determines the associated action

$$\hbar_\upsilon = m\upsilon a\,, \tag{4.4}$$

where a is an amplitude of displacement, which is inseparable from the wave action,

$$\hbar_c = mca\,. \tag{4.5}$$

The simplest relation α, characterizing the scale correlation of the superstructure and the basis, is the ratio of the *transverse* wave of the superstructure $\lambda_t = 2\pi a$ to the *longitudinal* wave of the basis $\lambda = c/\nu$ [12] (Fig. 4.1):

$$\alpha = \frac{\lambda_t}{\lambda} = \frac{2\pi a}{\lambda} = \frac{a}{\lambda\!\!\!^{-}} = \frac{\upsilon}{c}\,, \tag{4.6}$$

where $\upsilon = \omega a$ is the oscillatory speed of the wave of superstructure, and c is the wave speed of basis. The same result gives the ratio of the actions (4.4) and (4.5).

Thus (4.6) represents the elementary relations existed between *amplitude* of oscillations, *wavelengths* and *speeds* inherent in the wave process, as a two-level longitudinal-transversal wave system.

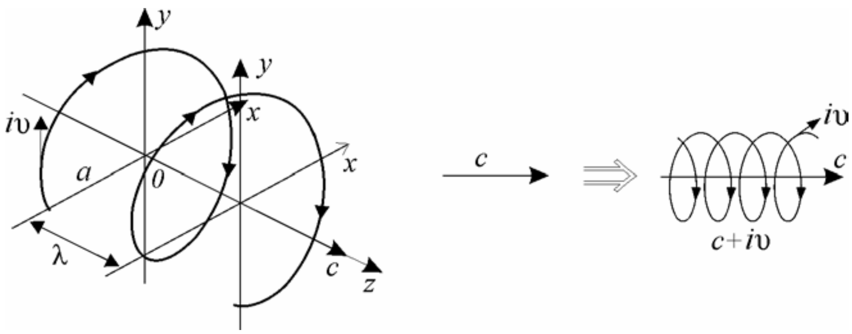

Fig. 4.1. A graph of the longitudinal-transversal wave field; c is the wave (beam) speed of basis, $i\upsilon$ is the circular frontal speed of superstructure.

In the dynamic model of elementary particles (DM) the speeds υ and c have the analogous meaning, namely υ (see (3.1)) is the oscillatory speed of boundary wave shells of particles and c is the base wave (phase) speed of their wave exchange at the subatomic and atomic levels. The ratio of these speeds reflects the firm interrelation (originated from (3.7)), existing between *active* and *reactive exchange charges* related with these speeds:

$$Q_a / Q = ka = \omega a / c = \upsilon / c\,. \qquad (4.7)$$

The *maximal possible* ratio of the oscillatory and wave speeds, which the coupled particles can have, is presented by the *fine-structure constant*, where $\upsilon = \upsilon_0$ is the speed of the electron on the Bohr first orbit:

$$\alpha = \upsilon_0 / c = 7.297352533 \cdot 10^{-3}, \qquad (4.8)$$

Thus, the maximal oscillatory speed which a lighter particle of superstructure can have, with respect to the basis speed c of its interaction (binding) with the conjugate heavier particle of the basis at equilibrium, is defined by the ratio:

$$\alpha = \upsilon_{\max} / c = \upsilon_0 / c\,. \qquad (4.9)$$

We can say, running a few steps forward and generalizing, that this ratio expresses the *scale correlation* of basis and superstructure of wave field-spaces of *objects* or conjugate oscillatory-wave processes in the Universe at different its levels (we show it further).

Let us turn now to the wave dynamics at the level of the axial wave of basis.

We regard a compact section of a linear wave of the mass m as a ***quasiparticle*** [6]. Such a quasiparticle moves with the wave speed c and simultaneously participates in local oscillations with the speed υ. From this standpoint, a running wave can be formally considered as a *flow of quasiparticles* (or a *wave beam*) with two components of the complex speed, namely wave c and oscillatory υ.

Because the quasiparticle of mass m is localized simultaneously on two sublevels of motion, wave and oscillatory, the following relation (originated from (4.4) and (4.5)) is valid

$$\hbar_{\upsilon} = \frac{\upsilon}{c}\hbar_{c}\,. \tag{4.10}$$

Any *oscillating mass* (*i.e.*, a *quasiparticle*, according to the above definition) of any microlevel of the Universe is characterized, in wave space, by an oscillating scalar *amplitude* moment of momentum $\hbar_{\upsilon}$ of the carrying fundamental frequency ω:

$$\hbar_{\upsilon} = m\upsilon_m a = J\omega\,, \tag{4.11}$$

where υ_m is the amplitude speed of displacements, a is the amplitude of displacements, $J = ma^2$ is a scalar amplitude moment of inertia of an oscillating level.

The *amplitude* kinetic energy of the oscillating mass becomes

$$E_m = m\upsilon_m^2/2 = J\omega^2/2 \tag{4.12}$$

or, taking into account (4.10),

$$E_m = \hbar_{\upsilon}\omega/2\,, \tag{4.12a}$$

where $\omega = kc = c/\lambdabar$.

Thus, we can formally consider the wave space as a flow of quasiparticles or moving nodes (or points of the discreteness of the wave field).

The ratio of the amplitude mass m of the compact section, localized in such a node, to the mass of the incompact section m_0 of the same volume is equal to the relative deformation of the beam section,

$$\frac{m}{m_0} = \left(\frac{\partial\hat{\Psi}}{\partial l}\right)_{\max} = \frac{\upsilon_m dt}{cdt} = \frac{\upsilon_m}{c}, \tag{4.13}$$

where $\hat{\Psi}$ is the displacement at oscillations, $dl/dt = c$ is the phase (basis) speed of the wave beam.

From another hand, in the wave process, the change of the extension, Δl, of the wave element of space (along the wave-beam) takes place. The change of the *field mass*, Δm, related with the element of space l, occurs as well. The following relation approximately expresses this peculiarity:

$$\frac{\Delta l}{l} = \frac{\Delta m}{m}, \tag{4.14}$$

where m is the *field mass* related with the quantum of the wave λ.

The Δl is the local change, therefore, $\Delta l = \upsilon\Delta t$. But $l = c\Delta t$, hence we obtain

$$\frac{\Delta l}{l} = \frac{\Delta m}{m} = \frac{\upsilon}{c} = \frac{\omega a}{c} = ka, \tag{4.15}$$

where a is the amplitude of axial displacements.

The axial element of the mass of "*thickening*" m_r (the mass of radiation and scattering of the unit wave quantum, or a *quasiparticle*) along the wave-beam of the basis is thus defined by the equality

$$m_r = \Delta m = \frac{\upsilon}{c} m = mka. \tag{4.16}$$

The local momentum p_r (momentum of superstructure) of a quantum of the mass of radiation m_r can be presented as

$$p_r = m_r \upsilon = \frac{m\upsilon^2}{c} = \frac{h}{\lambda}, \tag{4.17}$$

recalling Louis de Broglie's formula, where $h = 2\pi m\upsilon a$ is the orbital action analogous to the Planck action (constant) (1.7).

If the field mass m is equal to the mass of an electron m_e, regarded as the electron wave λ, and assuming $\upsilon = \upsilon_0$ and $a = r_0$, the wave "thickening" m_r takes the following value

$$m_r = \frac{\upsilon_0}{c} m_e \approx \frac{1}{137} m_e . \qquad (4.18)$$

Thus, we see that the ratio υ_0 / c (1.3) has universal meaning in wave processes whose sources are exited atoms.

As was mentioned above, the ratio α exhibits itself at different levels, not only electromagnetic. An important example related to the level of acoustic waves, presented below, will make this statement clear.

5. Threshold parameters of sound waves perceived by man – an example

One of the dynamic parameters of man is the *threshold of audibility*. The latter is equal to the sound pressure $P_{\min} = 2 \cdot 10^{-4}$ $dyne \cdot cm^{-2}$ at the frequency nearly $\nu = 1122$ Hz in the air under normal conditions (300 K temperature and 1 atm pressure). The acoustic action h_a and acoustic pressure P are related by the equality

$$h_a = mP / \rho\nu , \qquad (5.1)$$

where m is the average mass of air molecules, and ρ is the density of air.

Hence, the minimal acoustic action $h_{a,min}$ on the threshold of audibility of man, corresponding to the minimal sound pressure P_{min}, is

$$h_{a,\min} = m_r u P_{\min} / \rho\nu = 6.627 \cdot 10^{-27} \; erg \cdot s , \qquad (5.2)$$

where $m_r = 28.96$ is the average relative mass of air molecules, $\rho = 1.293 \cdot 10^{-3}$ $g \cdot cm^{-3}$ is the density of air under normal conditions, $u = 1.66053873 \cdot 10^{-24}$ g is the unified atomic mass unit.

We see that the action $h_{a,min}$ (5.2), related to the *acoustic process*, practically coincides with Planck's action (the Planck constant)

$h = 6.62606876 \cdot 10^{-27}\ erg \cdot s$ [13], having the relation to *electromagnetic processes*.

It is no wonder, Nature demonstrates the perfect harmony within any one and between different its levels. A human body contains 9.5% hydrogen atoms; therefore, some of the sensitive parameters of man, at the atomic level, coincide with one of the basic parameters of the hydrogen atom, which is its orbital moment of momentum *h*.

It should also be noted that at the level of the threshold of audibility the minimal threshold amplitude of acoustic oscillations a_{min}, at the frequency 1781.25 *Hz*, is

$$a_{\min} = P_{\min} / 2\pi\rho\upsilon_a \nu = 4.1696 \cdot 10^{-10}\ cm, \tag{5.3}$$

where $\upsilon_a = 3.3146 \cdot 10^4\ cm \cdot s^{-1}$ is the (basis) speed of sound in air under normal conditions. The resulting value coincides with the theoretical radius of the electron sphere r_e,

$$r_e = \left(m_e / 4\pi\varepsilon_0\right)^{1/3} = 4.169588 \cdot 10^{-10} cm, \tag{5.4}$$

obtained from the formula (3.3) in the framework of the dynamic model of elementary particles, where $k^2 r_e^2 << 1$ and $\varepsilon_r = 1$ [8].

On the upper acoustic *threshold of pain*, at the sound pressure $P_{\max} = 10^4\ dyne \cdot cm^{-2}$, the threshold oscillatory speed is

$$\upsilon_{osc,\max} = P_{\max} / \rho\upsilon_a = 2.418 \cdot 10^2\ cm \cdot s^{-1}. \tag{5.5}$$

The ratio of the obtained *threshold oscillatory* speed $\upsilon_{osc,\max}$ to the base *wave* speed in air, sonic speed, $c = \upsilon_a$ is equal to

$$\alpha = \upsilon_{osc,\max} / \upsilon_a = 1/137.08023. \tag{5.6}$$

The resulting value (5.6) almost coincides with the accepted value of the fine-structure constant α (1.2).

Thus, the found regularity for the ratios of the characteristic speeds of basis and superstructure in two different wave processes, electromagnetic (1.2) and sound (5.6), confirms the supposition expressed above that the constant α has the universal character for wave processes. In the light of the last example, the Bohr speed υ_0 is the *threshold* (*limiting*) *oscillatory* speed of the electron on the Bohr first orbit r_0 of the hydrogen atom, whose *basis* wave speed of exchange with an environment is equal to the speed of light *c*.

We proceed now to consider the physical meaning of the α–constant, which is hidden in the right part of the equality (1.4a). Relying on the concepts and formalism presented above, we will derive α in the form (1.1), contained four basic physical constants $e, \hbar, c,$ and ε_0. This time we will base on the energetic features of wave processes.

6. The energies of exchange and their interrelation

Let a set of quasiparticles of a microlevel, representing an elementary mass-volume, moves (oscillates) regularly with an average speed υ by the exponential law

$$\hat{\upsilon} = \upsilon(kr)\exp(i\omega t)\,. \tag{6.1}$$

If this motion imposes on the wave motion with the speed *c*, the *total energy* of a quasiparticle is presented as

$$E = \frac{m(c+\hat{\upsilon})^2}{2} = \frac{mc^2}{2} + mc\hat{\upsilon} + \frac{m\hat{\upsilon}^2}{2}\,. \tag{6.2}$$

The constituent of the total energy,

$$E_{c\upsilon} = mc\hat{\upsilon}\,, \tag{6.3}$$

takes into account the transfer of the additional energy caused by the ordered motion of a quasiparticle. This energy can be also obtained by the following way [6, 11].

For the mass exchange process, with the base speed *c* at the level, the following equation is valid:

$$F = \frac{dm}{dt}c\,. \tag{6.4}$$

Hence, the energy of the wave mass exchange is

$$\hat{E}_{c\upsilon} = \int F d\hat{\Psi} = \int \frac{d\hat{\Psi}}{dt} c dm = c\hat{\upsilon} \int dm = mc\hat{\upsilon}\,, \qquad (6.5)$$

where $\hat{\Psi}$ is the displacement at the motion with the speed $\hat{\upsilon}$. The corresponding *energy density* of the mass exchange is

$$\hat{w}_{c\upsilon} = \varepsilon_0 \varepsilon c \hat{\upsilon}\,. \qquad (6.6)$$

The wave flow of motion with the resulting energy density (6.6) is perceived physiologically as "*pressure*", and therefore it is called a ***pressure***. On the level of solids this (kinematic-dynamic) energy density is termed a ***stress***.

The first term in (6.2) is the *kinematic energy* of the basis level

$$E = \int m \frac{dc}{dt} dl = \frac{mc^2}{2}\,. \qquad (6.7)$$

The *carrier energy of mass exchange* at the basis level, where $\langle dl \rangle / dt = c$, we call it the ***dynamic energy of a particle at the basis level***, is

$$E_c = \int F \langle dl \rangle = \int c \frac{dm}{dt} \langle dl \rangle = c^2 \int dm = mc^2\,, \qquad (6.8)$$

We arrive at the value, which recalls in form the well-known in physics (owing to Einstein) "*relativistic*" energy of particles. The latter appears in manipulations with the fictitious mathematical empty spaces, which were the subject of an interest of some famous scientists, including Einstein. In his formula, the energy $E = m_0 c^2$ (obtained in 1907) is rest energy, because m_0 is *rest mass*. Since contemporary physics is based on the questioned at present manipulations (relativity theory) and the Standard Model of Elementary Particles (SM) (used the notion of rest mass), it cannot explain of principle the nature of the aforementioned "rest" energy.

The first step on the way of understanding of the aforementioned fundamental expression (6.8), from our standpoint, must be uncovering the nature of mass, that has been undertaken in works of the present author with L. Kreidik (see Sect. 3 and References).

The corresponding *density of the dynamic energy* is

$$w_c = \varepsilon_0 \varepsilon c^2\,. \qquad (6.9)$$

The third term in (6.2) is the oscillation energy

$$E = m\hat{\upsilon}^2 / 2 . \quad (6.10)$$

The mass exchange energy at the oscillation level, where $F = \frac{dm}{dt}\hat{\upsilon}$ and $\hat{\upsilon} = d\hat{\Psi} / dt$, is

$$E_{\upsilon} = \int F \langle d\hat{\Psi} \rangle = \int \frac{dm}{dt} \hat{\upsilon} \langle d\hat{\Psi} \rangle = \hat{\upsilon}^2 \int dm = m\upsilon^2 . \quad (6.11)$$

The density of the dynamic energy at the oscillation (superstructure) level is

$$\hat{w}_{\upsilon} = \varepsilon_0 \varepsilon \hat{\upsilon}^2 . \quad (6.12)$$

On the level of solids, the energy density (6.12) is termed a ***modulus of elasticity***.

The densities of mass exchange energy at the basis-superstructure level $\hat{w}_{c\upsilon}$ and the basis level $\hat{w}_c$ are related by the equality

$$\hat{w}_{c\upsilon} = \frac{\hat{\upsilon}}{c} \hat{w}_c . \quad (6.13)$$

The ratio of the density $\hat{w}_{\upsilon}$ to $\hat{w}_{c\upsilon}$ leads to the same result. The experimental data shows that the maximal value of the ratio $\hat{\upsilon} / c$ at which solids destroy, called the *ultimate stress*, is approximately equal to α, namely

$$\hat{\upsilon} / c \approx 1/137 . \quad (6.14)$$

Note that at the level of solids, the basis speed c is equal to the sound speed in them.

Let us turn now to the case, when the oscillatory speed of a quasiparticle υ is equal to the oscillatory speed υ_0 of the electron on the Bohr first orbit r_0; and its mass m is equal to the associated mass of the electron m_e, defined by the formula (3.3),

$$m_e = 4\pi\varepsilon_0 r_e^3 \quad (6.15)$$

where $k^2 r_e^2 << 1$ and $\varepsilon_r = 1$ [6], r_e is the radius of the electron sphere (5.4) [8].

If we apply Equations (6.15) and (3.10) to (6.11), and take into account the condition of the circular motion (cylindrical field) [6], *i.e.*, Kepler's third law,

$$\upsilon^2 r = const\,, \tag{6.16}$$

we arrive at the energy of mass exchange at the *oscillatory* level in the following form:

$$E_\upsilon = m_e \upsilon_0^2 = \frac{m_e^2 \upsilon_0^2}{m_e} = \frac{m_e^2 \omega_e^2 \upsilon_0^2}{4\pi\varepsilon_0 r_e^3 \omega_e^2} = \frac{e^2}{4\pi\varepsilon_0} \cdot \frac{\upsilon_0^2}{r_e^3 \omega_e^2} = \frac{e^2}{4\pi\varepsilon_0 r_0}\,. \tag{6.17}$$

The *oscillatory-wave* energy of mass exchange (6.5) under above conditions is

$$E_{\upsilon c} = m_e \upsilon_0 c\,. \tag{6.18}$$

The ratio of the resulting energies of mass exchange, oscillatory (6.17) and oscillatory-wave (6.18), defines the *fine-structure constant* in the form (1.1) which, according to the definition, contains the fundamental constants $e, \hbar, c,$ and ε_0:

$$\alpha = \frac{E_\upsilon}{E_{\upsilon c}} = \frac{\upsilon_0}{c} = \frac{e^2}{4\pi\varepsilon_0 m_e \upsilon_0 r_0 c} = \frac{e^2}{4\pi\varepsilon_0 \hbar c}\,. \tag{6.19}$$

It is obvious that in the case of the ratio of *oscillatory-wave* energy (6.18) and *wave* (*dynamic*) energy (6.8), equal under the above conditions to $E_c = m_e c^2$, we arrive at the same formula (1.4a), so that finally we have

$$\alpha = \frac{E_\upsilon}{E_{\upsilon c}} = \frac{E_{\upsilon c}}{E_c} = \frac{\upsilon_0}{c} = \frac{e^2}{4\pi\varepsilon_0 \hbar c}\,. \tag{6.19a}$$

Thus, this time considering the energies of particles, participating in the wave motion, we come again to the same fundamental ratio of two characteristic speeds inherent in wave processes.

To complete the picture, let us turn again to the equation (6.8) and express our more expanded insight into the speed of light c and the electron radius r_e.

7. The fundamental quanta of wave exchange

The speed of light c enters as well in the “relativistic” expression for energy of particles, which was introduced in physics earlier than the fine-structure constant a. In this connection, let us recall the role (or a physical meaning if there is any), which was attributed to c in the aforementioned expression. This is necessary for deeper understanding of the present *status quo* with this fundamental constant.

It is a long time since the famous formula

$$E = m_0 c^2 \tag{7.1}$$

was obtained by Einstein as a result of transformations of mathematical (fictitious, empty) spaces. However, hitherto physics has no answer to the principal question, what is the nature of the relationship, which exists between *rest mass* of a particle m_0 and the speed of light c in the formula where motion is out of the question? Or, in other words, why does the speed of light c play the fundamental role for the *internal* energy of a particle?

Contemporary physics, stating only the fact of an existence of the direct relation between the energy and rest mass, considers c^2 merely as the coefficient of proportionality without any objective content. The Standard Model of Elementary Particles (SM) cannot shed light on this matter of principle. By this reason, and not only, it is widely recognized that the SM "*will not be the final theory*" and "*any efforts should be undertaken to finds hints for new physics*" [14]. Experimentalists and theorists all over the world are actively trying to find ways to move beyond the current particle physics paradigm.

The SM was designed within the framework of Quantum Field Theory (QFT), consistent both with Quantum Mechanics and the Special Theory of Relativity. But QFT is not applied to General Relativity and, therefore, the SM cannot unify fundamental interactions with gravity.

There are many promising ideas to replace the SM. In the SM, particles are considered to be points. In String Theory, a "string" is a single fundamental building block for all particles. There are five different theories of strings (three superstrings and two heterotic strings). There is also an underlying theory called M-theory of which all string theories are only. M-theory considers that all the matter in the Universe consists of combinations of tiny membranes, *etc*. However, many problems of the SM are still open.

One of the promising "*hints for new physics*" [14] is the *Dynamic Model of Elementary Particles* (DM) [5]. The latter reveals the mystery of the formula (7.1) (see (6.8)) and logically and non-contradictory elucidates, as we see from all above considered, the nature of the fine-structure constant α. In the DM, particles are pulsing microobjects, *i.e.*, they are dynamic formations but not static. For them, the speed of light c is their base wave speed on which they realize an interaction, *i.e*., ceaseless *wave* exchange of matter-space and motion-rest (matter-space-time for brevity) with environment. In the framework of the DM, the energy (7.1) obtains its natural physical meaning. It is the proper dynamic energy of a particle (as a micropulsar) at the subatomic level, or in other words, its (carrier) *energy of the mass exchange* at this level.

Taking into account that the *speed of light is the base (beam) speed of the wave process*, let us consider the physics of mutual transformations of basis and superstructure, for example, in a wave process at the *galactic field level* [12]. We assume that the propagation of waves (including the light range) with the basis speed c runs like propagation of any material waves, for example, sound waves in an ideal gas. And the absolute speed of every object is a multidimensional (multilevel) speed, which is irrespective of any frames of reference, because this speed is determined by the motion at all (micro-, macro-, mega-) levels in the Universe.

During the definite time interval the beam speed of some wave-basis can rise. The latter does not influence on the total energy of the wave system, which remains equal to zero [6]. In the course of raising the field of motion, the field of rest also rises by the same value. Actually, the additional growth of kinetic energy is compensated in Nature by the increase of potential energy, at the same value but opposite in sign.

When the beam speed reaches the speed of light c and exceeds it, the formation of the superstructure begins. The latter is expressed in an appearance of two mutually perpendicular longitudinal-transverse waves of the oscillatory kind. The resulting speed of such a system, as the vector sum of the initial beam speed c and the additional speed of the superstructure υ, forms the screw cylindrical wave (Fig. 4.1) with the right or left spiral trajectory. Thus, during the superstructure's birth, the beam speed of the wave is transformed into the screw speed.

Hence, the *absolute* speed of an object-satellite, moving along the screw trajectory, will be equal to

$$\hat{C} = c + i\upsilon\,, \tag{7.2}$$

and the modulus of the speed is

$$\left|\hat{C}\right| = \sqrt{c^2 + \upsilon^2}\ , \tag{7.3}$$

where $i\upsilon$ is the frontal kinetic speed of the superstructure, negating the speed of the basis c.

In turn, when the frontal speed $i\upsilon$, as the beam speed υ, exceeds the light speed c, the wave of superstructure becomes the base wave; as a result, one more superstructure rises, *etc*. Thus, the *absolute* speed of a n-wave level becomes

$$\hat{C} = nc + i\upsilon\ . \tag{7.4}$$

The above considered allows us to suppose that the *speed of light c is the fundamental period-quantum* of the wave speed of exchange of matter-space-time. The modulus of the speed of an arbitrary level of basis-superstructure is defined, to within the period c, by the formula (7.2). In fact, at considerable absolute speeds, the mutual speed of the nearest galaxies reaches the speeds compared with the period-quantum of speed c that is observed in astronomy.

The fundamental period-quantum of the wave speed of exchange c defines as well an average discreteness of space at the subatomic level of exchange (interaction). Actually, the *fundamental wave radius* is equal to

$$\lambda\!\!\!^{-}_e = c/\omega_e = 1.60388649\cdot 10^{-8}\ cm\ , \tag{7.5}$$

and its double value, $D = 2\lambda\!\!\!^{-}_e = 0.32\ nm$, correlates with the average value of lattice parameters in crystals.

Taking into account the elementary relations (4.6) existed in wave processes between two particular speeds, oscillatory and wave, and also between amplitude of oscillations, a, and the wavelength, λ, we arrive at the following ratios:

$$\frac{\upsilon_e}{c} = \frac{r_e\omega_e}{c} = \frac{a_e}{\lambda\!\!\!^{-}_e} = \frac{a_e\omega_e}{c}\ . \tag{7.6}$$

From the latter it follows that $r_e = a_e$. It means that the radius of the *electron sphere* r_e can be considered as the *fundamental quantum-amplitude of oscillations* of the field of matter-space-time. The value of the theoretical radius of the electron sphere, originated in the DM from the formula of electron mass (6.15), is

$$r_e = (m_e / 4\pi\varepsilon_0)^{1/3} = 4.16958795 \cdot 10^{-10}\ cm\,, \qquad (7.7)$$

where $m_e = 9.10938188 \cdot 10^{-28}\ g$, $\varepsilon_0 = 1\ g \cdot cm^{-3}$. This radius restricts the main part of an electron from its field part merging gradually with the ambient field of matter-space-time. The oscillatory speed of exchange at the electron sphere (7.7) is

$$\upsilon_e = r_e \omega_e = 7.79363769 \cdot 10^8\ cm \cdot s^{-1}\,. \qquad (7.8)$$

An equatorial electron circumference $2\pi r_e$, regarded as an elementary electron wave of basis, is located two times at the Bohr radius, because

$$r_0 \approx 2(2\pi r_e)\,, \qquad (7.9)$$

as if it were the radial wave. In this sense, the wave sphere of H-atom is the binary electron wave.

We return to the condition (6.16), obtained from the solutions of the wave equation in cylindrical coordinates [6]. Let us apply it to the speeds of transversal oscillatory motion and the radii of two wave surfaces with the radii r_0 and r_e. Then, the speed of oscillatory motion υ_0 on the surface of a sphere of the Bohr radius r_0, calculated on the basis of the aforementioned condition, is turned out to be equal to

$$\upsilon_0 = (r_e / r_0)^{1/2} \upsilon_e = 2.18769219 \cdot 10^8\ cm \cdot s^{-1}\,. \qquad (7.10)$$

The speed obtained almost coincides in value with the Bohr speed. This fact indicates that the proton and electron are formations of the same hierarchical level of the field of basis-superstructure.

The concept touched in this section, on an existence in the Universe the fundamental *period-quantum* of speed c and the fundamental *quantum-amplitude* of oscillations r_e, was put forward for the first time in 1998 [12]. We assume that this concept will be tested further, just like it takes place now with the fine-structure constant introduced first long ago in 1916.

Before to bring a conclusion, let us recall that the fine-structure constant α serves in modern physics as a convenient measure of the *strength of the electromagnetic interaction*. All above considered and the new data, obtained in the framework of the DM, enable expressing the above measure of the strength together, for comparison, with the strengths of strong and gravitational interactions. This possibility is realized owing to the concept of exchange charges (3.10) and energetic relations, originated from the universal law of central exchange (8.2). We proceed now to consider this subject.

8. The strengths of strong, electromagnetic, and gravitational interactions

We brought above the quite strong arguments, which prove that the fine-structure constant α defines the scale correlation of basis and superstructure of wave processes. More correctly, the constant α represent the ratio of two characteristic speeds, namely the threshold oscillatory speed and the basis wave speed. The fine-structure constant, as the combination of basic physical constants, contains the equilibrium dynamic parameters of the electron in the hydrogen atom (e, m_e, υ_0, r_0) (see Sect. 1). The latter represents the simplest proton-electron system, which radiates electromagnetic waves under the definite conditions. Therefore it is no wonder that α enters in the formula of spectral terms of the hydrogen (and hydrogen-like) atom and is used for the estimation of the strength of the electromagnetic interaction.

Basing on the *unified approach*, originated from the DM [8], and the corresponding formula, there is the possibility to compare the "*strengths*" of the three at once fundamental interactions distinguished in modern physics, which is impossible to perform by α. For this aim, we have to take into account the fact that every particular kind of the fundamental interactions (exchange) is defined by the corresponding particular *exchange charge*.

According to the DM [8], the *universal law of central exchange* has the form

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}, \qquad (8.1)$$

where Q_1 and Q_2 are *exchange charges* having the dimensionality $g \cdot s^{-1}$, $\varepsilon_0 = 1\, g \cdot cm^{-3}$ is the *absolute unit density*, 4π expresses the spherical character of the field of the central exchange [8]. The exchange charges Q_1 and Q_2 are defined, in full agreement with the formula (3.10), by *associated masses* of interacting particles and *fundamental frequencies* on which they (as dynamic formations) exchange (interact) with environment at the basis level.

Accordingly, taking into account (3.10), the *universal law of central exchange* (8.1) takes the following explicit (expanded) form

$$F = \omega^2 \frac{m_1 m_2}{4\pi\varepsilon_0 r^2}\,. \qquad (8.2)$$

Here ω is the fundamental frequency of the given basis level; m_1 and m_2 are the associated masses of interacting particles.

At the *atomic and subatomic levels*, the fundamental frequency (accurate to three significant digits after comma) is $\omega_e = 1.869 \cdot 10^{18}\ s^{-1}$ (see (3.13)).

The *fundamental frequency of the gravitational level* ω_g is defined from the expression

$$G = \omega_g^2 / 4\pi\varepsilon_0\,, \qquad (8.3)$$

obtained at the comparison of the universal law of central exchange (8.2) with the particular case of this law, the Newton law of universal gravitation,

$$F = G\frac{m_1 m_2}{r^2}\,, \qquad (8.4)$$

where $G = 6.673 \cdot 10^{-8}\ cm^3 \cdot g^{-1} \cdot s^{-2}$ is the gravitational constant [15]. On this basis we have

$$\omega_g = \sqrt{4\pi\varepsilon_0 G} = 9.157 \cdot 10^{-4}\ s^{-1}, \qquad (8.5)$$

As the measure of interconnection of two particles of the mass *m*, at a distance *r*, one can serve the quantity presented in the form of the potential energy of mass exchange (taken from [6]))

$$E = -\omega^2 \frac{m^2}{8\pi\varepsilon_0 r} = -\frac{Q^2}{8\pi\varepsilon_0 r}\,, \qquad (8.6)$$

defined by the exchange charges $Q = m\omega$. The frequency ω represents in this expression one of the two fundamental frequencies: ω_e (3.13), in the case of strong and electromagnetic interactions, or ω_g (8.5), for the gravitational interactions. The mass *m* is equal to the associated mass of a nucleon m_n, for the strong and gravitational interactions; and it is equal to the associated electron mass m_e, in the case of electromagnetic interactions.

The electron exchange charge $e = 1.703 \cdot 10^{-9}\ g \cdot s^{-1}$ (3.12) responses for the strength of *electromagnetic interactions*, in particular, for interatomic bonds in molecules and crystals [6]. Actually, the energy of electron binding (its absolute value) is equal to

$$E_e = \frac{e^2}{8\pi\varepsilon_0 \lambdabar_e} \approx 4.49\ eV\,, \tag{8.7}$$

where $\lambdabar_e = c/\omega_e = 1.6039 \cdot 10^{-8}\ cm$ is the characteristic distance in wave atomic spaces [8], *i.e.*, the fundamental wave radius (7.5), defined by the fundamental frequency of the subatomic level ω_e; $\varepsilon_0 = 1\ g \cdot cm^{-3}$.

The energy (8.7) practically coincides with the dissociation energy of the molecules: H_2 ($4.48\,eV$), HD (4.51 *eV*), HT (4.52 *eV*) and close to the dissociation energy of the molecules O_2 (5.1 *eV*) and OH (4.4 *eV*) [16] (p. 425), *etc*. The energy of electron binding (8.7) correlates also with the break energy of bindings in molecules and radicals. For instance, reactions $\mathrm{H_2O \rightarrow H + OH}$ and $\mathrm{N_2O \rightarrow NO + N}$ require energy $5.0\,eV$, $\mathrm{NaOH \rightarrow Na + OH}$ requires $4.8\,eV$.

The binding energy (of the electron level) per mole of substance defines the so-called characteristic dissociation energy of chemical bonds

$$E_{d,mol} = E_e N_A = 433.121\,kJ/mol = 103.449\,kcal/mol\,. \tag{8.8}$$

This value is consistent with the experimental data for the break energy of chemical bonds in CH_4 (101 *kcal/mol*), C_2H_4 (104 *kcal/mol*) [17], *etc*.

The electron-binding energy at the distance of the Bohr radius r_0 is

$$E_e = \frac{e^2}{8\pi\varepsilon_0 r_0} = 2.18 \cdot 10^{-11}\ erg = 13.60\ eV\,. \tag{8.9}$$

This value coincides with the ionization energy of the electron in the hydrogen atom.

Strong (nuclear) *interactions* are defined by the *rate of exchange* (exchange charges) *of nucleons*. For example, the exchange charge of a neutron is

$$q_n = \omega_e m_n = 3.1307 \cdot 10^{-6} \ g \cdot s^{-1}, \tag{8.10}$$

where $m_n = 1.67492716 \cdot 10^{-24} \ g$ is the neutron mass. In this case, according to the *shell-nodal atomic model* (multicenter or molecule-like) [18] and the DM [6, 8], the energy of internodal bindings, for example, of the length $r = 1.20 \cdot 10^{-8} \ cm$, has the value

$$E = \frac{q_n^2}{8\pi\varepsilon_0 r} = 20.29 \ MeV , \tag{8.11}$$

which is characteristic for strong (nuclear) interactions.

The resulting value correlates with the experimental data for the binding energy of a neutron in a carbon nucleus and with the threshold energy of (γ, *n*) reactions equal to 18.7 *MeV*; and it is close to the threshold energy 20.3 *MeV* of (*n*, 2*n*) reactions [16] (p. 887), *etc*.

Exchange *gravitational charges* of H-atoms, to which we referrer protons, neutrons and hydrogen atoms, defines the *strength of gravitational interactions*, which are realized on the fundamental frequency ω_g of the gravitational field (8.5). For estimates, we take the average associated mass of H-atoms equal to the unified atomic mass unit

$$m_u = m(^{12}C)/12 = 1.66053873 \cdot 10^{-24} \ g . \tag{8.12}$$

We consider the H-atom of the mass m_u as the fundamental quantum of mass and, simultaneously, as the *fundamental graviton* with *gravitational charge* of exchange q_G equal to

$$q_G = m_u \omega_g = 1.66053873 \cdot 10^{-24} \cdot 9.157 \cdot 10^{-4} \approx 1.52 \cdot 10^{-27} \ g \cdot s^{-1}. \tag{8.13}$$

The energy of fundamental interactions (interchange) on every level (see, for example, (8.7) and (8.11)), originated from the universal law of exchange (8.1), is defined by the square of the exchange charges. In this connection, let the pure number measuring the energy (strength) of the *electromagnetic interaction* is about 1. Then, on this scale, the *strong interaction* has the order of

$$q_n^2 / e^2 = 3.4 \cdot 10^6 , \tag{8.14}$$

and the *gravitation interaction* has the order of

$$q_G^2 / e^2 = 0.8 \cdot 10^{-36} . \qquad (8.15)$$

Hence, the strengths of three fundamental interactions: *strong*, *electromagnetic*, and *gravitational*, relate approximately as

$$10^6 : 1 : 10^{-36} , \qquad (8.16)$$

overlapping the range of 42 decimal orders in magnitude.

We would like to stress finally that the proposed here unified estimation of the strength of the three fundamental interactions is based on the single theoretical concept of exchange interaction formulated in the *universal law of central exchange* (8.2).

9. Conclusion

All above presented shows that the "fine-structure constant" α of the microworld expresses the *scale correlation of threshold states of conjugate oscillatory-wave processes* at different levels of the Universe, including electromagnetic.

In particular, the constant α reflects the scale correlation of *basis* and *superstructure* of wave field-spaces of such objects in the Universe, having the contradictory spherical-cylindrical character, as, for example, the hydrogen atom. The latter represents a dynamic paired centrally symmetrical system. A central spherical component (proton) has the spherical wave field. By this radial field, proton relates (exchanges) with the surrounding field-space and with the orbiting electron. The orbital motion, in turn, is associated with the cylindrical wave field. Both dynamic components of the proton-electron system are described, accordingly, by spherical and cylindrical wave functions [6].

At the electromagnetic field level, the "threshold" speed of oscillations (of superstructure) is equal to the Bohr first speed υ_0, and the wave speed (of basis) is equal to the speed of light *c*. In the above sense, the Bohr speed υ_0 is the threshold (limit) speed of the electron on the stationary (first) orbit in the hydrogen atom.

The physical quantities and fundamental constants, constituted the formula (1.1) of the fine-structure constant, have the definite meaning in the approach presented in this paper. They play the key role in revealing the physical meaning of α. Therefore, it makes sense to recall their sense in conclusion as well.

Mass is the *measure of exchange* of matter-space-time, and an electron of the mass m_e is the *elementary quantum of the mass exchange*.

Electric charge is the *rate of exchange* of matter-space-time, or briefly, the rate of mass exchange of the dimensionality $g \cdot s^{-1}$.

The *electron charge e* is the *elementary quantum of the rate of mass exchange*; and the *electron radius* is the *fundamental quantum-amplitude of oscillations* of the field of matter-space-time.

The *speed of light c* is the *basis wave speed of exchange* of matter-space-time at the subatomic level, or the *fundamental period-quantum* of the field of speed of exchange.

The constant ε_0 is the *absolute unit density of matter* equal to 1 $g \cdot cm^{-3}$.

In view of the approach used here, the energy $E = m_0 c^2$ is the *carrier energy of mass exchange at the basis level*, *i.e.*, the *dynamic energy of a particle at the subatomic level*.

The particular *exchange charges* (squared), responsible for every particular kind of the interactions, can serve as the natural measure of the strength of the fundamental interactions: strong, electromagnetic, and gravitational.

Although this fact was not considered here, nevertheless, towards the end, it should be noted in addition that the value of the inverse "fine-structure" constant α^{-1} is close to the hundredfold measure of the fundamental half-period equal to $\frac{1}{2}\Delta = \pi \log e = 1.3644$. The fundamental period-quantum itself, $\Delta = 2\pi \log e$, follows from the Law of the Decimal Base (the Decimal Code of the Universe) [10, 19, 20].

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