The Fine-structure Constant Got «from Computer»

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Abstract

More than 20 years ago, in 2002 the small book «Vacuum dynamics and the soliton theory of elementary particles» was published that showed Maxwell's model effectiveness in describing elementary particles as solitons in vacuum. Already in this book there was a derivation of the equation for the internal field of electromagnetic soliton (electron), which solution gives the value of the fine structure constant theoretically or, how it used to say R. Feynman, from computer, not putting it there secretly.

Then this calculation was made, but convincing result was not yet achieved because the applied method of calculation has not provided adequate accuracy of the received constant value.

And now, 20 years after, the great dream of physicists at last has become the truth: the fine structure constant was got from that equation with good accuracy and rather simple, using for calculation a customary notebook, so that everybody who wants can do it without hard work.

Keywords: fine-structure constant, physical vacuum, elementary particle, soliton, electromagnetic field.

1. Introduction

What at first glance seems to be empty space, in fact appears for the modern physics as a greatest mystery of the Universe. Now there are no doubts that vacuum actually is a particular medium, which manifests itself in most different effects [1].

Hardly will we ever for certain know what a surprising medium is underlying all the reality around us providing the harmony of the Universe.

However it is quite possible to study it, in particular, by means of the most known *method of physical modeling* based on the reliable experimental data.

There are most different representations of the inner structure of vacuum, but preference, apparently, should be given to the model of James K. Maxwell. More than one and a half centuries back he had presented original mechanical model of vacuum (ether), which has given him an opportunity to derivate famous equations of electromagnetic field remained substantially unchanged up to now.

Thus, the Maxwell's equations actually describe properties of vacuum as medium, and the model visually shows how it is possible to imagine the processes occurring in this extraordinary medium.

Now the importance of Maxwell's model is in the full scale revealed because it has also shown itself as the unique tool for creating electromagnetic (soliton) theory of elementary particles.

In the mentioned monography [2] by means of the Maxwell's model was shown, how the elementary energy excitations in the form of rotating electromagnetic solitons arise in vacuum. These energy structures really are universal elements, which form the substance.

The elementary energy excitation of vacuum, as dynamic object, has numerous remarkable properties:

- A rotating soliton due to its characteristics (energy and impulse of rotating field, diameter and the period of rotation) satisfies Heisenberg's uncertainty principles;

- The angular momentum of the soliton (spin) is equal to $\hbar/2$, and the magnetic moment - to a magneton $e\hbar/2m$ (depends on mass or total energy of a particle), where $\hbar$ - reduced Planck constant; e, m - electric charge and mass of a particle - soliton;

- The energy of a soliton consists of the same amount of electric and magnetic field energy and the total energy is equal to the minimum energy of the equivalent quantum oscillator $\hbar\omega/2$;

- The ratio of the width of rotating electromagnetic field layer to the diameter of rotation of a soliton is equal to a fine structure constant α.

- The internal field of a soliton has areas, both with positive, and with a negative divergence of the electric field, but the total charge is different from zero, so the elementary soliton as a whole always has either negative, or positive charge $\pm e$.

The Maxwell’s model has enabled in detail to study and visually to interpret complex dynamic processes taking place in vacuum during the rotation of the soliton. As a matter of fact, it’s about previously unknown types of electromagnetic field.

In particular, it was shown, that the interior rotating field of a soliton includes both azimuth (transverse) and radial (longitudinal) components of wave, as well as related with it special component bound with particular tension in vacuum that creates the electric field divergence, different from zero (charge).

The external field of a soliton is pulsating and includes both constant component (due to the charge), and variable components in the form of standing waves having an infinite number of harmonics. The magnitude of the external field is determined by the fine structure constant.

The interaction between solitons is provided through external fields. The energy-mass exchange generates, ultimately, quantum-mechanical laws of a microcosm, and also underlies regularities of the masses series of fundamental particles.

The successful experience of extending of the electromagnetic theory to the area of fundamental particles, which now is confirmed also by theoretical calculation of the fine structure constant, testifies to adequacy and efficiency of the original Maxwell's model as a tool of research of vacuum – universal primary medium.

Just like the number π, that is, the ratio of the circumference of a circle to its diameter, can be considered as a sign of Euclidian space, so the vacuum also can be characterized by the fine structure constant α - parameter of elementary energy excitation of vacuum, which is equal to the ratio of the width of the layer of a soliton's rotating field to the diameter of rotation.

It should be emphasized that the representation of fundamental particles as solitons in vacuum does not contradict modern scientific ideas about the laws of the microcosm, but on the contrary, enables us to look at problems of fundamental physics from other point of view. The opportunity to theoretically calculate and give a visual physical interpretation of a fine structure constant is evidence of the fruitfulness of this approach.

2. Maxwell's vacuum

The properties of vacuum are so unusual that by Maxwell's own admission he had to think for a long time, before he could offer the famous mechanical model imitating properties of ether or light-bearing medium.

But he never identified the model with real vacuum and considered it just as the research tool, making changes to the model when it was necessity to solve with convenience the concrete problem.

Therefore here we shall remind the most important properties of model and we shall try to present it in the most simplified form [3].

According to the model (fig. 1) all space is filled by very small «bubbles» (named by Maxwell as «molecular vortices») reminding adjacent cells, which, thus, form hard «framework» of vacuum. Bubble's shells can move and be deformed only in tangential direction. That is, the walls of bubbles remind movable rubber shells, while the interior contents of the bubbles are immobile and non-deformable.

Between bubbles there are extremely small particles, which transmit without slippage motion of shells from one bubble to other bubble, so the shells of bubbles rotate in the same direction. These extremely small particles (between bubbles) collectively behave like a kind of liquid.

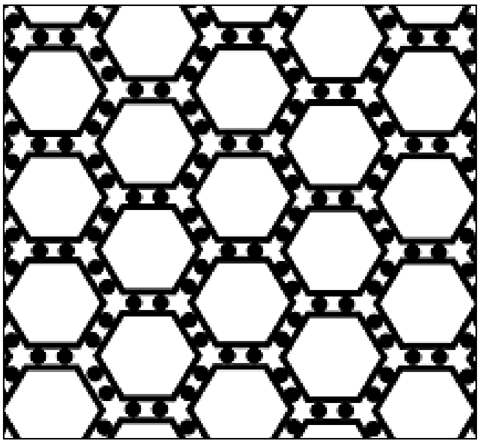

Fig. 1. Maxwell's vacuum [3]: the adjacent cells in the form of polyhedra make a hard structure of vacuum; the rotation of shells of these bubbles is transmitted through extremely small particles, which collectively behave like a kind of liquid being between bubbles (cells).

Maxwell has shown that the size of bubbles has no key value for the analysis. Therefore we shall figure that each bubble - cell of vacuum occupies conditional unit volume of space.

In addition, for the convenience of analysis, it is always possible (in any concrete point of space) to arrange the coordinate system so that one of axes coincided with the axis of rotation of the bubble shells, that is, with a direction of a magnetic field. For example, in a fig. 2 magnetic field is directed from the reader perpendicular to the plane of a figure. Cells can also be presented as cylinders, so that the linear velocity of each shell is the same everywhere and then this velocity can be considered as analog of the magnetic field strength ***H***. Accordingly, mass of an elastic shell of the cell (cylinder) is analog of magnetic permeability of vacuum μ_0. So, the impulse of a shell is similar to the magnetic induction $\boldsymbol{B}$, and the kinetic energy of shell of a cell, occupying a unit volume of space, will be analog of the magnetic field energy density w_m

$$B = \mu_0 H, \qquad w_m = \frac{\mu_0 H^2}{2} = \frac{B^2}{2\mu_0}. \tag{1}$$

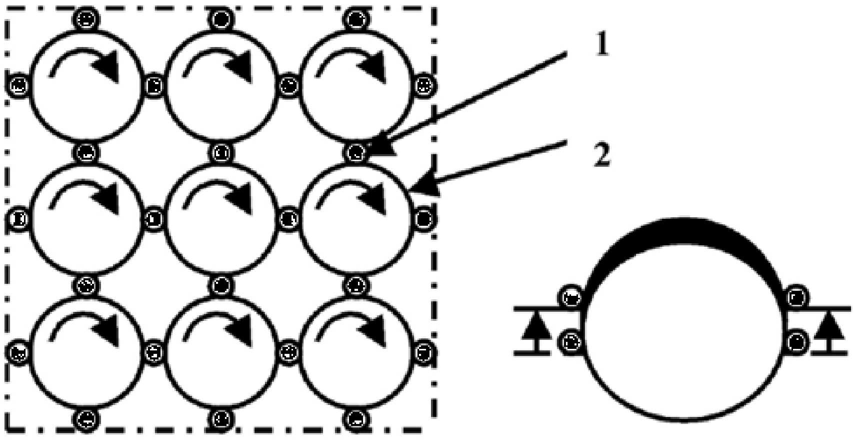

Fig. 2. The simplified Maxwell's model: the small particles 1 transmit a motion from a shell to a shell, forcing them to rotate in the same direction; cells are represented as cylinders 2. Tangential deformation of a wall of a cell on the right is conditionally shown as a result of displacement of small particles liquid.

In order to prevent nonlinear effects the deformation of a wall of a cell is assumed to be small and is considered as analog of electric displacement field $\boldsymbol{D}$. Accordingly elasticity coefficient of a wall is compared to the inverse value of dielectric constant of vacuum $1/\varepsilon_0$. The force with which the deformed shell wall acts on small particles is analog of an electric field strength $\boldsymbol{E}$; and the energy of elastic deformation of a unit cell wall corresponds to the energy density of the electric field w_e

$$E = \frac{1}{\varepsilon_0} D, \qquad w_e = \frac{D^2}{2\varepsilon_0} = \frac{\varepsilon_0 E^2}{2}. \tag{2}$$

And at last, the non-zero divergence of the electric field (density of charge) can be represented as a deviation from the average density of small particles liquid between walls of cells (fig. 3). It occurs in a case, when the degree of compression of one wall does not meet the degree of stretching of other adjacent wall. Really, as between particles and walls of cells there is no slippage, so the compression of one of the adjacent walls increases density of particles in the gap between the walls; and the stretching of the other adjacent wall, on the contrary, reduces density of particles. The resulting density will be determined by the action of these opposite factors.

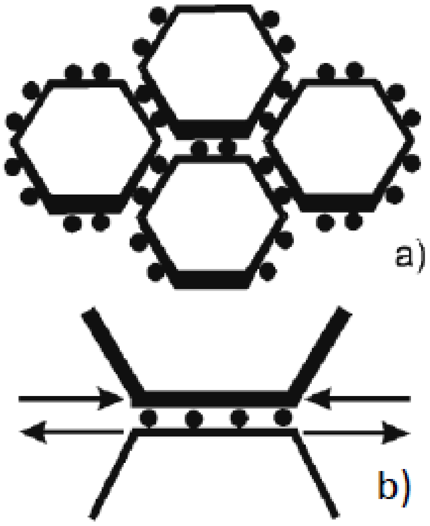

Fig. 3. At a uniform deformation of shells (a) density of particle's liquid in the gap between walls meets the average value. If the degree of compression of one of the adjacent walls (b) exceeds the degree of stretching of other adjacent wall (compression is conditionally shown by thicker line, and stretching – by thin line), then in the gap between walls there are more particles and density raises.

The deviation from average density of particles creates the effect of volumetric charge density and is determined by the formula

$$\rho = divD. \quad (3)$$

Thus, the mechanical Maxwell's model so organically imitates the properties of electric and magnetic fields, that there is no need to enter the designations of mechanical quantities separately.

Having made these preliminary remarks, we will show how the Maxwell's model can be used to illustrate various processes occurring in vacuum.

A. Electromagnetic field equations

First of all, let's consider well-known electromagnetic field equations, named after their creator James Maxwell.

Immediately note that these famous equations are only a special case, although very important, from all the variety of energetic excitations and processes, which can occur in vacuum. This special case represents transverse electromagnetic waves, but charges and currents are introduced as some extraneous concepts which are not produced by vacuum itself. This kind of electromagnetic field corresponds to model, in which particles between cells can rotate, but cannot be displaced and make a forward motion.

So, imagine the model of undisturbed vacuum and mentally mark on fixed walls of each cell the points which have an identical position, for example, corresponding to the position of the hands, when they show exactly 12 o'clock. In the perturbed vacuum the marked points of model will move along with the cell walls, and the values of path traveled by each point ψ will characterize the dynamic process taking place in vacuum. Values ψ simultaneously can be considered as phases of rotation of cell shells.

For example, if there is a constant magnetic field in some area of space, then the phases of rotation ψ will increase uniformly with time, and the cell walls will not deform. If we are dealing with an alternating electromagnetic field, then in model of vacuum the rotation speed of shells (and values ψ) will be different, that will cause mechanical tension and walls deformation.

Let's take a closer look at how it happens. In fig. 4 the fragment of vacuum model is shown as a chain of three cells interacting with each other.

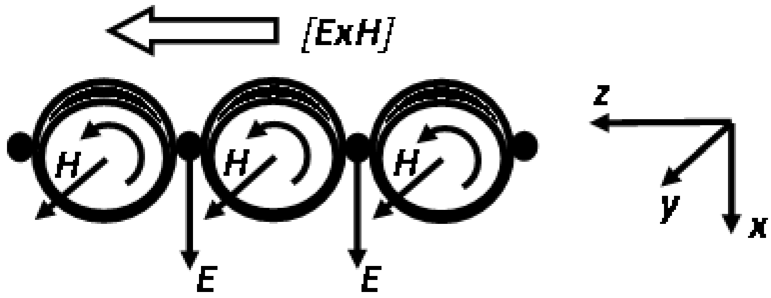

Fig. 4. The fragment of vacuum model is shown as a chain of three cells interacting with each other. The magnetic field ***H*** is directed to us perpendicular to the plane of the figure along the coordinate axis y; the electric field ***E*** (the force acting on small particles) is directed downwards along the coordinate axis *x*. Thus, the electromagnetic field energy flow (vector product ***[ExH]***) is directed to the left along the axis *z*.

It is clear that in the conditions specified above, the phases of rotation differ from each other only at the expense of deformation of walls of adjacent cells. Therefore, the value of the electric displacement (deformation) is expressed by space coordinate *z* derivative of ψ. Thus, the magnetic field force (velocity) is determined by time derivative of ψ:

$$D = \frac{\partial \Psi}{\partial z}, \qquad H = \frac{\partial \Psi}{\partial t}. \tag{4}$$

The energy flow in the chain of three cells in fig. 4 is directed to the left according to the vector product formula ***[ExH]***. It is easy to see this, for example, by considering the effect of forces on the meddle cell. Really, the surface velocity at the right side of the cell coincides with the direction of the force with which small particle is acting on this surface, and at the left-hand side velocity and force have the opposite directions. Therefore, at the right side cell accepts energy, and at the left - donates it further through the chain in direction *z*.

Generally, the forces acting on the right side and on the left side of a medial cell may not equal each other, and then the rotation of the cell surface will either accelerate or slow down. Writing down the equation of motion of the cell surface (second Newton's law), we get at the same time the Maxwell's equation for the magnetic induction and the wave equation

$$\frac{\partial B}{\partial t} = -rotE, \qquad \mu_0 \frac{\partial^2 \Psi}{\partial t^2} = \frac{1}{\varepsilon_0} \frac{\partial^2 \Psi}{\partial z^2} \qquad \left(\frac{1}{c^2} \frac{\partial^2 \Psi}{\partial t^2} = \frac{\partial^2 \Psi}{\partial z^2} \right), \qquad c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}. \qquad (5)$$

The minus sign in front of *rotE* is explained by the fact that the forces acting on the cell surface are opposite to the forces ***E***, with which the cell surface acts on small particles (the force of action and the force of reaction have opposite directions).

The equation (5) reflects the fact that taking in account formula (4) and the unit cell size the difference of forces acting on the left side and on the right side of the cell surface (-*rotE*) is proportional to the ψ derivative of the second degree in coordinate

$$-rotE = \Delta\left(\frac{1}{\varepsilon_0} D \right) = \frac{1}{\varepsilon_0} \frac{\partial^2 \Psi}{\partial z^2}. \qquad (6)$$

The solution of the equation (5) is the wave propagating at the speed of light *c*.

Thus, the wave properties of vacuum are determined by its ability to accumulate a magnetic field energy (kinetic energy) and electric field energy (potential energy of elastic deformation) and by the possibility of their mutual transformation. The speed of propagation of the field (speed of light *c*) is determined by the properties of vacuum – dielectric permittivity and magnetic permeability (elasticity coefficient $1/\varepsilon_0$ and density μ_0).

In view of expressions (4) and taking into account the propagation of the field at the speed of light (5), we get well known relations

$$H = \frac{\partial \Psi}{\partial t} = \frac{\partial \Psi}{\partial z} \cdot \frac{\partial z}{\partial t} = D \cdot c. \qquad (7)$$

$$w_m = \frac{\mu_0 H^2}{2} = \frac{\mu_0 D^2 c^2}{2} = \frac{D^2}{2\varepsilon_0} = w_e. \qquad (8)$$

Let's note that the electrical displacement ***D*** according to Maxwell's model can have different nature. Or it is the deformation of a cell surface caused by dislocation of a liquid of particles, as it is shown in fig. 2 on the right, or it is a consequence of dynamic processes, when cells slow down or accelerate their rotation by acting on each other.

If the rotation speeds of the right and left cells are different (fig. 4), then also the phase difference of their rotation will change with time. It means that the degree of deformation of the medial cell surface will change accordingly. In the language of formulas this process is expressed by one more Maxwell's equation (for the displacement current):

$$rotH = \frac{\partial D}{\partial t}. \qquad (9)$$

As it can be seen, the displacement current is explained by model simply and naturally. The varying deformation plays role of the conduction current density j, which creates a non-zero magnetic field rotor. This causes to rotate in opposite directions the cells located on opposite sides of the conduction current (fig. 5).

$$rotH = j. \qquad (10)$$

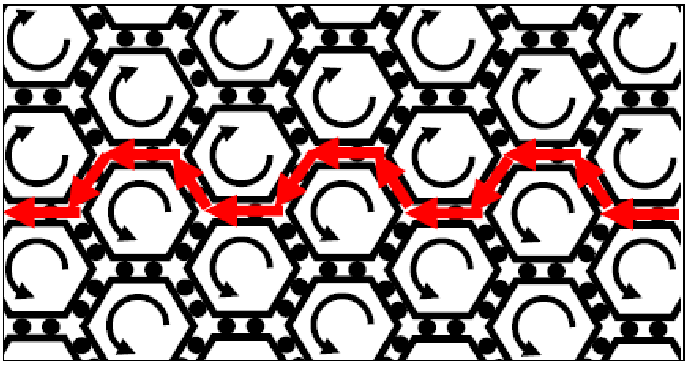

Fig. 5. The cells located on opposite sides of the conduction current rotate in opposite directions [3].

In the Maxwell's theory the external charges and currents create the electromagnetic field, and the vacuum itself, figuratively speaking, is considered as neutral medium

$$divD = 0, \qquad divH = 0, \qquad \mu_0 \frac{\partial H}{\partial t} = -rotE, \qquad \varepsilon_0 \frac{\partial E}{\partial t} = rotH. \qquad (11)$$

Under these conditions, the electromagnetic waves in vacuum can be represented as the solution of classical Maxwell's equations (11).

B. Self-organization of electromagnetic field in vacuum

Actually a lot more complex and interesting processes take place in vacuum, what determines the electromagnetic field's ability to self-organize. This most important property of vacuum arises (according to the Maxwell's model) due to ability of small particles between cells to shift and to create «neutral currents» (not related to the motion of ordinary charged particles).

Let's consider these processes taking an example of a closed electromagnetic energy flow in the form of elementary vacuum excitation with cylindrical symmetry - rotating electromagnetic soliton. Representatives of such sort of solitons are the simplest elementary particles of substance, such as electron, muon and tau.

So, let's imagine that the motion of small particles between cells can be diverse. They can not only rotate in place, but also move in space, rolling over the surfaces of cells, or like a liquid consisting of particles be forced through the gaps between the cells, causing deformation of their surfaces.

A typical example of such a displacement of particles is the action of electrical charge on vacuum - static electric field (fig. 6).

The shaded area in the centre of the figure shows a part of the space with a non-zero divergence of electric field – the electric charge. In this case density of a liquid of particles in shaded area is less than the average value (charge negative), that is, some of particles are displaced from this area. As a result, the excess liquid of particles in surrounding space is uniformly forced into the gaps between cells, causing deformation of their surfaces (is conventionally shown by thickenings of cells walls).

Thus, the static electric field is a reaction of cells surfaces to the pushing of liquid of particles into the gaps between cells. The resulting elastic deformation force (electric field *E*) prevents this movement and acts on small particles in an opposite direction, that is, the field is directed to the centre.

As the field divergence in surrounding space is equal to zero, the particles here behave as an incompressible liquid, and the deformation of cells surfaces decreases in inverse proportion to the square of the distance from a charge

$$D = \frac{Q}{4\pi r^2}. \qquad (12)$$

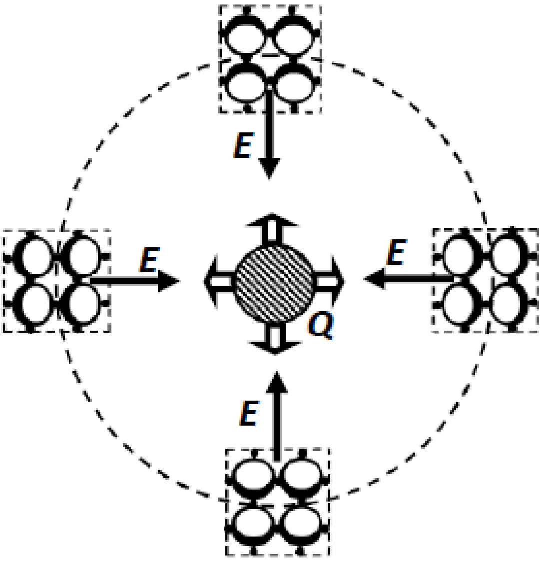

Fig. 6. Negative charge *Q*: some volume of a liquid of particles from central shaded area is displaced into environmental space. As a result, deformation of cells surfaces occurs and the counterforce (electric field *E*) acts on a liquid of particles (is directed to the centre).

Thus, the electric charge (according to Maxwell's model) is considered as area of vacuum having deviation of density of particles from the average value, and the magnitude of the electric charge Q is some volume of a liquid of particles, pushed or drawn into this area.

The deformation of cells surfaces indicates the energy costs associated with the formation of an electric charge. Denoting as R the radius of the area, where the charge is allocated, and taking into account formula (12) we get the total energy of the spherically symmetric electric field in the space, surrounding the electric charge, by integrating the energy density:

$$W = \int_R^\infty \frac{D^2}{2\varepsilon_0} \cdot 4\pi r^2 dr = \frac{Q^2}{8\pi\varepsilon_0} \int_R^\infty \frac{dr}{r^2} = \frac{Q^2}{8\pi\varepsilon_0 R}. \qquad (13)$$

The formula (13) can be interpreted as the energy cost of pushing the volume of liquid of particles Q out of the area having radius R; at the same time, the growing pressure (potential φ) is overcome.

In view of the formula (12) we get:

$$\varphi = \int_R^\infty E dr = \int_R^\infty \frac{1}{\varepsilon_0} \frac{Q}{4\pi r^2} dr = \frac{Q}{4\pi\varepsilon_0 R}, \qquad W = \frac{1}{2} Q\varphi. \qquad (14)$$

The multipliers ½ in the formula for energy reflects the fact that pressure (potential) and volume of a liquid of particles (charge) are related to each other and change simultaneously.

Let's now proceed directly to the analysis of the electromagnetic soliton with rotating field [2] (fig. 7).

As a first approximation, let's figure that the magnetic field of a soliton is completely concentrated inside the cylindrical gap between the outer r_0 and inner r_1 radiuses and does not change in a radial direction.

Just as in volumetric resonators the surface currents limit the electromagnetic field location area, so in soliton the neutral currents J_0, which are formed as a result of small particles rolling on surfaces of cells, shape cylindrical boundaries of the soliton structure.

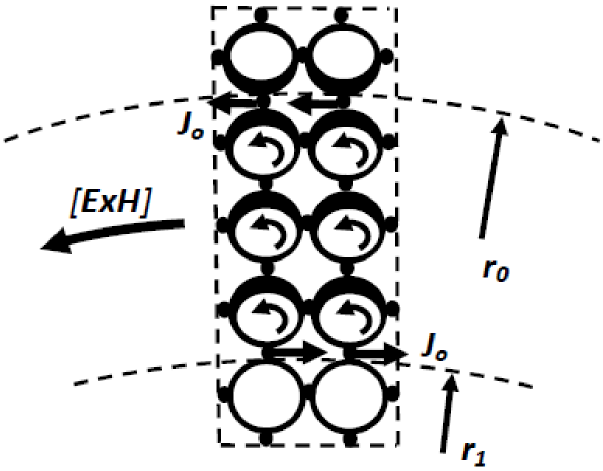

Fig. 7. The rotating electromagnetic soliton. As a first approximation, it is assumed that the magnetic field is completely concentrated inside the cylindrical gap between the outer r_0 and inner r_1 radiuses; the electrostatic field of a soliton arises in the inner active area (between cylinders), but mostly occupies the outer area $r > r_0$.

The outer area of the soliton, as a first approximation, is represented by electrostatic field. In this area, the crosslinking of fields occurs, namely, a cylindrically symmetrical field in the immediate vicinity of the outer boundary of the active area is crosslinked with a field having spherical symmetry at large distances from the soliton (fig. 8). At the same radius value r_0 the outer surface of the cylinder is equal to the surface of the sphere when the height of the cylinder l is equal to its two radiuses

$$S = 2\pi r_0 \cdot l = 4\pi r_0^2, \quad l = 2r_0. \tag{15}$$

Based on this, the potential of an electric field directly on the outer cylindrical surface of the soliton is related to the electric field value on the same surface by a formula valid for a spherical charge of radius r_0.

$$\varphi(r_0) = E_0 \cdot r_0. \tag{16}$$

The relation (16) follows directly from the formula for electrostatic potential (14).

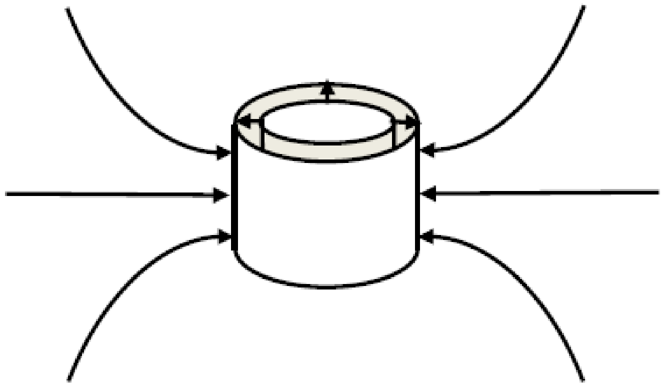

Fig. 8. The crosslinking of a cylindrically symmetrical electric field, which exists in the immediate vicinity of the soliton, with a field having spherical symmetry at large distances from the soliton.

Exactly the same potential value should be obtained when integrating the electric field in a gap between interior and exterior radiuses of active area

$$\varphi(r_0) = \int_{r_1}^{r_0} E(r)dr = E_0 \cdot r_0. \qquad (17)$$

Thus, there is a balance between pressure acting on a liquid of particles in active area and pressure from the outside, where the electrostatic field of soliton (electric charge) acts.

The equation for the interior electromagnetic field of a soliton is based on the equality of energy density of magnetic field in each point of active area to the total energy density of electric field (equations (7), (8)). The result is the equation (18), the solution of which enables us to calculate a fine structure constant

$$\frac{D_0^2}{2\varepsilon_0} = \frac{D^2}{2\varepsilon_0} + \frac{1}{2}\frac{D}{\varepsilon_0} \cdot D_e - \frac{1}{2}\varphi \cdot divD,$$
$$D_e = D_0 \frac{r_0}{r} - D, \qquad \varphi = \frac{1}{\varepsilon_0}\int_{r_1}^{r} D(r)dr. \qquad (18)$$

Here are the necessary explanations to the equation (18).

Density of a magnetic field energy in a left-hand side of the equation is written using some imaginary quantity D_0 of electric displacement ($H = cD_0$). On the right side of the equation (18) there are three components of the energy density of the electric field. The equation contains a usual electric displacement D (deformation) and electric displacement D_e, related with displacement of a liquid of particles by the electrostatic field, originated in active area. The relation between three types of electric displacement is based on the assumption that the magnetic field does not change in a radial direction, and that the soliton rotates as a whole (the propagation velocity of the field is proportional to the radius of rotation).

$$H = cD_0 = c\frac{r}{r_0}\cdot(D + D_e), \qquad D_e = \frac{r_0}{r}D_0 - D. \tag{19}$$

The term of the equation, containing the divergence of the field, has a minus sign, since the energy created by the charge in the external space has the opposite sign to the energy costs of the inner area (where the charge is formed).

Here again the principle of action and counteraction manifests itself.

And at last, the component of energy density of the electric field associated with the electrostatic displacement of small particles D_e reflects energy costs of overcoming the forces of elasticity of cells walls D/ε_0. In this case, the multiplier ½ occurs for the same reasons as the other energy components (simultaneous emergence and growth of interrelated parameters).

The equation (18) taking into account the formula (19) can be written in the following form

$$\frac{D_0}{2\varepsilon_0 r_0} = \frac{D}{2\varepsilon_0 r} - \frac{1}{2}\frac{\varphi divD,}{D_0 r_0}. \tag{20}$$

In such form the equation can be clearly interpreted. The actual domed envelope line of the soliton in the azimuth direction can be replaced by an isosceles triangle (fig. 9). Then the left-hand part of the equation (20) can be considered as an electric field rotor on the leading and trailing edges of the soliton, consisting of two components. The first component is the steepness of the front, created by conventional electric field, and the second rotor component is interlinked to energy of the volumetric electric charge (electric charge energy divided by the phase raid within the front $\psi_0 = D_0 r_0$).

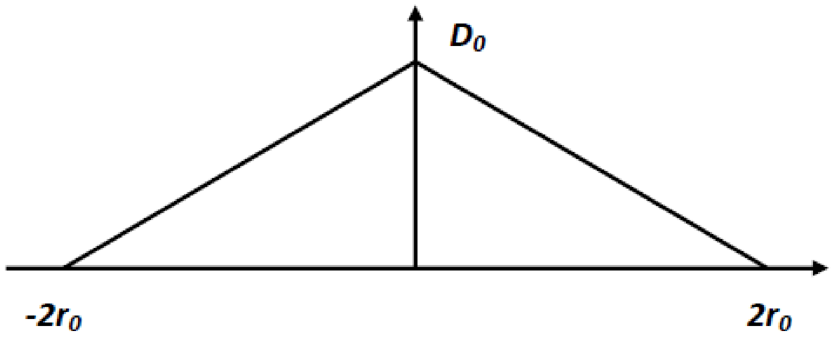

Fig. 9. The scanning of the soliton envelope according to azimuthal coordinate (actual dome envelope of the soliton is replaced by linear approach as isosceles triangle).

The solution of the equation (20) enables to define the boundaries at which the rotational motion of the electromagnetic field is possible subject to all above mentioned conditions.

Previously it can be argued that the outer radius of the soliton is limited by inability to propagate the electromagnetic field at a speed exceeding the speed of light. As for the inner radius, it is determined by the whole set of dynamic processes in active area, that is, mathematically it is the result of the self-consistent solution, and physically this is a result of soliton's self-organization.

The fine structure constant characterizes the power of the electromagnetic interaction (ratio of the energy of the external field of electron to its total energy - mass). That is, this constant determines the external field value of a soliton (the electric charge), which, according to developed model [2], depends on ratio of the width of the rotating field layer to the diameter of rotation (item 4).

3. Solution of the equation for the internal field of a soliton

The numerical solution of the equation (20), taking into account capabilities of modern computers, is not difficult. In addition, only the relative values of the variables included in the equation matter, since the left and right sides of the equation can be simultaneously multiplied (or divided) by any number. Therefore it is possible to use the simplest form of writing the equation

$$\frac{D}{r}-1=\varepsilon_0\varphi\left(\frac{D}{r}+\frac{dD}{dr}\right), \qquad \varepsilon_0\varphi=\int_{r_1}^{r}D(r)dr. \qquad (21)$$

Here $D_0=1$, $r_0=1$, and variables D, r are considered as relative values. Besides, in formula (21) the expression for divergence in cylindrical coordinates (in brackets) is written in the presence of only the radial component of the field.

It is convenient to start solving the equation (21) by calculating reliably determined values near the outer radius of the soliton.

Let us set some arbitrary value of the inner radius r_1, meaning, that outer radius is equal to unity. As the soliton is rotating as a whole (*[ExH] ~ r*), the electric field should be on the average proportional to radius, providing a total energy flow in the azimuth direction.

Based on these reasons, we get the potential magnitude on the outer surface of the soliton

$$\varepsilon_0 E \approx D_0\frac{r}{r_0}, \qquad \varepsilon_0\varphi_0=\int_{r_1}^{r_0}\varepsilon_0 E dr=\frac{1-r_1^2}{2}. \qquad (22)$$

The sign of approximate equality in expression for the electric field strength (22) reflects the fact that *the formation of the non-zero divergence of electric field is due to radial oscillations in the soliton,* which cause radial flows of energy [2], however the total energy flow in the azimuth direction (and value of $\varepsilon\varphi_0$) thus remains unchanged.

Knowing the potential value on the outer surface of the soliton (22), it is possible to determine the magnitude of electric field on the outer surface of the soliton (17)

$$\varepsilon_0\varphi_0 = \varepsilon_0 E_0 r_0, \qquad \varepsilon_0 E_0 = \frac{1-r_1^2}{2}. \tag{23}$$

This value is simultaneously equal to the value of electrostatic component of the electric displacement in active area at the outer surface of the soliton. From here, regarding (19), we get the electric displacement in dynamic area at the outer surface

$$D_e = \varepsilon_0 E_0 = \frac{1-r_1^2}{2}, \qquad D(r_0) = D_0 - D_e = 1 - \frac{1-r_1^2}{2} = \frac{1+r_1^2}{2}. \tag{24}$$

After that, it is possible to proceed to the step-by-step solution of the equation (21).

Dividing the difference between the outer radius $r_0 = 1$ and the arbitrarily selected value of the inner radius of active area $r_1 = 0.99$, for example, by 500, we get the step value $dr = 2\cdot10^{-5}$.

From the equation (21) we get the derivative of electric displacement and the increment value dD (multiplying the derivative value by the step value dr)

$$\frac{dD}{dr} = -\frac{D}{r} + \frac{1}{\varepsilon_0\varphi}\left(\frac{D}{r} - 1\right). \tag{25}$$

Having calculated the concrete values, we can fill in the first table row ($r = 1$) in the program Excel, which will further allow us to calculate and to fill in the next row etc. (tab. 1). The potential ($\varepsilon_0\varphi$) is determined by subtracting the product of current electric field (D) by the step value dr from potential value of the previous row. As additional (reference) information the table shows values of a divergence of the field and the magnitude of the nascent electrostatic field D_e (19).

Table 1

	R	$\varepsilon_0\varphi$	D_e	divD	dD	D
1	1	0,00995	0,00995	1	3,98E-05	0,99005
2	0,99998	0,00993	0,00993	0,995991803	3,972E-05	0,99009
3	0,99996	0,00991	0,00991	0,991975398	3,964E-05	0,99013
4	0,99994	0,009891	0,009891	0,98795075	3,956E-05	0,990169
- - -	- - -	- - -	- - -	- - -	- - -	- - -
496	0,9901	9,88E-05	0,019088	-8,29061474	-0,000146	0,990911
497	0,99008	7,9E-05	0,019254	-8,762247615	-0,000155	0,990765
498	0,99006	5,92E-05	0,01943	-9,388138914	-0,000168	0,99061
499	0,99004	3,94E-05	0,019618	-10,32178524	-0,000186	0,990442
500	0,99002	1,96E-05	0,019825	-12,17931124	-0,000224	0,990256
501	0,99	-2,3E-07	0,020069	*144,10443*	*0,0029021*	0,990032

As a result, the large table was formed by step-by-step calculation of values included in the equation starting from the outer boundary of soliton active area and ending with its interior boundary. The numbers in the last row marked with the underscore, apparently, do not make sense, since the corresponding potential value has already passed zero.

In fig. 10 the solution for the dynamic electric displacement *D* in active area depending on radius is shown.

The function *D(r)* has many remarkable properties, which are discussed in detail in [2]. In particular, from the table 1 and the fig. 10 follows, that in a soliton there are areas both with positive, and with a negative divergence of electric field, and the presence of the resulting charge indicates the prevalence of one area over another.

The equation (21) implies the boundary condition that must be met at the inner boundary of the active area. As potential value here is equal to zero, the ratio *D/r* should be equaled to unity

$$(D/r)\big|_{r=r_1} = 1. \qquad (26)$$

As can be seen from the last row of the table 1, the condition (26) is not met ($D - r_1 \neq 0$) for arbitrary selected value $r_1 = 0.99$.

Therefore the task is to find a value of interior radius r_1 that satisfies the boundary condition (26).

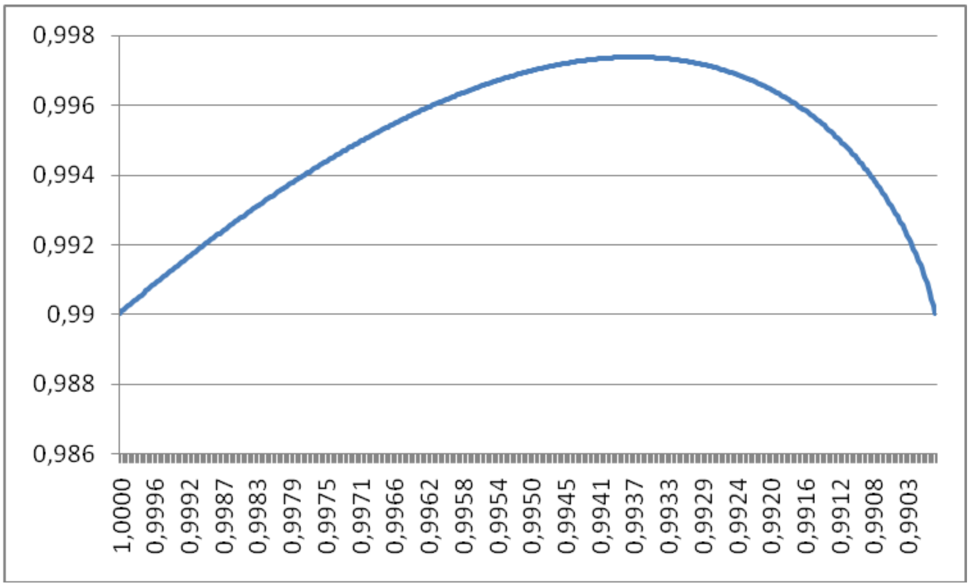

Fig. 10. Dependence of the dynamic electric displacement D on the radius r in active area.

The selection of r_1, at which the boundary condition (26) is met, does not take much time and gives the following result: r_1 = 0.96204573 and $D\text{-}r_1 \sim 1.5\cdot 10^{-10}$. Having further calculated the corresponding ratio $a = (1\text{-}\ r_1)/2 \approx 0.018977$, we get a value that more than twice exceeds the known value of the fine structure constant α ($\alpha \approx 1/137.036 \approx 0.007297353$).

The calculation result naturally cannot be considered as satisfactory, though this result is very important qualitatively, as it shows that the equation has the solution, and that this solution has an order of magnitude of the fine structure constant.

To increase the accuracy of calculation it is logical to divide the segment (1- r_1) into smaller steps and repeat the integrations. Such calculations were carried out for sequentially increasing partition numbers:

1000, 1500, 2000, 2500 and 3000 steps. The result is shown in the table 2 and in the fig. 11.

Table 2 (to compare: $\alpha \approx 1/137.036 \approx 0.007297353$).

Number of partition	*1/a*	*a*
1000	73,412	0,013622
1500	89,636	0,011156
2000	103,495	0,009662
2500	115,82	0,008634
3000	127,056	0,007871

The dotted line in the fig. 11 corresponds to the actual value α.

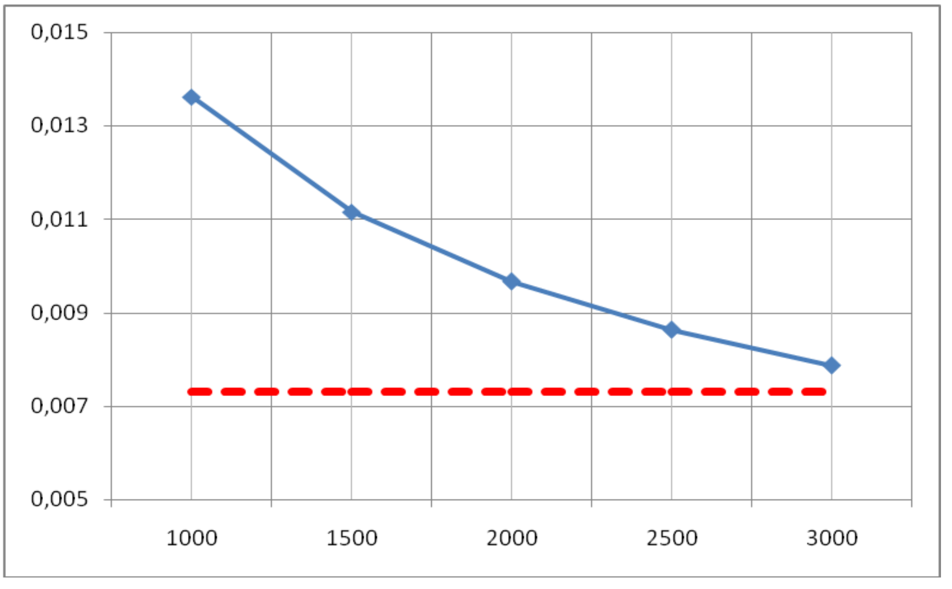

Fig. 11. The result of calculations of the ratio $a=(1- r_1)/2$ for different partition numbers of integration segment. The dotted line corresponds to the actual value of the fine structure constant α.

It is clear, that the ratio approaches the value of the constant α, however the accuracy of calculations turns out to be insufficient even with the number of partition 3000.

How can the accuracy of calculations be significantly improved?

First of all, we have to pay attention to the form of the function *D(r)*, which resembles the trajectory of a projectile, first gaining altitude and then falling steeper down (fig. 10). The dependence of the field divergence on radius (fig. 12) also indicates a sharp change in the function *D(r)*. It is on the steep section of the function *D(r)* adjacent to the inner boundary of the dynamic area that the greatest errors in calculations occur.

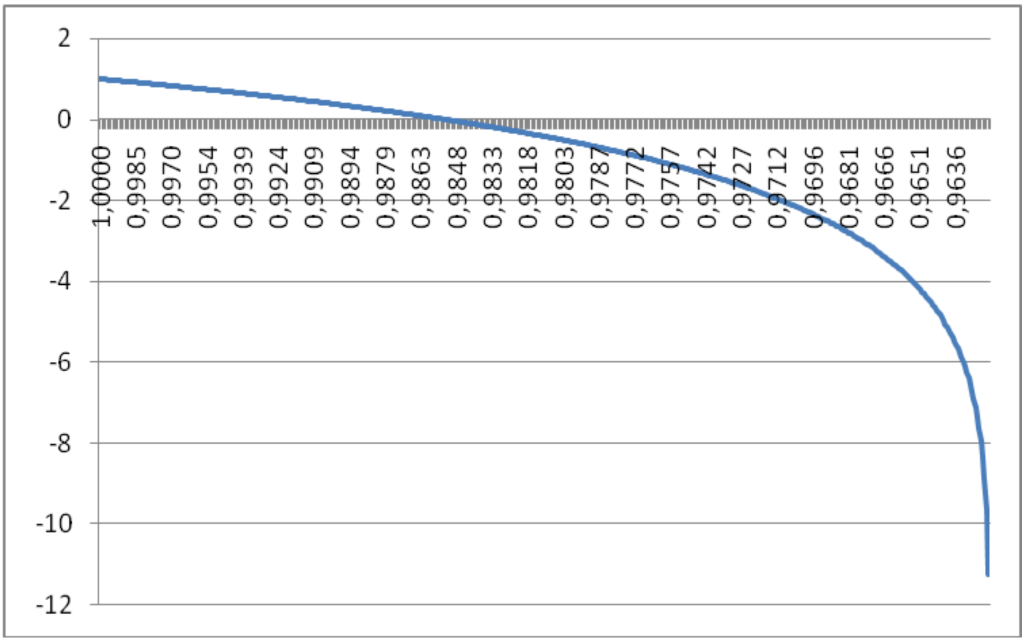

Fig. 12. At the inner boundary of active area of a soliton the change of function div*D* sharply increases (almost vertical part of the curve).

Therefore to improve the accuracy of calculations, the segment of last ten integration steps adjacent to inner radius r_1 was also divided into 1000, 1500, 2000, 2500 and 3000 steps. So, next to each basic table (similar to the table 1) there are tables for small integration segments having the same number of rows. In the first row of each additional table the values of the eleventh row from the end of the basic table must be recorded (the increment *dD* should be recorded taking into account the change in the integration step).

The results of calculation are represented in table 3 and in fig. 13.

Table 3. The results of calculation with additional partitioning of the segment, including 10 last integration steps of basic table (for matching: $\alpha \approx 1/137.036 \approx 0.007297353$).

Partition number	*1/a*	*a*
1000	145,6198	0,006867
1500	138,8744	0,007201
2000	139,2981	0,007179
2500	136,8916	0,007305
3000	136,8392	0,007308

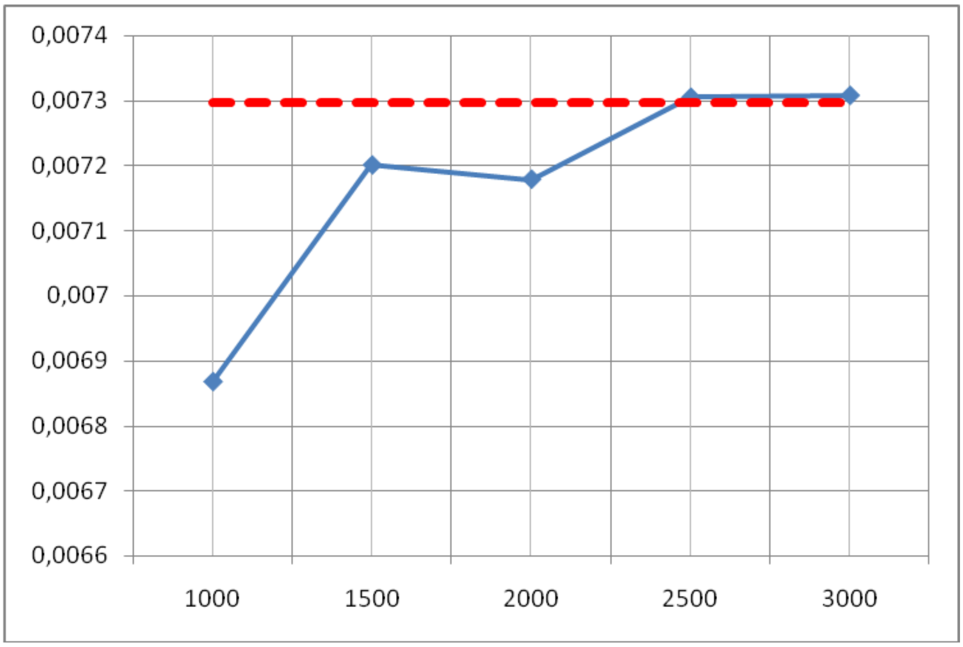

Fig. 13. The results of calculation of the ratio $a=(1- r_1)/2$ at various partition numbers of the integration segment with additional partition of the small segment, including 10 steps adjacent to the interior radius. The dotted line corresponds to actual value of the fine structure constant α.

To get even smaller integration step on the steepest section of the function $D(r)$ the same calculation was made with additional partition of the small segment consisting not of ten but only of five last steps of basic tables.

The results are represented in table 4 and are shown in fig. 14.

Table 4. The results of calculation with additional partition of 5 last integration steps (for matching: $\alpha \approx 1/137.036 \approx 0.007297353$).

Partition number	*1/a*	*a*
1000	147,4057	0,006784
1500	139,596	0,0071635
2000	136,73	0,0073135
2500	137,15	0,00729125
3000	137,019	0,00729825

The accuracy of calculation in general turned out to be really higher.

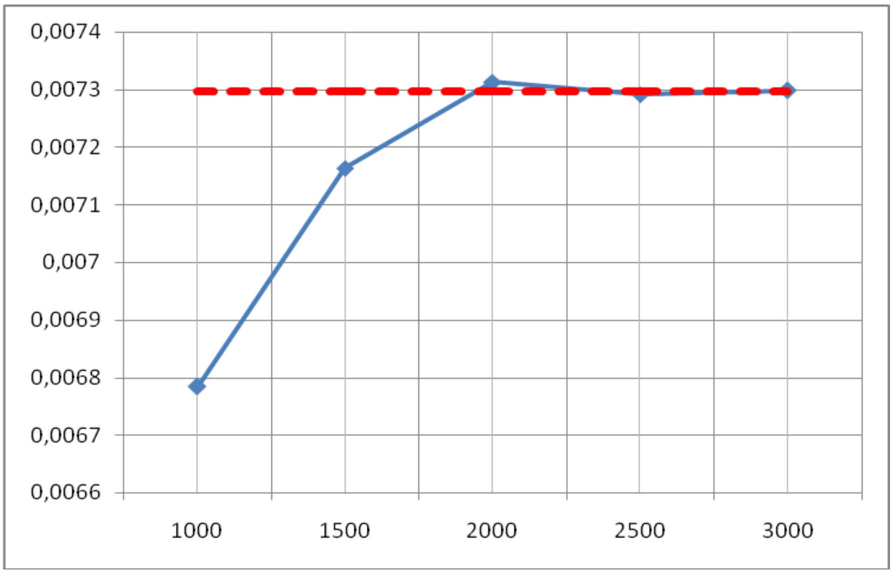

Fig. 14. The results of calculation of ratio $a=(1- r_1)/2$ at various partition numbers of the integration segment with additional partitioning of the small segment, including 5 steps adjacent to the inner radius. The dotted line corresponds to the actual value of the fine structure constant α.

This quite satisfactory result was obtained due to the extremely small integration step on the problem segment adjacent to the inner boundary of dynamic area (~ $8.11 \cdot 10^{-9}$ at partition number 3000 and with additional partitioning of the small segment, including last 5 integration steps of the basic table). At the same time as the integration step in the basic table at partition number 3000 is much larger (~ $4.87 \cdot 10^{-6}$).

Use of this trick made it possible without powerful computing tools to overcome difficulties caused by the mentioned feature of the function *D(r)* at the inner end of the integration domain.

It reminds a known fairy tale, in which the Koshchei's death was very inventively hidden at the tip of a needle, and needle was hidden in an egg etc. But the Nature, as we have seen, not less ingeniously hides its secrets.

4. Basic characteristics of an electron

The fine structure constant determines microcosm properties. As we have seen, this main physical constant is the general characteristic of the structure of rotating solitons and consequently underlies properties of these bricks of substance.

Using the example of an electron, as the most elementary fundamental particle, we shall show how its inner structure defines and units all the characteristics of a rotating soliton.

First of all, we shall pay attention to the resonant character of formation of the electron-positron pair (particle and its antiparticle) from quantum of electromagnetic energy. Therefore the frequency of soliton rotation is equal to the frequency of the original quantum, whose energy corresponds to twice the mass of the electron. From here we get the electron radius

$$2mc^2 = \hbar\omega = \hbar\frac{c}{r_e}, \qquad 2r_e = \frac{\hbar}{mc} = \lambda\!\!\!^{-}_k = 3{,}86 \cdot 10^{-13}\,м. \qquad (27)$$

Thus, the diameter of the electron is equal to known value of Compton wave length of the electron.

The width of the rotating electromagnetic field layer is equal to the so-called classical electron radius

$$\Delta = \alpha \cdot 2r_e = \alpha \lambda\!\!\!^{-}_k = 2{,}82 \cdot 10^{-15}\, м. \tag{28}$$

The spin of a soliton does not depend on mass

$$S = mc \cdot r_e = mc \cdot \frac{\hbar}{2mc} = \frac{\hbar}{2}. \tag{29}$$

The fine structure constant (the ratio of the energy of the external field to the total energy-mass of a soliton), taking into account (27), is expressed in terms of other constants

$$\alpha = \frac{W_e}{W_0} = \frac{e^2}{8\pi\varepsilon_0 r_e} : \hbar\frac{c}{2r_e} = \frac{e^2}{4\pi\hbar c\varepsilon_0} = \frac{e^2}{2hc\varepsilon_0}. \tag{30}$$

Neglecting the scattering fields and considering that electrical and magnetic field energies are equally represented in a soliton, it is possible to estimate the average values of the internal fields of the electron. For this purpose, we divide half of the total energy of the electron by the volume of the dynamic area

$$\frac{\mu_0 H^2}{2} = \frac{\varepsilon_0 E^2}{2} \approx \frac{W_0}{2} : 4\pi r_e^2 \Delta. = \frac{\hbar c}{4r_e} : 8\pi r_e^3 \alpha = \frac{\hbar c}{32\pi r_e^4 \alpha}. \tag{31}$$

Taking into account (30), we get:

$$E = \frac{\hbar c}{2r_e^2 e}. \tag{32}$$

$$H = \frac{\hbar}{2\mu_0 r_e^2 e}. \tag{33}$$

The magnetic moment is equal to the product of the magnetic field (33) by the volume, occupied by it

$$P \approx \frac{\hbar}{2\mu_0 r_e^2 e} . \cdot 4\pi r_e^2 \Delta = \frac{h}{\mu_0 e} \frac{2r_e e^2}{2hc\varepsilon_0} = ecr_e = \frac{e\hbar}{2m}. \tag{34}$$

That is, the magnetic moment of an electron is equal to the Bohr magneton.

Using the formulas (32) and (28), you can also easily make sure that the magnitude of the potential on the outer surface of an electron is equal to the potential difference in the dynamic area of an electron and balances it

$$\varphi_0 \approx E \cdot \Delta = \frac{\hbar c}{2r_e^2 e} \cdot 2r_e \frac{e^2}{2 \cdot 2\pi\hbar c\varepsilon_0} = \frac{e}{4\pi\varepsilon_0 r_e}. \tag{35}$$

From here, as a test reverse calculation, taking into account (30), we obtain the dependence of α on the parameters of an electron structure

$$\Delta = \varphi_0 / E\cdot = \frac{e}{4\pi\varepsilon_0 r_0} \div \frac{\hbar c}{2r_0^2 e} = \frac{e^2}{2hc\varepsilon_0} \cdot 2r_0 = \alpha \cdot 2r_0, \qquad \alpha = \frac{\Delta}{2r_0}. \quad (36)$$

Such simplified calculations of averaged characteristics of a soliton are possible due to the very small value of the fine structure constant ($\alpha \approx 1/137.036$), so that practically the whole energy-mass of a particle is concentrated in its internal structure.

The remarkable conclusion that follows from the expression (30) is that the elementary charge depends only on the properties of the vacuum and Planck's constant (energy density per hertz)

$$e \approx \sqrt{\alpha} \cdot \sqrt{2hc\varepsilon_0}. \quad (37)$$

But the most amazing vacuum property is the fine structure constant, which is determined only by the vacuum structure. This constant is an inherent property of the vacuum itself and to some extent reminds number π, characteristic of Euclidean space.

5. Conclusion

Now we can say with confidence that the myth of the impossibility to obtain the fine structure constant for general reasons has finally been dispelled. Maxwell's mechanical model, simulating the properties of vacuum, implicitly already comprises a fine structure constant. The main constant of physics turned out to be a characteristic of the elementary energy excitation of the vacuum.

Without Maxwell's model the fine structure constant cannot be deduced theoretically. Having actually thrown out the concept of ether from the theory (and, therefore, the model of vacuum), physicists have cut off the possibility of developing electrodynamics for a long time. The Maxwell's equations, unlike the model of vacuum, do not comprise all the opportunities for describing various electromagnetic phenomena in vacuum.

The model of vacuum is irreplaceable laboratory for research and development of electrodynamics. Especially diverse processes occur in vacuum during the formation of elementary energy excitations (rotating electromagnetic solitons) – universal bricks that make up the substance.

Thus the most complex pattern of fields is observed in dynamic area of a soliton limited by special neutral currents that are not associated with conventional charge carriers. It is in this thin layer of the dynamic area that the bulk of the soliton energy is concentrated.

Conventional transverse (azimuth) waves and longitudinal radial waves here interact with each other; therefore there is a non-zero divergence of the electric field, that is, the soliton charge is formed.

In this area the complex dynamic processes of self-organizing of the electromagnetic field are developing, as a result of which the thin layer of rotating electromagnetic field is formed. The ratio of the width of this layer to the diameter of rotation determines the fine structure constant value.

The remarkable physicist, the Nobel laureate R. Feynman said [4] that it is desirable to be able to consider the same problem from different points of view; it would be useful for a modern theoretical physicist to have a wide range of different physical points of view on the same theory. Certainly, the truth may lie just in the fashionable direction. But if it can be found only in another way, obvious from an unpopular point of view in the field theory, who will find it then?

Now we can say with confidence that the electromagnetic soliton theory of elementary particles, as the alternate view of Nature, has proved to be fruitful.

Remarkably that in this search for an extraordinary solution of a problem the help has come from James Clerk Maxwell, who a century and a half ago has proposed an ingenious model of vacuum.

As is known, author of the famous equations of electromagnetic field considered them as the description of properties of the ether - a special medium that fills the entire space. Most likely, in those far times he did not realize that substance too is a special form of a self-organizing field.

The mechanical ether model was the scaffolding for the electromagnetic field theory. But then the ether, and hence the Maxwell's model was abandoned. And the field equations began to be considered not as the description of vacuum (ether) properties, but as the mathematical description of the field properties in empty space. On this occasion R. Feynman said that the perfect building of the electromagnetic theory holds on by itself without the scaffolding with which it was build.

It can be said that the field equations thus have gained independence, but at the same time the theory of the electromagnetic phenomena has lost both the visibility, and the ability to develop. The conditionality of the electromagnetic phenomena by the properties of ether as primary light-bearing medium, which was obvious to Maxwell, was lost.

The dissatisfaction with the lack of a complete logical physical picture of the world, consisting of actually unrelated separate fragments, has always been incentive to search for the foundations on which the unity of the world is based. Only now it becomes clear that at the heart of everything there is a basic element of Nature, which is considered to be emptiness or vacuum. This is a special primary medium that occupies the entire space of the Universe, and its energy excitations represent radiation and matter as different forms of electromagnetic field. The exclusion of ether from the theory, which occurred more than a hundred years ago, became an insurmountable obstacle to achieve understanding of the Nature unity, since the strange medium called vacuum or ether is just the basic element or quintessence of the entire Universe.

The extension of Maxwell's theory to the description of elementary particles has revealed new properties of vacuum, including, mechanism of rotation of the electromagnetic soliton associated with electric charge formation. The most elementary particle of substance has appeared to be a complex dynamic structure, in which previously unknown field types are involved. From the outside the solitons are surrounded by standing waves, including the basic frequency and harmonic components, through which the solitons interact with each other.

The undoubted advantage of the soliton theory is its visibility and ability to represent the parameters of fundamental particles in their unity and interrelation, based on the internal dynamics and the soliton structure. On this basis, it is possible to comprehend a character of all kinds of interactions that exist in nature, including gravitational interaction.

The interaction between solitons on basic frequencies and harmonic components creates conditions for establishing a general equilibrium in the Universe and formation of the universal characteristics as well as regularities of mass numbers of elementary particles.

Over the years, the soliton theory of elementary particles has essentially strengthened its positions as one of the most fruitful points of view on processes occurring in the microcosm.

However the potential of the soliton theory of elementary particles is far from being exhausted and new discoveries are waiting for us ahead.

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