Electromagnetic nature and structure of cosmic vacuum

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This article was published like chapter 2 in the Leonov's book: Quantum Energetics. Volume 1. Theory of Superunification. Cambridge International Science Publishing, 2010, pp. 68-166. Space vacuum is a specific electromagnetic field which in the region of the ultra microworld of Leonov's length of 10^{-25} m can be considered as a static electromagnetic field. Electromagnetic phenomena (electric and magnetic fields, electromagnetic waves) arise in a cosmic vacuum as a result of the violation of its electromagnetic equilibrium. Gravitational phenomena (gravitation and antigravity) arise in a cosmic vacuum as a result of its deformation (Einstein's curvature). The carrier of this electromagnetic field is quanton and quantized space-time. The analytical derivation of Maxwell's equations was first obtained by me as a result of electromagnetic polarization of the quantized space-time. The quantized space-time is carrier of superstrong electromagnetic interaction (SEI) - fifth fundamental force (Superforce). SEI is a global electromagnetic field permeating our entire universe.

2 .1. Introduction

The discovery of the space-time quantum (quanton) and the superstrong electromagnetic interaction (SEI) was used as the basis for developing the Superunification theory combining, in the first stage, electromagnetism and gravitation. A very simple equation with a deep physical meaning was derived for the general description of magnetism and gravitation:

$$\Delta x = \pm y \tag{2.1}$$

where Δx and Δy is the displacement of the electrical e and magnetic g elementary charges – quarks from the equilibrium state inside the quanton in the quantised space-time, m. The sign (–) in (2.1) determines the electromagnetic interactions caused by electromagnetic polarisation of the quantised space-time. Equation (2.1) can be transformed quite easily into the main equations of the electromagnetic field in vacuum together with solutions to these equations. The sign (+) in (2.1) corresponds to gravitation interactions caused by spherical deformation and, according to Einstein, by the 'bending' of the quantised space-time.

Electromagnetism and gravitation can be combined as a result of the application of two global Einstein concepts: 1) the concept of the united field, combining electromagnetism and gravitation, 2) the concept of determinism of quantum theory in the path of unification with the theory of relativity. For this purpose, it was necessary to return to physics the absolute space-time, as an elastic quantised medium whose fundamental property is the principal relativity. The quantised space-time is the united Einstein field, the field form of weightless primary matter, which is a carrier of the superstrong electromagnetic interaction (SEI). The elementary particle of this united field is the space-time quantum (quanton) which is also the carrier of electromagnetism and gravitation interactions.

To discuss further the problems and properties of quantised space-time in the path of unification of electromagnetism and gravitation, it is necessary to evaluate the current state of physical science which was described very accurately by Academician S.P. Novikov in a discussion at the Presidium of the Russian Academy of Sciences: 'I think that we can now talk about the crisis in world theoretical physics. The point is that many extremely talented scientists, well-prepared for solving the problems of the physics of elementary particles and the quantum theory of the field, have become in fact pure mathematicians. The process of mathematisation of theoretical physics will not have the happy end for science [1]. The well-known English theoretical physicist, Nobal Prize Laureate S. Weinberg note: 'basically, physics is entering some era in which the experiments are no longer capable of casting light on fundamental problems. The situation is very desperate. I hope that the sharp of experimentators will find some solution to the situation' [2].

The solution was found when the following were discovered in 1996: the space-time quantum (quanton) and superstrong electromagnetic interaction (SEI). New fundamental discoveries have made it possible within 10 years to complete work on the development of the theory of the elastic quantised medium (EQM) and the theory of Superunification of fundamental interactions.

The new fundamental discoveries were made 'om the tip of the feather' as a result of analysis of a large number of experimental data in the area of electromagnetism, photon radiation, gravitation, the physics of elementary particles and the atomic nucleus, neutrino physics, astrophysics. From the theoretical viewpoint, the Superunification theory is the theory of open quantum-mechanical systems which could not previously been investigated in theoretical physics but which has made it possible to combine quantum theory with the theory of relativity. The physics of the open quantum-mechanics systems is the physics of the 21st century which provides a large amount of additional information on the universe, without changing the well-known fundamental physical laws, and explains for the first time the mechanisms of their action.

The physics of the 20th century can be characterised basically as the physics of closed quantum-mechanics systems although in reality, as shown by analysis of the discoveries, there are no such systems in nature. In fact, there are only open quantum-mechanics systems. Because of the fact that the physical realities were not realised, a crisis occurs in physics where any elementary particle or solid, including cosmological objects, were regarded as isolated objects, i.e. like matter in itself [3], not linked with the quantised space-time. This approach inhibited the unification of interactions because only the quantised space-time is the carrier of the integrating superstrong electromagnetic interaction (SEI). The SEI is the fifth unification force, more accurately the Superforce. Only the large force can sunjugate a smaller force. This is the golden rule of mechanics, including quantum mechanics.

Attempts to find the fifth force started in physics long time ago [4], and there were no united views on this subject. Russian physicists assumed that the fifth force is 'something incredibly weak' [5]. The views in the West are opposite. The well-known English theoretical physicist and science populariser Paul Davis in his book Superforce says: 'the entire nature, in the final analysis, is governed by the effect of some superforce, reflected in different 'hypostases'. This force is sufficiently powerful to create our universe and provide it with light, energy, matter and give it a structure. However, the Superforce is something greater than something creating the beginning. In the Superforce, matter, space-time and interaction are combined into an inseparable harmonious body generating such unity of the universe which was not assumed by anybody' [2]. Later, using the Superunification theory, Davies formulated the concept of the Superforce which fully corresponds to the new fundamental discoveries of the quanton and the SEI.

However, even earlier, at the beginning of the 20th century, H. Lorentz, developing the theory of electrons on the basis of the aether consideration of weightless matter, predicted 'that it is the medium which is the carrier of electromagnetic energy and transporter of many, probably all forces, acting on the matter with a mass' [6]. However, this was only the brilliant forecast of the integrating 'superforce', and the search for this Superforce had lasted almost a century.

Further, attempting to combine electromagnetism and gravitation, Albert Einstein formulated the scientific concept of the united field, determining the new direction of investigations [7, 8]. It is unjustifiably assumed that Einstein did not exceed in the development of the united theory of the field. It is sufficient to quote Academician A.F. Ioffe: 'Einstein was also convinced that there is a united field, and that gravity and electromagnetism are different manifestations of this field. He worked constantly on the development of the united theory of the field but he could not develop this theory. However, Einstein could not leave this serious problem. He spent more than 30 years of his life, up to his death, working on this problem and could not study any other problem for 30 years' [9].

This was the opinion of Einstein's followers and they were very wrong.

Einstein specified a direction to uniting interactions and this path has proved to be the only correct direction. Naturally, having colossal scientific intuition, Einstein could not return from this path. No persuasion could stop him from working on the problem of combining gravitation and electromagnetism within the framework of the general theory of relativity (GTR). Einstein himself characterises the state of general theory of relativity as follows, analysing the metrics of space-time: 'now, we can see how the transition to the general theory of relativity has changed the concept of space... The empty space, i.e., the space without the field, does not exist. The space-time does not exist on its own, but only as a structural property of the field. Thus, Descartes was not far from the truth when he assumed that the existence of the empty space must be ignored. A concept of a field as a real object in combination with the general principal relativity was missing, in order to show the true concept of the Descartes idea: there is no space 'free from the field' [10].

The current speculations regarding the scientific heritage of Einstein which suggest that he left to physics only the metrics of the empty space-time do not correspond to reality. Yes, he bravely substituted the concept of the old-fashioned mechanistic aether by a more universal concept of space-time. Analysis of Einstein studies shows that his main effort was directed to the discovery of the field structure of space-time as some universal form of the united field, combining gravitation and electromagnetism. Quite simply, one human life was not sufficient to solve such a global scientific problem. However, his devotion to the very concept of combining interactions, his scientific bravery and will, will remain examples of true service to science for many generations of investigators. No scientist has had such an effect on the development of the thery of EQM and Superunification as Einstein.

In his last scientific study, Einstein clearly defined that the solution of the problem of unification must be associated with the quantisation of the spatial field, transferring to it from the geometry of continuous space-time: 'it can be proven convincingly that the reality cannot be represented by a continuous field. Obviously, quantum phenomena show that a finite system with finite energy can be fully described by a finite set of numbers (quantum numbers). Apparently, this cannot be combined with the theory of continuum and a purely algebraic theory is necessary for describing the actual situation. However, at present, nobody knows how to find a basis for such a theory' [11].

To understand the meaning of these considerations, it is necessary to comment on the above Einstein quote and clarify the concept of quantisation and discreteness of space-time. Quantisation is an energy process and discreteness is a geometrical concept. The attempt for discrete representation of space-time within the framework of the four-dimensional geometry and the conventional coordinate systems have been made many times in studies of well-known scientists V. Ambartsumyan, D. Ivanenko, H. Snyder and others, but they have not been successful [12–15]. It is evident that the applicability of the conventional coordinate systems in the area of the ultra-microworld of the individual quantum of space-time is not fully justified. Different approaches should be used to quantisation of space-time which exclude coordinate systems on the level of the space-time quantum which is regarded as some volume which cannot further be divided and accumulates enormous finite energy.

If we accept the concept of quantised space-time, it may be asserted that some 'finite system with finite energy' should exist in nature. There is no doubt that the phenomenon of quantisation of space-time, as an energy process, is linked strongly with its fundamental length. Thus, 'the finite system with finite energy' in description of the structure of space-time leads to the concept of the energy space-time quantum and defines at the same time the discreteness of space. This is the posthumous will of Einstein, left to his followers.

It can be seen that when solving the given problem Einstein arrived to the general quantum representations of the nature of matter through the 'finite system with finite energy' which can be observed only in the quantised space-time. On the other hand, he was worried about the deterministic approaches to the solution of the phenomena. For this reason, he did not accept the statistical nature of quantum mechanics, regardless of the fact that he laid the foundations of quantum mechanics. He saw the solution of the problem in combining the interactions through space-time. Undoubtedly, the main task of integrating interactions is the unification of the quantum theory of the field and the theory of relativity. Einstein defined accurately the main direction of investigations. The solution of the problem is in the area of the field quantised structure of space-time and is determined by the 'finite system with finite energy'. He referred to the 'finite system with finite energy' as the space-time quantum and only characterised its properties. The space-time quantum as the 'finite system with finite energy' should have finite dimensions regarded as the fundamental length and should also be a bunch of finite energy.

With the introduction of the space-time quantum (quanton), the quantum theory received the most powerful analytical apparatus for matter because the radiation quantum (photon) did not make it possible to propose the total picture of energy interactions in the quantised space-time. At the same time, the radiation quantum is only a secondary formation inside the quantised space-time, having the form of a wave-corpuscule. On the other hand, the discovery of the quanton has enabled the deterministic base to be returned to the quantum theory. Einstein insisted on this base in his dispute with Bohr.

The problems of quantised space-time are associated not only with the problem of the fundamental length and the magnetic monopole and are associated with the entire spectrum of the problems which can be regarded as a 'Ginzburg list' within the limits of the physics of closed quantum mechanics systems [16]: if we consider the fundamental interactions: gravitation, electromagnetism, physics of elementary particles and the atomic nucleus (strong interactions), electroweak interactions associated with the participation of the neutrino, then the reasons for fundamental interactions are not known in modern physics. In particular, I have specified four singular points of the most important problems which have not been included in the 'Ginzburg' list:

1. **In the gravitation region.** Principles of **gravitation and inertia** are not known.
2. **In the region of electromagnetism.** The reasons for magnetism and its link with electricity are not known. The **Maxwell** equations are written in the purely empirical form and still have no analytical conclusions.
3. **In the area of the physics of elementary particles.** The structure of no elementary particles, including the main particles: electron, positron, proton, neutron, photon, neutrino, is known. The reasons for the formation of mass at the particles are not known.
4. **In the area of physics of the atomic nuclei.** The nature of the nuclear forces and the reasons for the defect of the mass of the atomic nucleus, as the basis of energy generation, are not known.

It is gratifying that all these problems of physical science have been solved in the Superunification theory. At the present time, these two theories are the most powerful analytical apparatus for the investigation of matter.

Prior to transferring to the problem of electromagnetic quantisation of space-time, it is necessary to mention briefly the principle of the relative-absolute dualism. Previously, it was erroneously assumed that relativity is not compatible with the absolute space. Now, in the Superunification theory it has been proven that the principle of relativity is the fundamental property of the absolutely quantised space-time. It has been established that during movement in a quantised vacuum medium the particle is not subjected to Lorentz shrinking in the direction of motion and remains spherically invariant in the entire range speed, including relativistic ones. Lorentz shrinking is the effect of relative measurements observed by an exterior observer.

The principle of spherical invariance is the fundamental property of the quantised space-time not only for elementary particles but, in accordance with the principle of superposition of the fields, it extends to the cosmological objects. For this reason, no aether wind was detected in interference experiments carried out by Michaelson and Morley during movement of the Earth since the principle of spherical invariance excludes the aether wind as such, and quantised space-time is a quantum medium with the unique properties and has no analogues with the known matter media, excluding the mechanistic gas-like aether.

Electromagnetism and gravitation are different states of the united electromagnetic field represented, in accordance with (1), by the quantised space-time which is a carrier of the superstrong electromagnetic interaction (SEI). This is the united field, mentioned by the Einstein. At present, physics faces the dilemma of replacing the concept of the field by exchange of virtual particles and elongated objects – strings. Figure 2.1 shows the stages of development of gravitation theory, described by M, Kaku, an expert in the area of the theory of superstrings [17]. The gravitation in the form of distortion of the space-time is regarded by Kaku only as Einstein's assumption, believing that the gravity is only the exchange of closed strings, excluding the process of distortion of space-time according to the gravitational theory. In this regard, the theorists not only ahead the events but also profoundly mistaken. Evidently, this is caused by the fact that in their considerations the classic theory of the field appears to be exhausted and not capable of solving the problem of unification of interactions.

However, the theory of EQM and Superunification shows that Einstein was right and that gravitation is based on the distortion (deformation) of the quantised space-time which can be regarded as the united field within

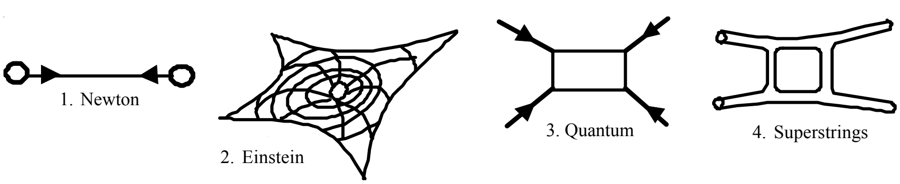


Fig. 2.1. Stages of the development of gravitational theory. Every step, shown in the scheme, is based on the success of the previous step. 1) Newton regarded gravity is a force acting instantaneously at a distance. 2. Einstein assumed that gravity is the curvature of the space-time. 3. The naive unification of the general theory of relativity and quantum mechanics gives a divergent theory, the so-called quantum gravitation, in which it is assumed that gravity is generated by the exchange of unique 'particles' – gravitons. 4. In the string theory, it is assumed that the gravity is caused by the exchange of closed strings (M. Kaku) [16].

the framework of the classic field theory. As regards strings and superstrings, they have a real physical basis, they determine the tension of the quantised space-time but do not solve the problem of unification of interactions as it is solved by the Superunification theory.

Analysing the failures of theoreticians in the area of unification of interactions, it has been established that the first stage of unification has been ignored, i.e., the state which starts with the unification of electricity and magnetism into electromagnetism as a result of electromagnetic quantisation of space-time.

2.2. Electromagnetic quantisation of space-time

2.2.1. Basis of the theory of EQM and Superunification

When discussing the development of the fundamental theory, the scientific basis of the theory is placed in the leading positions. Developing the special theory of relativity (STR), Einstein used the constancy of the speed of light as the basis. It is then true that the speed of light has become a variable quantity already in the general theory of relativity, and the basis is represented by the geometry of the distorted four-dimensional space-time. In quantum chromodynamics (QCD), the basis is represented by quarks, fine electrical charges, which are not detected in experiment. References to single effects, as if they belong to fine charges, are not convincing and can be explained using different approaches.

The basis in the theory of EQM and Superunification is represented by whole elementary electrical and magnetic charges of the monopole. These are whole quarks, i.e., bricks of construction of the universe. It was getting to a point. These four charges – quarks are sufficient to construct from them all the main elementary particles: electron, positron, proton, neutron, neutrino, photon and, hopefully, other investigators will form the structure of all known elementary particles with the appropriate properties and in future will determine the entire variety of inanimate and living nature.

The monopole charges – quarks are the elementary whole charges e and g of weightless matter. These are the most stable constants in the universe and are independent of pressure, temperature, speed, the quantum density of the medium, gravitation, and the entire range of natural factors. The elementary electrical charge $e = 1.6{\cdot}10^{-19}$ C is so stable that it could be measured with the accuracy to e^{-21}. At present, this is the really fantastic accuracy which can be only be achieved in science. No other constant is equal to the elementary electrical charge as regards the measurement accuracy. On the basis of the colossal stability of the electrical charge it may be assumed that such a charge cannot be fractional because this would violate the basic properties of the charge as the most stable constant

No direct measurements have been taken of the value of the elementary magnetic charge. From the procedural viewpoint, these measurements can be taken because magnetic charges do not exist in the free state. They are bonded in a dipole inside a quanton. However, analysing the Maxwell equations and taking into account in them the total symmetry between electricity and magnetism when the elementary electrical and magnetic charges are regarded as equal partners, it may be accepted with a high degree of probability that the stability of the magnetic monopole is not lower than the stability of the elementary electrical charge.

Thus, the basis in the theory of EQM and Superunification is represented by the most stable constants of nature: electrical and magnetic monopoles (quarks – charges). Up to now, none of the currently available series has had such a fundamental basis whose carrier is the space-time quantum (quanton), including these constants.

The attempt for solving similar problems have been carried out for a long time in the framework of quantum chromodynamics (QCD) which was based at the beginning on three quarks, and now the number of parameters in QCD has exceeded 100, increasing the number of problems requiring a solution. I do not want to criticise QCD. QCD fulfilled its role by the introduction of quarks. I would like to only mention that in addition to justification of the charge in adrons, and description of the action of nuclear forces, it is important to solve the problem of formation of the mass of adrons and this can in principle be carried out by QCD. The quarks must be regarded as whole electrical and magnetic charges, and the interaction of whole quarks should be transferred to quantons and the capacity of the electrical monopoles in different combinations to realise spherical deformation of the quantised space-time. In this case, it should be possible to describe the structure and condition of any elementary particle, not only of adrons, but also of leptons determining the presence or absence in them of the non-compensated charge and mass.

The attempts to explain the presence of mass in the elementary particles by introduction to quantum theory of other particles, the so-called Higgs particles, which transfer mass to other particles, have proved to be unsustainable, regardless of the application of the most advanced mathematical apparatus. According to theoretical predictions, the Higgs particles should be detected by experiments in a giant accelerator (super collider) in CERN (Geneva). However, these particles have not been detected. The theory of EQM and Superunification has already saved billions of dollars to the world scientific community, describing the structure of elementary particles and also the nature of the gravitational field and mass. To substantiate this, it was necessary to develop the theory of EQM and Superunification based on whole elementary charges – quarks of the monopole type, and the first stage to unification is the unification of electricity and magnetism into electromagnetism.

2.2.2. Unification of electricity and magnetism into electromagnetism. Structure of the quanton

In order to unify electricity and magnetism into a single substance, i.e. electromagnetism, it is necessary to avoid using the conventional coordinate systems and attempts to separate the elementary volume of the space using the numbers 1, 2, 3 and 4 for only four points in space. One such point does not give anything. Two points can be used to denote a line in space. The surface can already be covered by three points. Only four points can separate the volume in the form of a tetrahedron. Nature is constructed in such a manner that it tries to ensure minimisation and rationalisation. We should mention Einstein's comment: 'evidently, quantum phenomena show that the finite system with finite energy can be described fully by the finite set of numbers' [11].

To transfer from the geometry of numbers to real physics, the numbers, denoting the tips of the tetrahedron must be given physical objects. In nature, there are no random coincidences as regards its fundamental situations. The physical objects are represented by four monopole charges– quarks: two electrical ($+1e$ and $-1e$) and two magnetic ($+1g$ and $-1g$), combined in the electromagnetic quadruple as a singular structure. Already the very fact of introduction of the electromagnetic quadrupole into theoretical physics requires attention because the properties of such a particle, combining electricity and magnetism, have never been analysed. Figure 2.2a shows schematically in projection an electromagnetic quadrupole formed from electrical and magnetic monopoles in the form of spherical formations of finite dimensions with a central point charge. However, in this form the electromagnetic quadrupole does not yet correspond to the properties of the space-time quantum (quanton).

Naturally, it is necessary to ask: 'what links together electricity and magnetism inside the electromagnetic quadrupole?' The answer is a phenomenological, i.e., it is the superstrong electromagnetic interaction (SEI) representing also some sort of adhesive bonding various physical substances: electricity and magnetism. The realias of electromagnetism have been confirmed by experiments.

Figure 2.2b shows the space-time quantum (quanton) in the form of a

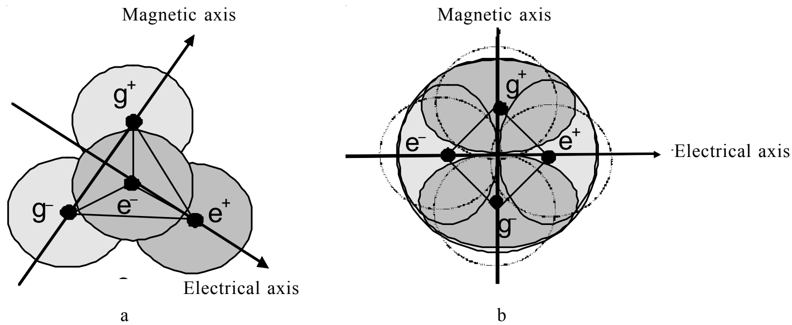


Fig. 2.2. a) Unification of electricity ($e^+ + e^-$) and magnetism ($g^+ + g^-$) into an electromagnetic quadrupole; b) Structure of the space-time quantum, i.e., quanton, in projection.

spherical particle obtained as a result of electromagnetic compression of the quadrupole (see also Fig. 1.2). Taking into account the colossal tensions between the charges inside a quanton, its stable state can be reached only when the quanton is spherical because this symmetry ensures compensation of the charges with opposite signs inside the quanton, determining its the equilibrium state as the electrically and magnetically neutral particles. Thus, the discovery of the quantum as the carrier of superstrong electromagnetic interaction determines the electromagnetic properties of the quantised space-time which in the non-perturbed condition is regarded as a neutral medium.

2.2.3. The charge of the Dirac monopole

The problem of the magnetic monopole was tackled by Dirac as an independent magnetic charge and in his honour it is referred to as the Dirac monopole [18–20]. Naturally, the search for magnetic monopoles and attempts to detect mass in them resulted in the experimental boom in the 60s which, however, has not yielded positive results. The Dirac monopoles have not been detected [20, 21]. The interest in them has been renewed because of the quantisation of space-time in the EQM theory which regards the magnetic monopole as a non-free particle bonded in space-time and this particle cannot be detected in the free state. Only the indirect registration of the manifestation of the properties of magnetic monopoles in disruption of the magnetic equilibrium of the space-time in accordance with the Maxwell equations is possible.

The fact that the role of magnetic monopoles in the structure of the space-time was not understood prevented for a very long period of time the development of a method of determination of the value of the charge g of the magnetic monopole. Dirac himself assumed that taking into account the unambiguity of the phase of the wave function of the electron intersecting the line of n-nodes consisting of magnetic poles, we obtain the required relationship which in the SI system contains the multiplier $4\pi\varepsilon_0$ [18–20]:

$$g = 2\pi\varepsilon_0 \frac{\hbar C_0}{e^2} en = 0.5\alpha^{-1} en = 68.5 en \quad [\mathrm{C}] \tag{2.2}$$

Here $\hbar$ = $1.054 \cdot 10^{-34}$ J·s is the Planck constant, α = 1/137 is the constant of the fine structure; C_0 = $3 \cdot 10^8$ m/s is the speed of light in the vacuum, non-perturbed by gravitation; ε_0 = $8.85 \cdot 10^{-12}$ F/m is the electrical constant; ε = $1.6 \cdot 10^{-19}$ C is the electron charge, n is the integer multiplier.

The Dirac relationship (2.2) was improved by the well-known American theoretical physicist J. Schwinger who proved that n in equation (2) should only be an even number, and at $n = 2$ we obtain $g = 137\ e$ [21].

However, the Dirac method is indirect in which *a line* of nodes can be separated in space from the magnetic charge included in the space-time structure. In reality, in the quantised only a line of quantons can be separated (Fig. 2.2b) in the form of an alternating string from magnetic and electrical dipoles. In particular, Dirac did not take into account the electrical component of the effect. In movement of an electron along such an alternating string, the electron is subjected to the effect of waves from the side of the space-time which is characterised by the constant fine structure α. This was also taken into account nonformally by Schwinger by introducing $n = 2$.

It would appear that there is no basis for doubting Dirac's method which has been accepted by physicists and is regarded as a classic method. From the mathematical viewpoint, the Dirac solutions are accurate. However, from the viewpoint of physics, the Dirac procedure contradicts not only the structure of the quantised space-time but also the solutions of the Maxwell equations for the electromagnetic field in vacuum.

The main problem of the Maxwell equations was the explanation of the realias of bias currents. Until now, the explanation of the electrical bias currents has been contradicting, and we cannot even discuss the magnetic bias currents, although Heaviside attempted to represent the bias points in the total volume. The introduction of the quanton into the structure of the space-time makes the electrical and magnetic bias currents realistic as a result of electromagnetic polarisation of vacuum as the carrier of SEI.

We write the Maxwell equations for the vacuum, expressing the density of the electrical $\mathbf{j}_e$ and magnetic $\mathbf{j}_g$ bias currents in the passage of a flat electromagnetic wave through the space-time by the time dependence t of the strength of the electrical $\mathbf{E}$ and magnetic $\mathbf{H}$ fields in the form of the system:

$$\begin{cases} \mathbf{j}_e = \text{rot}\,\mathbf{H} = \varepsilon_0 \dfrac{\partial \mathbf{E}}{\partial t} \\ \mathbf{j}_g = \dfrac{1}{\mu_o}\text{rot}\,\mathbf{E} = -\dfrac{\partial \mathbf{H}}{\partial t} \end{cases} \tag{2.3}$$

where $\mu_0 = 1.26 \cdot 10^{-3}$ H/m is the magnetic constant.

The system (2.3) reflects the symmetry of electricity and magnetism in the quantised space-time. The equations (2.3) are presented in the form published by the outstanding English physicist and mathematician Heaviside who introduced into Maxwell equations additional magnetic bias currents, determined by magnetic charges, giving the equations the completed symmetrical form.

The solution of the system (2.3) will be sought for the real relationship between the magnetic and electrical elementary charges inside a quanton which determines their bias currents in the quantised space-time. For this purpose, the densities of the bias currents $\mathbf{j}_e$ and $\mathbf{j}_g$ in (2.3) are expressed by the speed of displacement $\mathbf{v}$ of the elementary electrical e and magnetic g charges – quarks inside the space-time and the quantum density of the medium ρ_0 which determines the concentration of the quanta of the space-time in the unit volume:

$$\begin{cases} \mathbf{j}_e = 2e\rho_0\mathbf{v} \\ \mathbf{j}_g = 2g\rho_0\mathbf{v} \end{cases} \tag{2.4}$$

The multiplier in (2.4) is defined on the basis of the fact that the charges e and g are included in the composition of the space-time inside the quanton by pairs with the sign (+) and (–), forming on the whole a neutral medium. Taking into account fact that in the actual conditions the electromagnetic polarisation of space-time is associated with the very small displacement of the charges in relation to their equilibrium position, the speed of their displacement $\mathbf{v}$ is the same.

The problems of polarisation of the quantum have been examined in greater detail in [22, 23] in analytical derivation of the Maxwell equations. At the moment, it is important to understand that all the electromagnetic Maxwell processes in vacuum are associated with the constancy of the internal energy of the quanton in its electromagnetic polarisation. Extending the quanton (Fig. 2.2b) along the electrical axis, we also observe compression of the quanton along the magnetic axis. This is accompanied by the displacement of the charges inside the quanton which also determines the realias of the currents (2.4) of electrical and magnetic bias.

Attention should be given to the fact that the electrical and magnetic axes of the quanton (Fig. 2.2b) are unfolded in the space of the angle of 90°, determining the space shift between the vectors of the strength of the electrical **E** and magnetic **H** fields in all electromagnetic wave processes, and also determining the direction of the vector of speed **C** of propagation of the electromagnetic wave, the vector of the speed of light $\mathbf{C}_0$ in vacuum, non-perturbed by gravitation, is denoted by the parameters of the electromagnetic field. The ratio of these parameters was obtained in analytical derivation of the Maxwell equations [20, 21]:

$$\frac{1}{\varepsilon_0}\frac{\partial \mathbf{H}}{\partial \mathbf{E}} = \mathrm{C}_0 \qquad (2.5).$$

In fact, (2.5) is also the form of the singular Maxwell vector equation for vacuum in which the vector of speed of light $\mathbf{C}_0$ is situated in the plane of the orthogonal plane of the vectors **E** and **H** and the simultaneous change of the vectors with time also generates the electromagnetic wave.

Substituting (2.4) into (2.3) and taking (2.5) into account, we obtain the true relationship between the magnetic and electrical monopoles in the quantised space-time:

$$g = C_0 e = 4.8 \cdot 10^{-11}\,\mathrm{A{\cdot}m}\ \ (\mathrm{Dc}) \qquad (2.6)$$

In the EQM theory, all the calculations are carried out in the SI system. Therefore, in the SI system the dimension of the magnetic charge is defined as [Am] since the dimension of the magnetic momentum is [Am^2]. According to Dirac and Schwinger, the dimension of the magnetic and electrical charges is the same [C]. This is very convenient because it determines the symmetry between electricity and magnetism which in the ideal case would be expressed in the completely equal values of the magnetic and electrical monopoles. However, in the SI system, the dimensions of magnetism are determined by electrical current. Therefore, the equality between the magnetic and electrical charges in (2.6) is linked by the dimensional multiplier C_0. Taking into account pioneering studies by Dirac in the area of the magnetic monopole, the dimension of the magnetic charge in the SI system [Am] is referred to as Dirac (Dc) in his honour. At the moment, it is an arbitrary dimension but I assume that with time it will be officially accepted.

2.2.4. Dimensions of the quanton

The calculated diameter of the quanton L_{qo} for the non-perturbed quantised space-time, determined from the condition of elastic tensioning of space-time in generation in the quanton of elementary particles (nucleons) with the mass [22,23], is

$$L_{q0} = \left(\frac{4}{3}k_3\frac{G}{\varepsilon_0}\right)^{\frac{1}{4}}\frac{\sqrt{eR_s}}{C_0} = 0.74\cdot 10^{-25}\,\text{m} \tag{2.7}$$

here $k_3 = 1.4$ is the coefficient of filling of vacuum by spherical quantons; $R_s = 0.81\cdot 10^{-15}$ m is the neutron (proton) radius; $G = 6.67\cdot 10^{-11}$ Nm^2/kg^2 is the gravitation constant.

It can be seen that equation (2.7) includes the constants and constant parameters. Therefore, in the EQM theory, L_{q0} (2.27) is regarded as a conventional constant which determines the fundamental length of discrete space-time. In the space-time perturbed by gravitation, the diameter of the quanton L_q is a variable quantity and differs from L_{q0} (2.7) by the increment ΔL_q:

$$L_q = L_{q0} \pm \Delta L_q \tag{2.8}$$

The sign (+) in (2.8) determines the effect of gravitation or antigravitation for the external or internal region of the quantised space-time. For the external region of the space-time, the effect of gravitation is determined by the sign (+), the effect of antigravitation by (–). This means that in the region of the space subjected to gravitational perturbation the dimensions of the quantum increase and their concentration (quantum density) decreases.

2.2.5. Symmetry of electricity and magnetism inside a quanton

The uniqueness of the Maxwell equations (2.3) and (2.5) for vacuum is manifested in the complete symmetry between electricity and magnetism. To understand the reasons for this symmetry, we analyse the Coulomb forces inside a quanton (Fig. 2.2b). The fact is that the Coulomb law is a precursor of the Maxwell equations and the most extensively verified fundamental law.

The symmetry of electricity and magnetism inside a quanton (Fig. 2.2) may be demonstrated as follows. Into the Coulomb law we introduce, separately for electrical and magnetic charges, the equation (2.6) at the distance between the charges determined by the side of the tetrahedron equal to 0.5 L_{qo} (2.7). Consequently, Coulomb forces F_e and F_g as the attraction forces inside the quanton for the electrical charges and for magnetic charges, respectively, should be equal, i.e. $F_e = F_g$.

We use the reversed procedure. We write the Coulomb law inside the quanton for electrical charges and for magnetic charges on the condition of the equality of force electrical and magnetic components $F_e = F_g$ and the equality of the distances r_{oe} and r_{og} between the electrical and magnetic charges, respectively:

$$r_{eo} = r_{go} = 0.5L_{qo} = 0,37 \cdot 10^{-25}\,\text{m} \tag{2.9}$$

$$\begin{cases} F_e = \dfrac{1}{4\pi\varepsilon_0}\dfrac{e^2}{r_{e0}^2} = 1.6 \cdot 10^{23}\,\text{N} \\ F_e = F_g \\ F_g = \dfrac{\mu_0}{4\pi}\dfrac{g^2}{r_{g0}^2} = 1.6 \cdot 10^{23}\,\text{N} \end{cases} \tag{2.10}$$

The solution of the system (2.10) is obtained under the condition $\varepsilon_0\mu_0 C_0^2 = 1$

$$g = \sqrt{\frac{1}{\varepsilon_0\mu_0}}\; e = C_0 e \tag{2.11}$$

It may be seen that only when the parameters of the electrical and magnetic components inside the quanton are equal, in particular for the Coulomb forces (2.10), the relationship (2.11) between the values of the elementary magnetic and electrical charges corresponds to the previously determined relationship (2.6). Shorter distances between the charges inside the quanton determine colossal attraction forces (2.10) which characterise the quantised space-time by colossal elasticity.

Thus, the electromagnetic symmetry of the quanton determines the relationships (2.6) and (2.1) and also the correspondence of these relationships to the Maxwell equations (2.3) and the Coulomb law (2.10). The Dirac relationship (2.2) does not correspond to (2.3) and (2.10), is not written in the SI system and uses the procedure based on the unambiguous yield of the phase of the wave function of the electron whose parameters include not only the elementary electrical charge *e* but also other parameters, which determine the wave properties of the electron in the quantised space-time. It should be accepted that as regards the procedure, Dirac made an error but this does not reduce role in the investigations of the magnetic monopole. In the pure form, the monopole elementary electrical and magnetic charges are included only in the structure of the quanton, and the analysis of the properties of the quanton yielded the true relationships (2.6) and (2.11).

In fact, the forces (2.10) inside the quanton are colossal in magnitude and comparable with the attraction forces of the Earth to the Sun. These forces determine the colossal elasticity of the quantised space-time in the theory of the elastic quantised medium (EQM) which investigates the structure of vacuum. In particular, when examining the domain of the ultra-microworld of the quanton, the EQM theory has had to face the colossal forces attention and energy concentration.

We verify the energy symmetry of the quantum, analysing the energy of electrical W_e and magnetic W_g components of the charges interacting inside the quanton under the condition (2.9):

$$\begin{cases} W_e = \dfrac{1}{4\pi\varepsilon_0}\dfrac{e^2}{r_{e0}} = 0.62\cdot 10^{-2}\,\text{J} \\ W_g = \dfrac{\mu_0}{4\pi}\dfrac{g^2}{r_{g0}} = 0.62\cdot 10^{-2}\,\text{J} \end{cases} \tag{2.12}$$

As indicated by (2.12), the energies of interaction of the electrical charges and the magnetic charges inside the quanton are equal to each other, as are also the Coulomb forces (2.10). This property of the quantum determines the total electromagnetic symmetry of the quantised space-time.

Thus, the introduction into physics of the space-time quantum (quanton) enables us to understand the principle of electromagnetic symmetry and also penetrate into the depth of electromagnetic processes on the level of the fundamental length 10^{-25} m. Prior to the development of the EQM theory, physics did not have these unique procedural possibilities.

2.2.6. The structure of the monopole-quark

Classic electrodynamics shows that the magnetic and electrical charges of the opposite polarity, included in the structure of the quanton, should collapse into a point (annihilate) under the effect of colossal Coulomb forces (2.10). However, this does not take place. The quanton (Fig. 2.2b) has a finite dimension (2.7). This is also confirmed by Maxwell equations (2.3).

The definition of the finite size of the quanton (2.7) shows that the magnetic and electrical monopoles – quarks are not point objects and also have finite dimensions. After all, we cannot look into the microworld of the quanton to the level of the fundamental length of 10^{-25} m. We can construct the model of the quanton only indirectly, analysing physical phenomena. Even using various devices, nobody has been able to examine the structure of larger particles, such as the electron, proton, neutron and others. In this respect, the analytical apparatus of the EQM theory is at present the most powerful tool of nature investigators capable of analysing both the structure of elementary particles and the space-time quantum (quanton) [22–25].

Thus, the monopole should have the property with colossal elasticity and a finite size. The electromagnetic collapse of charges of the opposite polarity inside the quanton can be restricted in this case only. These properties of the monopole–quarks are described most efficiently by the model in the form of a berry (ovule), shown in Fig. 2.3. This model resembles a biological ovule whose centre contains the nucleus 1 of the monopole charge, surrounded by protoplasma 2 with the shell 3.

In particular, the nucleus 1 is the source of the field (electrical or magnetic) in the form of a point charge which is capable of moving to some extent in relation to the centre of the monopole. It may be assumed that the dimensions of the monopole nucleus are determined by the minimum size of the order of Planck length of 10^{-35} m. It has not as yet been possible to substantiate this parameter theoretically. The diameter of the monopole was determined as being of the order of 10^{-25} m on the basis of the diameter of the space-time quanton. The nature of the nucleus 1 as a source of the field is also unclear. At the moment, we can only comment on the very fact of the presence of the nucleus 1 as a source of the field.

The nature of protoplasma 2 with the shell 3 has also not been explained. At the moment, it is clear that the protoplasma may represent only field (immaterial) matter, like the quanton. However, we do not know what this field form of matter on the level of the fundamental length is. It may be assumed that on the level of the fundamental lengths of 10^{-25} m elastic forces of repulsion of the shell, preventing the deformation of the latter, start to act between the monopole charges with opposite polarity.

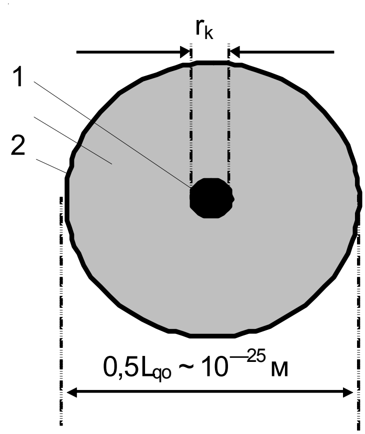


Fig. 2.3. Model of the structure of electrical and magnetic monopoles. 1) the nucleus of the monopole charge, 2) monopole protoplasma, 3) monopole shell.

Consequently, the length 10^{-25} m is the interface in the microworld for the interacting charges.

Regardless of some problems of the berry model of the monopoles (see Fig. 2 .2) which undoubtedly will be solved, the berry model of the monopole answers a large number of problems associated with the structure of the very space-time quantum. Firstly, the presence in the structure of the monopole of elastic protoplasma with the shell 3 prevents collapse of the monopoles into a point when they combine to form an electromagnetic quadrupole, forming electrical and magnetic dipoles inside the quadrupole (Fig. 2.2a). Secondly, the berry model of the monopole explains the unification of electricity and magnetism into a single substance which can take place only through intermediate medium, i.e., through the monopole protoplasma. Consequently, the monopole protoplasma represents some glue bonding together the electrical and magnetic dipoles inside the quanton. Finally, under the effect of the colossal forces of electrical and magnetic attraction, the electromagnetic quadrupole is compressed into a spherical particle whose properties correspond to the quanton (Fig. 2.2b). These properties determined the capacity of the quanton for the orientation and deformation polarisation, determined by the manifestation of the Maxwell equations (2.3) in vacuum. This is proved in the present book.

2.2.7. Electromagnetic quantisation of space

The unification of electricity and magnetism inside a quanton can be described by the following reaction:

$$(e^+ + e^-) + (g^+ + g^-) \rightarrow e_+^- + g_+^- \rightarrow q_{2g}^{2e} \rightarrow q_s \qquad (2.30)$$

where e_+^- and g_+^- are the electrical and magnetic dipoles, q_{2g}^{2e} is the electromagnetic quadrupole; q_s is the space-time quantum, i.e., quanton.

In (2.13), the electrical monopole is denoted by e^-. In contrast to the monopole, the electron is denoted by two indexes e_m^-, where the index m indicates the presence of mass in the particle carrying the charge with negative polarity.

It may be assumed that the reaction (2.30) consists of several stages. Initially, the monopole charges merge into electrical e_+^- and magnetic g_+^- dipoles. Subsequently, the dipoles merge to form the electromagnetic quadrupole q_{2g}^{2e} (Fig. 2.2a). Finally, as a result of electromagnetic compression of the quadrupole q_{2g}^{2e} under the effect of colossal forces (2.7) the electromagnetic space-time quantum q_s, i.e., quanton, forms and has the form of a spherical particle (Fig. 2.2b).

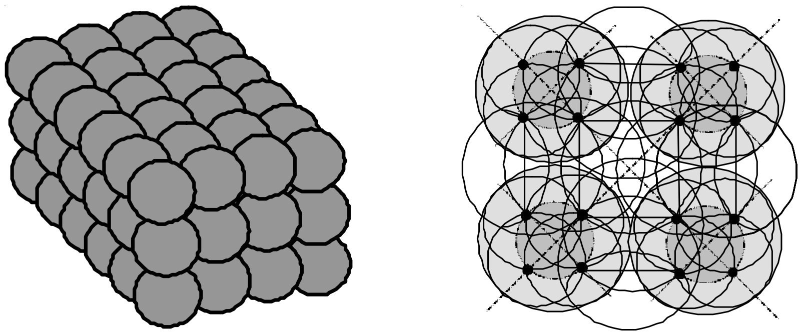
The process of electromagnetic quantisation of the space is reduced to filling the space with quantons. This process has taken place throughout the universe. At present, it is difficult to even propose a hypothesis regarding the primary source of quantisation of the universe. If there was the Big bang, it could have taken only in the quantised universe, and would have to be associated with the formation of matter in all its varieties: from elementary particles to stars and galaxies.

In the quantisation of the universe it is important to obtain the homogeneous and isotropic space-time. Consequently, the structure of the quanton can form. The special feature of this distribution of the charges on the tips of the tetrahedron inside the quanton prevents the formation of the spatial mirror symmetry of the electrical and magnetic axes (Fig. 2.2b). This arrangement introduces the element of chaos into the spatial orientation of the quantons when they fill the volume of the quantised space-time. In the quantised volume we cannot specify any priority direction of orientation along the electrical or magnetic axes of the large group of quantons. The direction of the electrical or magnetic axes of the quantons in the space changes randomly, determining the isotropic properties of the space-time.

Taking into account the small dimensions of the quanton of the order of 10^{-25} m, on the level of the dimensions of the elementary particles 10^{-15} m, the space-time already represents a homogeneous and isotropic medium. The quanton itself is an electrically and magnetically neutral particle ensuring on the whole the electrical and magnetic neutrality of the quantised space-time. All the manifestations of the magnetism and electricity are associated with the disruption of the electrical and magnetic equilibrium of space-time.

There is some analogy between the structure of the space-time and a network of force lines of electrical and magnetic fields, linking the entire universe together (Fig. 2.4a). Taking into account the linear form of the Maxwell equations in space, it may be assumed that the proposed structure of quantised space-time determines its electrical and magnetic constants of vacuum ε_0 and μ_0 whose effect also extends to the internal region of the quanton.

This network can be regarded as some solid-state field structure (Fig. 2.4b) with no analogy with conventional matter but characterised by colossal elasticity (see also Fig. 1.3). Consequently, the motion in the space-time of the elementary particle is determined by the wave transfer of matter [22, 23]. The wave transfer of matter forms the basis of the wave (quantum) mechanics and determines the effect of the principle of corpuscular-wave dualism in which the particle shows both wave and corpuscular properties, being the integral part of space-time.



a b

Fig. 2.4. a) Local section of the EQM consisting of four quantons (simplified in projection), b) The volume of quantised space-time.

2.2.8. Electrical symmetry of space

Quantised space-time, filled only with quantons, is a medium with no material matter and without the entire variety of the observed world. Excess electrical charges must exist to fill the universe with material matter.

The quanton itself ensures the electromagnetic symmetry of the quantised space-time by the fact that the number of magnetic charges inside a quanton is balanced with the number of the electrical charges. To ensure the electrical asymmetry of space, an excess of electrical charges must be supplied to the quantised space-time. It may be assumed that quantisation of the universe was accompanied by the colossal ejection of pairs of electrical ($e^+ + e^-$) and magnetic ($g^+ + g^-$) monopoles. The ejection of the number n_e of pairs of electrical monopoles ($e^+ + e^-$) in the quantitative aspect was slightly greater than the ejection of the number n_g of pairs of magnetic monopoles ($g^+ + g^-$), and this determines the electrical asymmetry A_e of the universe:

$$\frac{n_e}{n_g} = A_e > 1 \tag{2.14}$$

Presumably, A_e (2.14) differs only slightly from unity but the electrical symmetry A_e of the universe was then used as a basis for the formation of the entire variety of material matter, starting with the formation of elementary particles [7, 20, 32].

Possibly, quantisation of the universe took place at $A_e = 1$, without the excess of electrical charges, forming the spherical volume. However, the excess of the electrical charges was packed with displacement from the centre of the future universe in a very small volume expressed in cubic metres. For some reasons, the small volume was activated and this was followed by a big bang which resulted in the ejection of excess electrical charges into the quantised space-time. A cavity with some spatial asymmetry formed in the centre of the universe and the universe started to expand, forming the quantised shell. The scenario explains the enormously high rates of expansion of the universe, without considering the inflation model. In the post-explosion stage, we can use the Friedman shell model of the pulsating universe.

The redistribution of the quantum density inside the asymmetric shell of the universe resulted in the formation of gigantic vortices in the quantised space-time, which explain the formation of helical galaxies. Spherical constellations formed in the absence of these vortices.

However, not all started with the formation of constellations and galaxies, the formation of elementary particles was also important. In particular, the excess of electrical charges – quarks of the monopole types resulted in the formation of the entire spectrum of the elementary particles. For example, the ejection into the quantised space-time of an electrical massless charge with negative polarity resulted in the generation of an electron as a result of spherical deformation of space-time because of the pulling of the quantons to the centre of the charge. The massless monopole charge acquires mass, transforms into the electron – elementary particle – the carrier of mass and charge. The structure of elementary particles and the quantised space-time was examined in [2, 6, 7, 20, 32].

2.2.9. The speed of movement of the spatial clock

The quantum, as an universal integrating particle, is a volume electromagnetic resonator which determines the rate of time in space (Fig. 2.2b) [26]. We examine the vibrational process inside the quanton during the passage of an electromagnetic wave through the quanton. Evidently, the electromagnetic wave, acting simultaneously with the electrical and magnetic fields on the quanton, stretches the quanton in the first half cycle along the electrical axis and at the same time compresses it along the magnetic axis, and vice versa. We can calculate the time (period) T_0 of the given vibrational process which is determined by the duration of passage of the electromagnetic wave with speed C_0 through the quanton with the size L_{q0} (2.7):

$$T_0 = \frac{L_{q0}}{C_0} = 2.5 \cdot 10^{-34}\ \text{s} \tag{2.15}$$

Taking equation (2.15) into account, we determine the intrinsic resonance frequency f_0 of the quanton:

$$f_0 = \frac{1}{T_0} = 4 \cdot 10^{33} \text{ Hz} \tag{2.16}$$

Evidently, equation (2.16) determines the limiting frequency of electromagnetic processes in the quantised space-time. The harmonic components of the entire spectrum of frequencies are reduced in the final analysis to the limiting frequency (2.16).

The EQM theory shows that time changes in steps with a period (2.16), i.e., the time is quantised in its basis.

Naturally, gravitational perturbation of space-time is determined by its distortion under the effect of tensile deformation which increases the parameters of the quanton and reduces the rate of time (15) in space-time. The increase of the quanton diameter results in a decrease of electromagnetic energy forces inside a quanton and, correspondingly, reduces its elasticity in a volume resonator. This leads to a decrease of the resonant frequency (2.16) of intrinsic oscillations.

2.2.10. Stability and energy capacity of the quanton

It may be asserted that the quanton, together with the monopoles, is the most stable particle which cannot be destructed. This is confirmed experimentally by the absence of free magnetic charges in nature. Magnetism belongs completely to the quanton and quantised space-time.

The stability of the quanton can be confirmed by calculations. To split the quanton into compound monopoles, it is necessary to break bonds between the charges inside the quanton which are determined by the forces of the order of 10^{23} N. It is not possible to generate these forces artificially from the external side of the quanton.

We can estimate the energy capacity w_{qv} of the quanton on the basis of the accumulated total energy W_q (12) related to its volume V_q

$$W_q = W_e + W_g = 1.2 \cdot 10^{-2} \text{ J} \approx 10^{17} \text{eV} \tag{2.17}$$

$$w_{qv} = \frac{W_q}{V_q} = 6\frac{W_q}{\pi L_q^3} = 5.7 \cdot 10^{73} \frac{\text{J}}{\text{m}^3} \tag{2.18}$$

The concentration of electromagnetic energy (2.18) inside the quanton is colossal and cannot be produced artificially in order to break the electrical and magnetic bonds inside the quanton. If the energy of the quanton is reduced to the volume of the nucleon (proton), we obtain the value of the order of $1.6 \cdot 10^{28}$ J/nucleon or 10^{47} eV/nucleon. This energy is comparable only with the limiting energy of the proton when the latter reaches the speed of light [22, 23]. In reality it is not possible to reach these energy concentrations in accelerator systems. This means that the quanton is the most stable particle in the universe and is not capable of splitting into free monopoles and determines the stability of the space-time.

The electromagnetic space-time quanton was introduced for the first time in [27] and its discovery was used as a basis for the development of the EQM and Superunification theories; main assumptions of these theories can be found in [22–23].

2.3. Disruption of electrical and magnetic equilibrium of the quantised space-time

The common feature of the classic and existing quantum electrodynamics is that they are of the phenomenological nature and do not examine the reasons for electromagnetic processes taking place in the quantised space-time. The classic electrodynamics and the existing quantum electrodynamics have common problems, regardless of the fact that they affect different areas of knowledge. Naturally, the existing contradictions of the classic electrodynamics delay the development of quantum electrodynamics. Therefore, in this chapter we investigate the main problems of classic electrodynamics, and the problems of quantum electrodynamics of elementary particles will be investigated in the next chapter because they are linked directly with the unification of electromagnetism and gravitation through the superstrong electromagnetic interaction.

The main problems of classic electrodynamics remain: the nature of magnetism, analytical derivation of the Maxwell rotor equations (2.3), and the reasons for electromagnetic induction in vacuum, transformation of the Maxwell rotor equations (2.3) into the wave equations of a flat electromagnetic wave without excluding the rotors, the nature of rotors in vacuum, and others.

It is gratifying that these problems of electrodynamics are solved in the elementary manner by the Superunification theory. Prior to examining these problems, it is necessary to mention the extensive possibilities provided by the new theory. It is possible for the first time to investigate the topology of the space-time which was not investigated previously and ogy provides structural heterogeneities and introduces the element of additional internal anisotropy. This additional anisotropy can be detected only by analysing the disruptions of magnetic and electrical equilibria of quantised space-time.

2.3.1. The state of electromagnetic equilibrium of quantised space-time

Figure 2.4 shows the models of quantised space-time in the form of a field grid (a) and a solid-state structure (b). These two models are equivalent to each other. The solid state model (b) is in no way the analogue of the solid with the properties of material matter. The two models realise the field form of weightless matter whose properties differ from material (real) matter. However, in the model in Fig. 2.4a, the quantons are in complete electromagnetic equilibrium, whereas in the model in Fig. 2.4b their electromagnetic equilibrium is not determined.

Prior to analysing further the state of space-time, we sdefine the individual terms. The macroworld is the world of linear dimensions perceived by the naked human eye of the order of 10^{-5} m. The microworld of the elementary particles is the world of the linear dimensions of the electron, proton, neutron, of the order of 10^{-15} m. The ultra-microworld is the world of linear dimensions of the fundamental length determined by the quanton diameter, 10^{-25} m. The Planck length is the world of linear dimensions of point objects of the order of 10^{-35} m.

It may be seen that there is a very large interval up to 10 orders between the different worlds of the linear dimensions. This means that around us there are worlds (microworld, ultra-microworld, Planck length) which we do not completely detect and do not control, and indirect information on these worlds can be obtained only as a result of theoretical and experimental investigations.

The Newton classic mechanics could not penetrate deeper than the macroworld. The theory of relativity and quantum mechanics have penetrated into the microworld of relativistic particles, but a large number of unsolved problems has remained. The theory of EQM and Superunification theory have penetrated into the region of the ultra-microworld of quantised space-time. Every penetration into the depth of matter provides new results in understanding the phenomena in the nature.

On the level of the fundamental length determined by the quanton diameter of 10^{-25} m, the quantised space-time is a discrete structure of highly heterogeneous fields with an anisotropy in the volume of the quanton in the presence of electrical and magnetic axes (Fig. 2.2). In the region of the microworld of the elementary particles and in the macroworld, the quantised space-time already represents a continuous homogeneous and isotropic medium which may be both in the completely balanced state and in the state displaced from equilibrium.

Figure 2.2 showed the structure of the quanton in the completely balanced electrical and magnetic states. The orthogonality in the projection of the electrical and magnetic axes of the quanton enabled the introduction of a right-angle coordinate system with the axes *X* and *Y* which in reality do not intersect because of the tetrahedral arrangement of the charges inside the quanton. The *X* axis corresponds to the electrical axis, the *Y* axis to the magnetic axis. The distance between the charges on the electrical and magnetic axes is denoted by r_{ex} and r_{gy}. Consequently, the electromagnetic equilibrium of the quanton can be written in the form of the quality of its electrical and magnetic components for Coulomb forces $F_e = F_g$ (2.10) and energies $W_e = W_g$ (2.12)

$$F_e = F_g = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_{ex}^2} = \frac{\mu_0}{4\pi}\frac{g^2}{r_{gy}^2} \tag{2.19}$$

$$W_e = W_g = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_{ex}} = \frac{\mu_0}{4\pi}\frac{g^2}{r_{gy}} \tag{2.20}$$

The equations (2.19) and (2.20) determine the electromagnetic equilibrium of the quanton. In a general case, the electromagnetic equilibrium of the quanton can be described in the following form, taking into account (2.19) and (2.20):

$$\frac{W_e}{W_g} = \frac{F_e}{F_g} = \frac{r_{ex}}{r_{gy}} = 1 \tag{2.21}$$

The difference between (2.21) and unity displaces the quanton from the electromagnetic equilibrium state.

It should be mentioned that the equilibrium state of the quantum can be obtained only if the symmetry of its charges is fulfilled $(+1e, -1e)$ and $(+1g, -1g)$ (2.13)

$$\begin{cases} (+1e) + (-1e) = 0 \\ (+1g) + (-1g) = 0 \end{cases} \tag{2.22}$$

$$\begin{cases} |+1e| + |-1e| = |2e| \\ |+1g| + |-1g| = |2g| \end{cases} \tag{2.23}$$

The excess or shortage of the charge in the quanton disrupts the symmetry of charges. Equation (2.22) establishes the electrical and magnetic neutrality of the quanton which in the case of a large distance from the quantum treats the latter as a completely neutral particle. There is no neutrality inside the quanton and in its immediate vicinity, and the number of charges is described by the sum of the moduli of the charges (2.23).

The equilibrium state of the quanton is fully transferred to the equilibrium state of the quantised space-time on the condition that in the investigated region of the space all the quantons are in the equilibrium condition. To evaluate mathematically the equilibrium state of some specific region of the quantised space-time, it is necessary to use a calculation model which would reflect the aggregate of a large number of the quantons subject to their electromagnetic equilibrium.

Figure 2.5 shows the averaged-out calculation model of some region of quantised space-time. This model is idealised in the form of a flat projection system of quantons which in reality, because of the tetrahedral arrangement of the charges inside the quanton, is in fact distorted in a small group of the quantons. However, if it is assumed that the model includes a very large number of quantons, then the statistically average calculation model, shown in Fig. 2.5, may reflect the equilibrium state of the quantised space-time which can be efficiently described mathematically.

The following assumptions were used in the construction of the averaged-out model (Fig. 2.5).

1. The electrical and magnetic axes of the quantons are orthogonal in relation to each other. Consequently, the investigated system of the quantons can be written into the rectangular coordinate system *X*

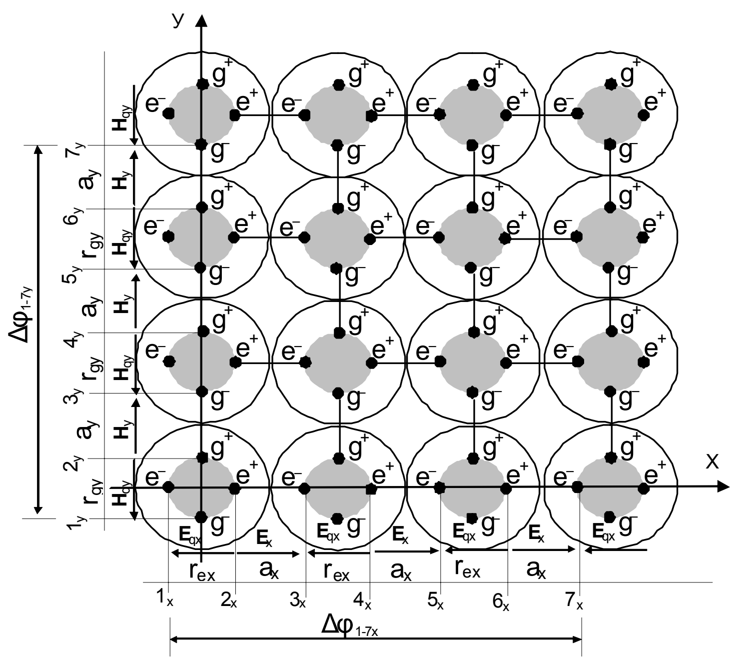


Fig. 2.5. Calculation of electrical and magnetic equilibrium of quantised space-time.

and Y, placing the electrical axes of the quantons along the X axis, and the magnetic axes along the Y axis.

2. The quantons are attracted to each other, forming external bonds between themselves. The external bonds are determined by the mutual attraction of only dissimilar electrical charges and only dissimilar magnetic charges. The external bonds cannot form by interaction between electrical and magnetic charges.
3. Between quantons, there are cavities which form a medium characterised by the constants ε_0 and μ_0. In this case, all the calculations carried out on the level of the ultra-microworld of the quantons are transferred in a linear manner into the region of the microworld of elementary particles and the macroworld.

A shortcoming of this average model is that it is more or less identical with the isotropic crystal lattice of the solid characterised. In its nature, the quantised space-time is anisotropic because of the tetrahedral arrangement of the charges inside the quanton. In a flat averaged-out model, Fig. 2.5, the isotropy is found initially as a result of the orientation of the electrical and magnetic axes of the quantons along the axes X and Y, respectively. However, this isotropy does not disrupt the electromagnetic equilibrium of quantised space-time. Therefore, the average model is fully suitable for solving the given task.

We investigate separately the conditions of electrical and magnetic equilibrium of quantised space-time. It is evident that the condition of electrical equilibrium is the absence in the quantised space-time of the difference of electrical potentials $\Delta\varphi$ over a specific length. As regards the model in Fig. 2.5, the length over which we calculate the difference of the electrical potentials $\Delta\varphi_{1-7x}$ is represented by the distance between the points 1_x and 7_x.

Consequently, the difference of the electrical potentials $\Delta\varphi_{1-7z}$ is determined by the integral of the strength of the electrical field $\mathbf{E}(x)$ in the path between the points 1_x and 7_x

$$\Delta\varphi_{1-7x} = \int_{1x}^{7x} \mathrm{E}(x)dx \tag{2.24}$$

In the unification path 1_x–7_x the function of the strength $\mathbf{E}(x)$ at the points of distribution of the charges shows breaks. In addition, at the points of distribution of the charges it is necessary to deal with the boundary conditions related to the specific diameter of the nucleus of monopole charges (Fig. 2.3). As the radius (diameter) of the nucleus of the charge we can accept approximately and without proof the Planck length $\ell_p \sim 10^{-35}$ m. However, this approach is not suitable for calculations because it results in a very high concentration of the strength of the field on the surface of the nucleus of the monopole charge. Therefore, it is more logical to surround the point charge of the monopole nucleus by some sphere with a radius r_k 10–100 times smaller than the diameter of the quanton L_{q0}. This sphere represents the equipotential surface. Consequently, the integral (2.24) can be determined as the sum of two integrals along the unification path, determining the unification ranges taking into account the boundary conditions for the radius r_k

$$\Delta\varphi_{1-7x} = \sum_{1x}^{7x} \left(\int_{r_k}^{ax-r_k} \mathbf{E}_\mathbf{x}\, dx - \int_{r_k}^{rex-r_k} \mathbf{E}_{q\mathbf{x}} dx \right) = 0 \tag{2.25}$$

where $\mathbf{E}_x$ is the function of the strength of the electrical field between the quantons on the X axis, $\mathbf{E}_{qx}$ is the function of the strength between the electrical charges inside the quanton along the X axis, a_x is the distance between the electrical charges of the adjacent quantons, r_{ex} is the distance between the electrical charges inside the quanton.

As shown by equation (2.25), the electrical equilibrium of space-time is determined by the absence of the difference of the electrical potentials over a specific distance, i.e., at $\Delta\varphi_{1-7x}= 0$. The point is that the consecutive distribution of the quantons on the X axis generates an alternating string from charges with alternating signs (Fig. 2.5). At the same distance between the charges of the alternating string, the pattern of the field is fully symmetric in every interval. This means that at $r_{ex} = a_x$ the functional dependence of the vector of the strength of the field inside adjacent intervals between the charges of the alternating string differs only in the sign of the direction of the vector, i.e. $\mathbf{E}_x= -\mathbf{E}_{qx}$. Therefore, the sum of the two identical integrals along the path 1_x-2_x-3_x with different signs is equal to 0 because it is determined by the identical unification ranges:

$$\Delta\varphi_{1-3x} = \int_{r_k}^{ax-r_k} \mathbf{E}_\mathbf{x} d\,x - \int_{r_k}^{rex-r_k} \mathbf{E}_{q\mathbf{x}} dx = 0 \tag{2.26}$$

Taking into account that the intervals 1_x–3_x are repeated many times with $\Delta\varphi_{1-3x}= 0$ along the X axis in the equalised quantised space-time, this space as a whole remains electrically balanced. In this case, the upper summation limit in equation (2.25) is practically unlimited in n intervals for the balanced discrete space-time.

It should be mentioned that inside the quanton and between the quantons, the strength of the electrical field and the potential have extremely high values although, on the whole, the quantised space-time remains electrically balanced.

The identical considerations may also be applied for the magnetic equilibrium of the quantised space-time which is analysed along the *Y* axis, and in a general case may be represented by the sum of the path in *n* intervals of discrete space (Fig. 2.5):

$$\Delta\varphi_{1-n_y} = \sum_{1x}^{n} \left(\int_{r_k}^{a_y - r_k} \mathbf{H}_y dy - \int_{r_k}^{r_{gy} - r_k} \mathbf{H}_{qy} dy \right) = 0 \qquad (2.27)$$

where $\mathbf{H}_y$ is the function of the strength of the magnetic field between adjacent quantons along the *Y* axis, $\mathbf{H}_{qy}$ is the function of the strength between the magnetic charges inside the quanton along the *Y* axis, a_Y is the distance between the magnetic charges of the adjacent quantons.

Taking into account (2.25) and (2.27), the condition of electrical and magnetic equilibrium of the quantised space-time can be expressed by a simple geometrical relationship:

$$\frac{r_{ex}}{a_x} = \frac{r_{ey}}{a_y} = 1 \qquad (2.28)$$

We can also investigate other variants of electromagnetic equilibrium in the quantised space-time but this results in a more complicated problem. For example, introducing other parameters of electrical and magnetic permeability into the region restricted by the sphere of distribution of the charges inside the quanton results in the situation in which the charges are represented by spheres with the finite dimensions which differ from the Planck length. In the final analysis, calculations in this direction can be carried out using the renal diameter of the charges. I have so far analysed the simplest variant.

The equilibrium state of the quantised space-time is referred to as tyhe zero state or zero level, and the disruption of the equilibrium state is associated with a deviation the from zero level [34–36].

2.3.2. Disruption of electrical and magnetic equilibrium in statics

If the condition of magnetic equilibrium of the quantised space-time is described by the relationship (2.28), disruption of its equilibrium is described by the inequality:

$$\frac{r_{ex}}{a_x} \neq \frac{r_{ey}}{a_y} \neq 1 \qquad (2.29)$$

In fact, the inequality (2.29) determines the displacement of the charges inside the quanton in relation to their equilibrium state. This results in the difference between the electrical and magnetic potentials in the quantised space-time manifested in the form of external electrical and magnetic fields. It is gratifying that the disruption of electromagnetic equilibrium of the quantised space-time is associated with actual points of displacement of the charges from their equilibrium state.

Figure 2.6 shows the pattern of disruption of the electrical equilibrium of the quantised space-time as a result of displacement of the charges in an alternating string under the effect of the external uniform electrical field, directed along the X axis. The source of the external perturbing field is not shown in Fig. 2.6. The transitional process of displacement of the charges is not investigated here and we analyse the disrupted equilibrium in the steady state.

As indicated by Fig. 2.6, the displacement of the charges disrupts the previously established electrical equilibrium of the system. The effect of the external field resulted in the deformation polarisation of the quantons in the string. The charges inside the quanton moves away from each other, and on the outside they came closer together, determining the inequality (2.29). The electrical field has been redistributed in the medium. The functions of the strength of the electrical field inside the quanton and outside it, along the X axis, have become equivalent, i.e. $\mathbf{E}_x \neq -\mathbf{E}_{qx}$. This was accompanied by changes in the unification limits $r_{ex} \neq a_x$, in accordance with (2.29). The external defects in the quantised space-time resulted in the establishment of the difference of the potentials, with the difference differing from zero:

$$\Delta\varphi_{1-nx} = \sum_{1x}^{n}\left(\int_{r_k}^{ax-r_k} \mathbf{E}_{\mathbf{x}} dx - \int_{r_k}^{rex-r_k} \mathbf{E}_{q\mathbf{x}} dx\right) \neq 0 \tag{2.30}$$

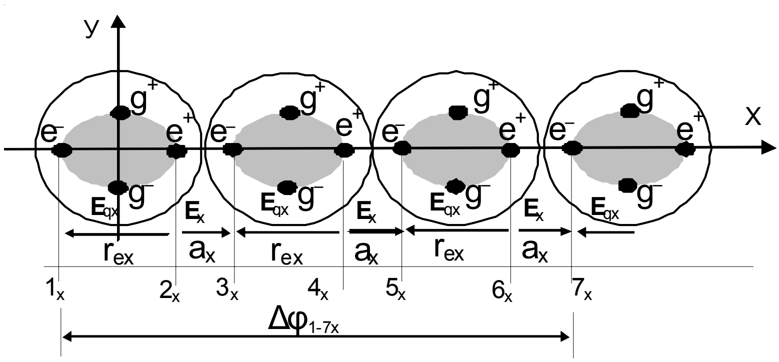


Fig. 2.6. Calculation of disruption of electrical equilibrium of quantised space-time.

The solution of the problem can be made more complicated by using the perturbation method for the function of the vector of the strength of the field of alternating charges along the x_{1-nx} axis and, in the final analysis, we obtain the result (2.30):

$$\Delta\varphi_{1-nx} = \sum_{1x}^{n} \left(\int_{r_k}^{ax-r_k} \mathbf{E_x} dx - \int_{r_k}^{rex-r_k} \mathbf{E}_{q\mathbf{x}} dx \right) = \mathbf{E} \cdot x_{1-nx} \tag{2.31}$$

Equation (2.31) determines the relationship between the manifestation of the external field and the disruption of the internal electrical equilibrium of the quantised space-time. Thus, the EQM theory returns the concept of short-range interaction to physics in which the external field may show itself only as a result of the ionisation of quantised space-time. This was confirmed in experiments by Faraday by demonstrating the manifestation of lines of force whose external component is the vectors of the strength of the fields of quantised space-time.

It is necessary to pay attention to the fact that the strength of the electrical field inside the quantum is very high and incommensurable in comparison with the strength of the external field of the quantised space-time. However, the variation of the strength of the field inside the quanton is commensurable in comparison with the strength of the external field of the quantised space-time.

Figure 2.7 shows the disruption of magnetic equilibrium of the quantised space-time as a result of the displacement of charges in the alternating string under the effect of an external uniform magnetic field directed along the Y axis (with the axis rotated in the horizontal direction).

Identical considerations also apply to the disruption of the magnetic equilibrium of quantised space-time. If the strength $\mathbf{H}$ of the uniform external perturbing magnetic field on the length y_{1-ny} is specified, the balance with the internal field is determined in accordance with (2.31):

$$\Delta\varphi_{1-ny} = \sum_{1x}^{n} \left(\int_{r_k}^{a_y-r_k} \mathbf{H}_y dy - \int_{r_k}^{r_{gy}-r_k} \mathbf{H}_{qy} dy \right) = \mathbf{H} \cdot y_{1-ny} \tag{2.32}$$

Thus, the effect of the external electrical or magnetic field leads to the displacement of the charges inside the quantum and disruption of the electrical and magnetic equilibrium of the quantised space-time. From the mathematical viewpoint, the equations (2.31) and (2.32) can be conveniently described by the linear dependence between the variation of the parameters of the primary field of the quanton $\Delta\mathbf{E}_{qx}$ and $\Delta\mathbf{H}_{qy}$ and the external perturbing field $\mathbf{E}$ and $\mathbf{H}$:

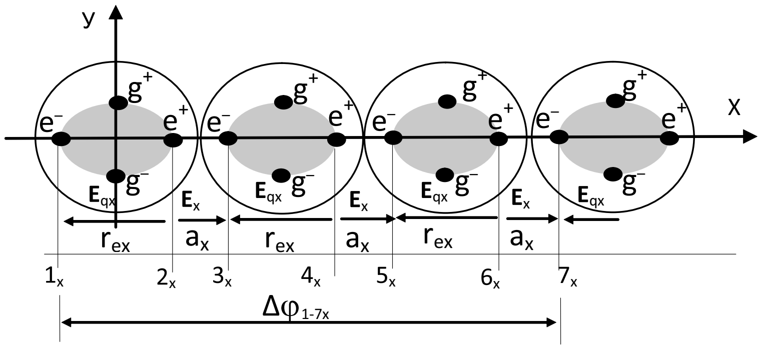


Fig. 2.7. Calculation of the disruption of magnetic equilibrium of quantised space-time.

$$\Delta\mathbf{E}_{qx} = -k_{\mathrm{E}}\mathbf{E}$$
$$\Delta\mathbf{H}_{qy} = -k_{H}] \tag{2.33}$$

where k_E and k_H are the proportionality coefficients.

2.3.3. Disruption of electromagnetic equilibrium in dynamics. Maxwell equations

Analysis of the disruption of the electrical and magnetic equilibrium in the quantised space-time has made it possible to determine the proportionality (2.33) between the changes of the parameters of the primary field of the quanton $\Delta\mathbf{E}_{qx}$ and $\Delta\mathbf{H}_{qy}$ and the external perturbing field **E** and **H**. Since the electromagnetic processes in the space-time are reversible, it may be asserted that the variation of the parameters of the primary field of the quanton $\Delta\mathbf{E}_{qx}$ and $\Delta\mathbf{H}_{qy}$ leads to the appearance of the external secondary field **E** and **H**. Consequently, we can investigate the dynamics of disruption of electromagnetic equilibrium in the conditions of passage of the electromagnetic wave through the quantised space-time and analyse the processes of electromagnetic polarisation of the quanton.

Without having the model of the electromagnetic ionisation of the quanton we cannot penetrate deeply into the principle of electromagnetic processes. This is the further development of concepts proposed by Faraday and Maxwell, the founders of dynamic electromagnetism [37, 38]. However, only in the theory EQM and Superunification theory has it been possible to combine electricity and magnetism in a single substance – electromagnetism, whose carrier is a new particle, i.e., the quanton and the superstrong electromagnetic interaction (SEI) in the form of the quantised Einstein space-time.

We consider the processes taking place in electromagnetic polarisation of the quanton as a result of the passage of an electromagnetic wave through the quanton. Experimental investigations of the propagation of electromagnetic waves show that the wave electromagnetic processes in vacuum are not associated with the extraction of excess energy from the vacuum. This means that the quanton retains its energy when the electromagnetic wave passes through it (2.17)

$$W_q = \text{const} \tag{2.34}$$

Since the energy of the quanton (2.34) in the electromagnetic processes remains constant, the energy capacity of the quantised space-time does not change. This means that there is no change in the concentration of the quantons (quantum density) in the medium and, correspondingly, the quanton diameter L_q also remains constant

$$L_q = \text{const} \tag{2.35}$$

Therefore, all further calculations of the electromagnetic polarisation of the quantum will be carried out taking the conditions (2.34) and (2.35) into account.

Figure 2.8 shows the different stages of electromagnetic polarisation of quantum in projection on the plane during the passage of an electromagnetic wave through the quanton. In the absence of electromagnetic perturbation (Fig. 2.8a), the quanton is in the equilibrium state. The dark part of the quanton represents its core. Inside the core of the quanton there is a tetrahedron whose tips carry the nuclei of the monopole charges (Fig. 2.2). Thus, the surface of the core of the quanton contains the nuclei of the monopole charges – quarks. The concept of the core of the quanton is introduced for the first time and is determined by the fact that in particular the core is subjected to deformation and orientation polarisation in

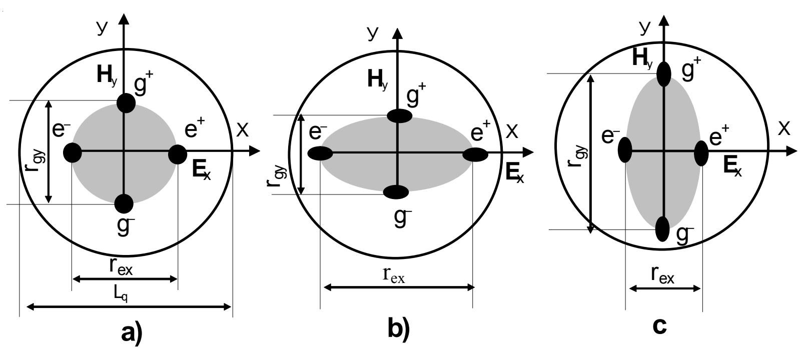


Fig. 2.8. Electromagnetic polarisation of the quantum during the passage of an electromagnetic wave.

electromagnetic processes ensuring the stability of the quanton diameter in accordance with the condition (2.35).

It is evident that when an electromagnetic wave passes through the quanton, in the first half cycle the core of the quanton should be stretched along the electrical axis *X* and should be compressed along the magnetic axis *Y*, or vice versa (Fig. 2.8b). In the second half cycle, the core of the quanton is stretched along the magnetic axis *Y* and compressed along the electrical axis *X*, or vice versa (Fig. 2.8c). The order of stretching and compression of the core of the quanton is determined by the direction of polarisation of the electromagnetic wave. After passage of the wave, the quanton returns to the equilibrium state (Fig. 2.8a). The charges are displaced in all cases of disruption of equilibrium of the quantum and this displacement determines the current of electrical and magnetic displacement of the electromagnetic field in the quantised space-time.

Figure 2.8 shows an idealised case of deformation polarisation of the quanton. Because of the tetrahedral arrangement of the charges inside a quanton, the electrical and magnetic axes of the quanton are randomly oriented in the real space-time. Therefore, when the electromagnetic wave passes through the quanton, both the deformation and orientation polarisation of the quantons take place, with polarisation determined by rotation of the axes of the quanton in space.

It should be mentioned that the displacement of the charges inside the quanton during the passage of the electromagnetic wave is extremely small leading to linearity (2.33). The EQM theory offers a method of calculating the displacement of the charges inside a quanton and this method will be described later.

On the other hand, the quantised space-time is a carrier of the electromagnetic wave, resulting in electromagnetic resonance of the quantum as a highly elastic element. It may be assumed that the quanton, as a volume resonator, has ideal properties ensuring the transfer of electromagnetic energy almost without any losses. If it would be possible to separate the quanton from the quantised space-time, then the quanton, once started, would oscillate for ever ensuring the exchange of electrical and magnetic energies (2.12). The presence of the electrical and magnetic elastic interaction between the charges of adjacent quantons inside the space-time ensures the transfer of electromagnetic energy of perturbation in the form of an electromagnetic wave. This means that the space-time is an elastic quantised medium capable of wave perturbations.

Therefore, it is very convenient to analyse the properties of the quanton under the effect of external perturbation. The value of the energy of external perturbation is not important in this case, it is important that the quanton retains its intrinsic energy (2.17), (2.34). This capacity of the quanton to retain its intrinsic energy determines the nature of electromagnetic processes resulting in the transformation of electricity to magnetism, and vice versa.

Because of the unique properties of the quanton, the transformation of electric energy to magnetic energy and back was carried out for the first time by the analytical derivation of the Maxwell equations for the electromagnetic wave in vacuum. The Maxwell equations are based on the processes taking place inside the quanton during the displacement of charges by a small value in relation to each other Δx and Δy, which is considerably smaller than the distances between the charges r_{qx} and r_{qy} inside the quanton (Fig. 2.8a):

$$\begin{aligned} \Delta x &<< r_{qx} \\ \Delta y &<< r_{qy} \end{aligned} \tag{2.36}$$

The displacement of the single charge in the quanton in relation to the equilibrium state is determined by the value 0.5 Δx and 0.5 Δy. The distance between the charges in the equilibrium state of the quanton is the same and equal to half the quanton diameter of $0.5L_q$. Consequently, we can describe the oscillatory electromagnetic processes of displacement of the charges inside the quanton by a harmonic function as the function of the distances between the charges r_{qx} and r_{qy} inside the quanton:

$$\begin{cases} r_{qx} = 0.5L_q + \Delta x \cdot \sin \omega t \\ r_{qy} = 0.5L_q - \Delta y \cdot \sin \omega t \end{cases} \tag{2.37}$$

where $\omega = 2\pi f$ is the cyclic resonance frequency of oscillations of the quanton, s^{-1}.

In the space-time non-perturbed by gravitation, the resonance frequency f of the oscillations of the quanton is determined by the equation (2.16) for f_0.

The displacements of the charges in the quanton are reduced to the system (2.37) because the small displacements Δx and Δy are equal to each other but their signs differ (2.1):

$$\Delta x = -\Delta y \tag{2.38}$$

The condition (2.38) determines the linearity of the electromagnetic processes in vacuum. Evidently, in reality, the displacements of the charges are so small that the regions of the non-linear electromagnetic processes in vacuum cannot be reached. Undoubtedly, the functional dependences of the parameters of the field between the charges inside a quanton are non-linear functions, but in the region of small displacements of the quanton in relation to equilibrium the section of the increase of the functions can be regarded as linear.

The difference in the sign in front of the displacements of the charges in (2.37) shows that the oscillatory processes of the charges inside the quanton along the axes X and Y take place in the counterphase. If the quanton nucleus is stretched along the X axis, then it is compressed along the Y axis and, vice versa, ensuring on the whole the constancy of the quanton energy (2.34). The equality of the increments of the electrical energy ΔW_e and the magnetic energy ΔW_g along the axes X and Y is expressed by the equation

$$\Delta W_e = -\Delta W_g \tag{2.39}$$

The increments of the energies (2.39) can be related to the displacement of the charges (2.38):

$$\frac{\Delta W_e}{\Delta x} = -\frac{\Delta W_g}{\Delta y} \tag{2.40}$$

The equations (2.39) and (2.40) describe the processes of conversion of electricity to magnetism and vice versa, through the increments of the energy (2.39) and the variation of the energy as a result of displacement of the charges (2.40). Since the expression (2.40) is determined by the very small displacement of the charges, it is fully justified to transfer from (2.40) to partial derivatives

$$\frac{\partial W_e}{\partial x} = -\frac{\partial W_g}{\partial y} \tag{2.41}$$

The partial derivatives (2.41) are determined from (2.2) taking into account that R_{qx} is situated on the X axis, and r_{qy} is on the Y axis:

$$\begin{cases} \dfrac{\partial W_e}{\partial x} = \dfrac{1}{4\pi\varepsilon_0} \dfrac{e^2}{x^2} \mathbf{1}_x = \mathbf{F}_e \\ \dfrac{\partial W_g}{\partial y} = -\dfrac{\mu_0}{4\pi} \dfrac{g^2}{y^2} \mathbf{1}_y = \mathbf{F}_g \end{cases} \tag{2.42}$$

where $\mathbf{1}_x$ and $\mathbf{1}_y$ are the unit vectors on the X and Y axes, respectively.

It may be seen that the partial derivatives (2.42) determine the forces (2.10) acting on the charges inside the quanton.

Expression (2.42) enables us to transfer from the energy parameters of the field to the parameters of the strength of the field $\mathbf{E}_x$ and $\mathbf{H}_y$ taking into account that in the region of small displacement of the charges, the strength of the field is determined by the strength of the field in the immediate vicinity of the charge, and the effect of other charges is very small, i.e.:

$$\mathbf{E}_x = -\mathbf{E}_{qx}, \quad \mathbf{H}_y = -\mathbf{H}_{qy} \tag{2.43}$$

Taking equation (2.43) into account, we can write equations of the strength for the single charge in the region of small displacements inside the quanton:

$$\begin{aligned} \mathbf{E}_x &= \frac{\mathbf{1}_x}{4\pi\varepsilon_0}\frac{e}{x^2} \\ \mathbf{H}_y &= \frac{\mathbf{1}_y}{4\pi}\frac{g}{y^2} \end{aligned} \tag{2.44}$$

From (2.44) we obtain partial derivatives:

$$\begin{aligned} \frac{\partial \mathbf{E}_x}{\partial x} &= -\frac{\mathbf{1}_x}{2\pi\varepsilon_0}\frac{e}{x^3} \\ \frac{\partial \mathbf{H}_y}{\partial y} &= -\frac{\mathbf{1}_y}{2\pi}\frac{g}{y^3} \end{aligned} \tag{2.45}$$

We introduce the partial derivatives (2.45) into (2.42), multiplying the right-hand part of (2.42) by *x*/*x* and *y*/*y*:

$$\begin{cases} \dfrac{\partial W_e}{\partial x} = \dfrac{ex}{4\pi\varepsilon_0}\dfrac{e}{x^3}\mathbf{1}_x = -\dfrac{1}{2}ex\dfrac{\partial \mathbf{E}_x}{\partial x} \\ \dfrac{\partial W_g}{\partial y} = -\dfrac{\mu_0 gy}{4\pi}\dfrac{g}{y^3}\mathbf{1}_y = \dfrac{1}{2}\mu_0 gy\dfrac{\partial \mathbf{H}_y}{\partial y} \end{cases} \tag{2.46}$$

Using the equality (2.41) for (2.46), we determine the relationship between the partial derivatives of the strength of the electrical and magnetic fields in electromagnetic polarisation of the quanton in the conditions of a small displacement (2.38) of the charges and constant quanton energy (2.34) at $x = y$ (x and y in this case represent the distance between the charges in the conditions of small displacements of the charges):

$$e\frac{\partial \mathbf{E}_x}{\partial x} = -\mu_0 g\frac{\partial \mathbf{H}_y}{\partial y} \tag{2.47}$$

Equation (2.47) can be expressed by the increments (2.39) and (2.40):

$$e\frac{\Delta\mathbf{E}_x}{\Delta x} = -\mu_0 g\frac{\Delta\mathbf{H}_y}{\Delta y} \tag{2.48}$$

In principle, the expression (2.47) and (2.48) are the final equations forming the basis of the laws of electromagnetic induction and Maxwell equations.

In fact, taking into account (2.38) and (2.6), from (2.47) we obtain

$$\Delta\mathbf{E}_x = -C_0\mu_0\Delta\mathbf{H}_y \tag{2.49}$$

$$\Delta\mathbf{H}_y = -C_0\varepsilon_0\Delta\mathbf{E}_x \tag{2.50}$$

The equations (2.49) and (2.50) show that any change in the electrical parameters of the strength of the field of the quanton results in the automatic disruption of the magnetic equilibrium of the quanton and vice versa, linking the increments $\Delta\mathbf{E}_x$ and $\Delta\mathbf{H}_y$. Taking into account (2.43) and returning to (2.33), it should be mentioned that any disruption of the internal equilibrium of the quantum results in the interaction of the secondary field **E** and **H** in the quantised space-time:

$$\Delta\mathbf{E}_x = -C_0\mu_0 k_H\mathbf{H} \tag{2.51}$$

$$\Delta\mathbf{H}_y = -C_0\varepsilon_0 k_E\mathbf{E} \tag{2.52}$$

Substituting (2.36) into (2.43) and taking into account electromagnetic symmetry of the quanton, when $k_E = k_H$, we obtain the required relationship:

$$C_0\varepsilon_0\mathbf{E} = -\mathbf{H} \quad \text{at} \quad \mathbf{E}\perp\mathbf{H} \tag{2.53}$$

Equation (2.53) corresponds to the experimentally observed equality of the vectors **E** and **H** in a flat electromagnetic wave. The vectors completely coincide in time but are shifted in space by 90°. Taking into account the harmonic nature of displacement of the charges (2.37) of the quanton during the passage of the electromagnetic wave, equation (2.53) can be conveniently written in the complex form, writing the harmonic functions of the strength with the point

$$C_0\varepsilon_0\dot{\mathbf{E}} = -\dot{\mathbf{H}} \quad \text{at} \quad \mathbf{E}\perp\mathbf{H} \tag{2.54}$$

Taking into account the fact that the speed of light in (2.54) is the vector $\mathbf{C}_0$ of the speed of propagation of the electromagnetic wave, the equation (2.54) should be presented in the accurate form of the vector products where all the three vectors $\mathbf{C}_0$, **E** and **H** are orthogonal in relation to each other in the quantised space-time:

$$\varepsilon_0\left[\mathrm{C}_0\dot{\mathbf{E}}\right] = -\dot{\mathbf{H}} \tag{2.55}$$

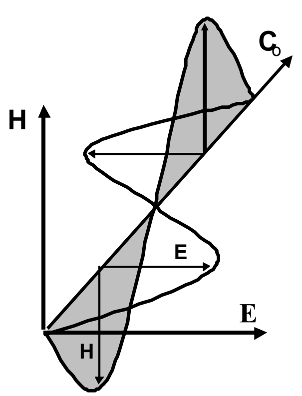
The equations (2.54) and (2.55) are well-known in electrodynamics and describe the flat electromagnetic wave (Fig. 2.9 and Fig. 1.1). Most importantly, the expressions (2.54) and (2.55) have not been derived as a result of formal transformations of the Maxwell equations (2.3) but they have been derived on the basis of the analysis of the electromagnetic transition processes taking place inside the quanton and quantised space-time. This means that the interaction of the quanton as a carrier of electromagnetic interactions is justified.

In fact, the equations (2.47), (2.48), (2.54), (2.55) are another form of writing the Maxwell equations (2.3) and, in the final analysis, have been derived as a result of transformation of the Coulomb laws (2.10) and (2.42), acting inside the quanton. The distinguishing feature of (2.47), (2.48), (2.54) and (2.55) is the absence of rotors, forming the basis of the Maxwell equations (2.3). It should be mentioned that the Maxwell equations (2.3) were modified to the current form by Heaviside. Maxwell did not attribute any importance to the rotors. His effort was directed to deriving wave equations obtained on the basis of analysis of the electromagnetic properties of the elastic electromagnetic aether. The wave equation of the electromagnetic field in the form presented by Maxwell [34] and shown in Fig. 2.9 is:

$$\frac{d^2\,\mathrm{F}}{dz^2} = K\mu \frac{d^2\,\mathrm{F}}{dt^2} \tag{2.56}$$

where F is the electromagnetic amount of motion – the generalised parameter of the electromagnetic field from which the magnetic field (1/μ) (dF/dz) and electrical force (dF/dt) (according to Maxwell) originate [34].

The scientific concept used by Maxwell for deriving the equation (2.56) will now be discussed: ‘in the theory of electricity and magnetism, accepted at present, we assume the existence of two types of energy – electrostatic and electrochemical, and it is also assumed that they are situated not only in electrified and magnetised solids but also in every part of the surrounding space where the effect of electrical and magnetic forces is detected. Consequently, our theory agrees with the wave theory in that this theory assumes the existence of a medium capable of being the receptacle of two



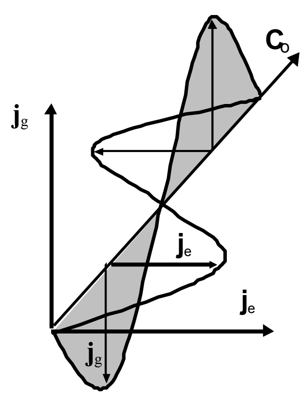


Fig. 2.9. A flat electromagnetic wave in quantised space-time in the coordinates **H** and **E**.
Fig. 2.10 (right)**.** A flat electromagnetic wave in the quantised space-time in the coordinates $\mathbf{j}_0$ and $\mathbf{j}_e$.

types of energy' [38]. Using the method of electromagnetic perturbation of the medium, Maxwell derived the equation (2.56) and other equations which were subsequently transformed to the form (2.3). In fact, equation (2.55) has also been transformed to the form (2.56).

The scientific concept of the Maxwell electromagnetic field is in complete agreement with the fundamentals of the EQM theory. Only the EQM theory has described the structure of the vacuum field as the quantised space-time being the 'receptacle of two types of energy'. Later, the theory of electromagnetism deviated from the Maxwell concept, formalising the Maxwell equations, and the electromagnetic wave in itself ceased to be regarded as an independent substance not requiring a carrier. As a result, the nature of the electromagnetic phenomena in vacuum remained on the Maxwell level for almost half a century.

If we analyse the generally accepted studies of the theory of electromagnetism, we detect the same repetition of the formal approach to the Maxwell equations in vacuum [39–45]. Whilst the physicists try not to go into the reasons behind the wave nature of electromagnetism, electricians prefer the vortex approach: 'Today, we prefer to consider the formation of the basic properties of the electromagnetic field as a result of changes over time in the electrical field, just as the formation of vortices of the electrical field due to changes over time in the magnetic field' [45]. However, this has not been confirmed by the experiments with the flat electromagnetic wave, Fig. 2.9. The vectors **E** and **H** of this wave (2.54) can exist only together and at the same time without any phase shift in time. If one of the vectors is removed, the electromagnetic wave is disrupted. In practice, this is used in the construction of electrical screens in the form of a conducting mesh which completely screens only the electromagnetic field and does not screen the magnetic field. The removal of the electrical component results in the disruption of the electromagnetic wave and in screening of electromagnetic radiation.

The simultaneous existence of **E** and **H** in (2.55) indicates that the rotors of the field have no direct relationship with the nature of the electromagnetic field in vacuum, although they can be detected as the secondary manifestation of fields which will be discussed later. The equation of the flat electromagnetic wave (2.55) is rotor-free and has been derived from (2.47) on the basis of analysis of the electromagnetic polarisation of the quanton and the quantised space-time which is easily reduced to the form (2.3), determining the real nature of the displacement currents in vacuum.

2.3.4. Displacement of the charges in the quanton and displacement currents

A paradoxic situation formed in the electrodynamics where the Maxwell equations (2.3) formally determine the density of currents of electrical $\mathbf{j}_e$ and magnetic $\mathbf{j}_g$ displacements which the theory of the field treats as virtual and which do not exist in nature. The presence of the quantised structure of space-time confirms for the first time that the displacement currents are the currents which actually exist in nature.

A distinguishing special feature of the displacement currents in vacuum is that these currents are determined by the simultaneous displacement from equilibrium in the counter phase of electrical and magnetic charges of the opposite polarity. Figure 2.5 shows in projection the region of quantised space-time which enables the vacuum to be regarded as a specific elastic medium filled with charges and capable of electromagnetic ionisation as a result of displacement of the charges from the equilibrium state (Fig. 2.8).

To determine the relationship between the displacement currents, we return to (2.47) presenting it in the following form:

$$C_0\varepsilon_0 \frac{\partial \mathbf{E}_x}{\partial x} = -\frac{\partial \mathbf{H}_y}{\partial y} \tag{2.57}$$

The equation (2.47) is converted to the form (2.3), expressing the density of the displacement currents. For this purpose, we transfer from the derivatives in respect of the coordinates *X* and *Y* to derivatives in respect of time *t*, taking into account the fact that the speed of displacement *v* of the charges in relation to the equilibrium state remains the same along the axes *X* and *Y* because of the small value of the displacement:

$$\mathbf{v} = \frac{\partial x}{\partial t}\mathbf{1}_x = -\frac{\partial y}{\partial t}\mathbf{1}_y \tag{2.58}$$

Taking (2.58) into account, we transform equation (2.57)

$$C_0\varepsilon_0 \frac{\partial \mathbf{E}_x}{\partial t} = \frac{\partial \mathbf{H}_y}{\partial t} \tag{2.59}$$

Equation (2.59) includes the densities of the currents of electrical $\mathbf{j}_e$ and magnetic $\mathbf{j}_g$ displacements (2.3). Consequently, (2.59) can be described by the vector product:

$$\left[C_0\mathbf{j}_e\right] = -\mathbf{j}_g \tag{2.60}$$

Like (2.55), expression (2.60) describes the flat electromagnetic wave (Fig. 2.10) in the coordinates $\mathbf{j}_g$ and $\mathbf{j}_e$. The wave in Fig. 2.10 is equivalent to the wave in Fig. 2.9 in the coordinates **H** and **E**. However, the displacement currents (2.60) are the primary currents and determine the strength of the field **E** and **H** in (2.55) as a result of the disruption of the electromagnetic equilibrium of the quantised space-time. This produces a specific phase shift between the vectors $\mathbf{j}_g$ and **H**, $\mathbf{j}_e$ and **E**, which will be discussed later.

The dimension of electrical current is [A = C/s]. The magnetic current also has the dimension [Dc/s] (2.6) but it has no name. It was proposed to call the magnetic current in honour of Heaviside [Hv = Dc/s]. Ampere [A] and Heaviside [Hv] are linked by the relationship [Hv] = C_0 [A]. The electrical current of 1 A is equivalent to the magnetic current of $3 \cdot 10^8$ Hv. We can construct a system of measurements in which the electrical and magnetic currents and also charges are measured in the same units. However, this would require violating the conventional SI system.

The dimension of the density of electrical displacement currents is determined as follows [$A/m^2 = C/m^2$ s]. We determine the dimension of the density of magnetic displacement currents [$Hv/m^2 = Dc/m^2$ s].

2.3.5. Displacement of the charges in the quanton in statics

After defining the dimensions, we can calculate the displacement of the electrical charges and the quanton, the speed of displacement of the charges, and current densities. For this purpose, we combined the equations (2.3) and (2.4). Number 2 in (2.4) indicates that in the quanton, the charges are considered in pairs

$$2e\rho_0 \mathbf{v} = \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \tag{2.61}$$

$$2e\rho_0 \frac{\partial x}{\partial t} \mathbf{1}_x = \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \tag{2.62}$$

Initially, the solution of (2.62) is determined for the linear function (the solution for the harmonic function will be different)

$$2e\rho_0 \Delta x \mathbf{1}_x = \varepsilon_0 \mathbf{E} \tag{2.63}$$

The resultant solution (2.63) makes it possible to link the linear displacement Δx in (2.37) of electrical charges in the quanton which induces the secondary external field in the space with the strength E.

From equation (2.62) we determine the displacement Δx of charges inside the quanton, for example, for an electrostatic field with the strength equal to the electrical strength of air of 30 kV/cm = 3×10^6 V/m ($\rho_0 = 3.55 \cdot 10^{75}$ m^{-3} [7, 20])

$$\Delta x = \frac{\varepsilon_0 E}{2e}\frac{1}{\rho_0} = \frac{\varepsilon_0 E}{2e}\frac{L_{q0}^3}{k_3} = 2.3 \cdot 10^{-62}\,\mathrm{m} \tag{2.64}$$

where ρ_0 is the quantum density of the space-time unperturbed by the gravitation; $k_3 = 1.44$ is the coefficient of filling of vacuum with spherical quantons

$$\rho_0 = \frac{k_3}{L_{q0}^3} \tag{2.65}$$

From equation (2.64) we determine the disruption of the electrical equilibrium in the quantised space-time as a result of the displacement of electrical charges in the quanton as the strength **E** of the secondary field:

$$\mathbf{E} = \frac{2ek_3\mathbf{1}_x}{\varepsilon_0 L_{q0}^3}\Delta x \tag{2.66}$$

As indicated by (2.64) and (2.66), disruption of the electrical equilibrium as a result of displacement of the electrical charges in the quanton by approximately 10^{-62} m induces in the space-time a strong electrical field with the strength characterised by the electrical strength of air. This confirms that the quantised space-time is a highly elastic medium, taking into account the fact that the distance between the charges in the quanton is determined by the value of the order of 10^{-25} m, and the diameter of the nucleus of the point charges in the quantons at the moment is defined by the Planck length of 10^{-35} m. Displacement of the charges in the quanton by 10^{-62} m is incommensurably small even in comparison with the Planck length. Regardless of this, this small displacement results in a significant disruption of the electrical equilibrium of the quantised space-time.

The secondary field **E** (2.66) is determined by the displacement Δx (2.64) of the charges of the quanton as a result of the superposition of the fields of a number of quantons included in the investigated region of the space. As shown previously, the relationship between the elements of the primary field $\Delta\mathbf{E}_{qx}$ of the quanton and the secondary induced field **E** is determined by the coefficients k_E and k_H (2.33), and $k_E = k_H$ (2.53). The further solution of the problem is reduced to the determination of the coefficients k_E and k_H. However, to find these coefficients, it is necessary to determine the variation of the strength of the field inside the quanton during displacement of the charges.

This can be carried out by solving (2.31). However, this solution is purely mathematical. We shall use a different procedure and examine the purely physical model whose mathematical solution is very simple and also describes the very physics of the phenomenon. Equation (2.31) shows that the disruption of the electrical equilibrium should be investigated on the elementary level, studying a section of length not smaller than the diameter of the quanton L_{q0}. Consequently, the solution of the problem should be found as the displacement of an entire charge between two adjacent charges with the same polarity. The displaced charge has the opposite polarity in comparison with the two stationary charges. Instead of the strength of the field we study the variation of force during displacement of the charge since it is quite easy to transfer to the parameter of the strength of the field if we know the force.

Figure 2.11 shows the calculation diagram of the displacement of a pair of electrical charges in the quanton from the equilibrium state in Fig. 2.5 by the value Δx in different directions from the origin of the coordinates, Fig. 2.6. To simplify calculations, the origin of the coordinates is transferred to the charge 1_x with negative polarity, assuming that the charge is stationary. Consequently, the displacement of the charge 2_x with positive polarity inside the quanton along the axis X is determined by the distance $2\Delta x$. The charge 2_x is situated between two charges with negative polarity 1_x and 3_x. The distance between the charges 1_x and 3_x remains equal to the quanton diameter $L_{q0} = L_{qx}$ in the displacement of the charge 2_x by $2\Delta x$. The distance r_{ex} between the charges 1_x and 2_x inside the quanton increases by $2\Delta_x$ and becomes equal to ($0.5\ L_{qo} + 2\Delta x$). The distance a_x between the charges $2x$ and $3x$ outside the quantum decreases by $2\Delta x$ and becomes equal to ($0.5\ L_{qo}$ - $2\Delta x$). Consequently, we can calculate the forces acting on the charge 2_x. From the side of the charge 1_x it is the force $-\mathbf{F}_{1x}$, from the side of the charge 3_x it is the force $+\mathbf{F}_{3x}$. The resultant force is $\mathbf{F}_{2x} = \mathbf{F}_{3x} - \mathbf{F}_{1x}$. We determine the resultant force $\mathbf{F}_{2x}$, taking into account that $\Delta x \ll L_{q0}$ and retain the significant terms:

$$\mathbf{F}_{2x} = \mathbf{F}_{3x} - \mathrm{F}_{1x} = \frac{e^2}{4\pi\varepsilon_0}\left(\frac{1}{a_x^2} - \frac{1}{r_{ex}^2}\right)\mathbf{1}_x =$$
$$= \frac{e^2}{4\pi\varepsilon_0}\left(\frac{1}{(0.5L_{q0} - 2\Delta x)^2} - \frac{1}{(0.5L_{q0} + 2\Delta x)^2}\right)\mathbf{1}_x = \frac{16e^2\mathbf{1}_x}{\pi\varepsilon_0 L_{q0}^3}\Delta x \qquad (2.67)$$

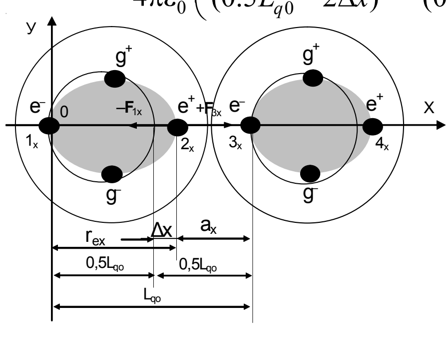


Fig. 2.11. Calculation of the displacement of the electrical charge from the equilibrium state in the quanton.

As indicated by (2.67), the resultant force $\mathbf{F}_{2x}$, acting on the charge 2_x, is proportional to the displacement Δx in the range of small displacements $\Delta x << L_{qo}$. In the equilibrium conditions at $2\Delta x = 0$, force $\mathbf{F}_{2x} = 0$. Force $\mathbf{F}_{2x}$ is completely equivalent to the force acting on an elastic spring when the force of tensile loading of the spring is proportional to its extension X. In the present case, the elongation is represented by the displacement $2\Delta x$ of the charge 2_x from the equilibrium state. The analogy between the properties of the elastic spring and the equivalent properties of the quantised space-time is referred to as the theory of the elastic quantised medium (EQM).

In order to determine the variation of the strength $\Delta\mathbf{E}_{qx}$ of the internal field inside the quantised medium we use the results obtained from (2.67) examining the charge 2_x as a testing charge, and the force $\mathbf{F}_{2x}$ acting on the charge is proportional to the variation of strength $\Delta\mathbf{E}_{qx}$ of the field as a result of disruption of electrical equilibrium of the medium:

$$\Delta\mathbf{E}_{qx} = \frac{1}{e}\mathbf{F}_{2x} = \frac{16e\mathbf{1}_x}{\pi\varepsilon_0 L_{q0}^3}\Delta x \tag{2.68}$$

When the charges are displaced by $\Delta x = 2.3\cdot10^{-62}$ m (2.64), from equation (2.68) we determine the variation of the strength of the primary field inside the quanton which is $\Delta\mathbf{E}_{qx} = 5.3\cdot10^6$ V/m. Comparing the result with the strength of the primary field for $E = 3\cdot10^6$ V/m for the displacement of the charges by $\Delta x = 2.3\cdot10^{-62}$ m (2.64), it is important to note that even the approximate solutions do not result in any large scatter of the parameters of the strength of the fields $\Delta\mathbf{E}_{qx}$ and $\mathbf{E}$. It should be mentioned that the parameters ΔE_{qx} have been calculated in the region of the ultra-microworld of the quantons, and the parameters E were taken from the region of the macroworld, using completely different approaches to solution of the problem. Now it can already be mentioned that this agreement is extremely unique and shows convincingly that the parameters of the ultra-microworld are directly linked with the macroworld.

The results obtained from (2.67) and (2.16) are slightly too high because they do not take into account the reduction of the strength of the field in the alternating string (Fig. 2.5) as a result of the effect of other charges taken into account by coefficient $\pi^2/12$ [4]. We improve the accuracy of (2.67) and (2.68):

$$\mathbf{F}_{2x} = \frac{\pi^2}{12}\frac{16e^2\mathbf{1}_x}{\pi\varepsilon_0 L_{q0}^3}\Delta x = \frac{4\pi}{3}\frac{e^2\mathbf{1}_x}{\varepsilon_0 L_{q0}^3}\Delta x \tag{2.69}$$

$$\Delta\mathbf{E}_{qx} = \frac{4\pi}{3}\frac{e\mathbf{1}_x}{\varepsilon_0 L_{q0}^3}\Delta x \tag{2.70}$$

Finally, from (2.33) we determine the coefficient k_E, dividing (2.70) by (2.66)

$$k_E = \frac{\Delta E_{qx}}{E} = \frac{4\pi}{3\varepsilon_0} \frac{e\Delta x}{L_{q0}^3} \frac{\varepsilon_0 L_{q0}^3}{2e\Delta x k_3} = \frac{2\pi}{3k_3} \approx 1.4$$

$$\cos\alpha_x = 1/k_E \approx \pm 0.7, \quad \alpha_x \approx \pm 45^\circ \qquad (2.71)$$

The result (2.70) describes quite accurately the field of the alternating string. The field can be determined with greater accuracy by taking into account the effect of adjacent strings, however, the improvement is only slight. The image of the field in the string in Fig. 2.6 is idealised. Inside a quanton, the charges are distributed on the tips of the tetrahedron. Therefore, in polarisation of the quantons, the direction of the vectors $\Delta\mathbf{E}_{qx}$ of the set of the quantons does not correspond with the direction of the axis X. It should be mentioned that the result (2.63) is averaged out for the vector **E** situated completely on the axis X. In fact, coefficient k_E (2.71) takes into account the projections of vector $\Delta\mathbf{E}_q$ on the X axis. The averaged-out angle α_x of inclination of the vector $\Delta\mathbf{E}_{qx}$ is determined by cos $\alpha_x = 1/k_E \sim\pm 0.7$. Consequently, we determine the required average angle $\alpha_x \sim\pm 45°$.

Thus, the calculations fully confirm the scientific concept of the quantised space-time. Analysis was made of the displacement of the electrical charges inside the quanton and disruption of electrical equilibrium of the space-time in the statics. These processes are reversible. In the presence of the external field, the charges are displaced in the quanton in relation to the equilibrium state. On the other hand, in the case of internal displacements of the charges in the quanton in relation to the equilibrium state, the electrical equilibrium in the quantised space-time is violated. This results in the appearance in the quantised space-time of the electrical field with the strength **E** formed as a result of the superposition of the fields from the set of quantons in the region of the electrically perturbed space.

The results and conclusions also fully relate to the displacement Δy of the magnetic charges g inside the quanton in the case of disruption of the magnetic equilibrium of space-time. Since the magnetic processes are identical with electrical processes, they can be described on the basis of the previously mentioned calculations using (2.61)–(2.71) by replacing the electrical constants with the equivalent magnetic constants along the Y axis:

$$2g\rho_0\mathbf{v} = -\frac{\partial\,\mathbf{H}}{\partial\,t} \qquad (2.72)$$

$$2g\rho_0 \Delta y \mathbf{1}_y = -\mathbf{H} \tag{2.73}$$

$$\Delta y = \frac{H}{2g}\frac{1}{\rho_0} = \frac{H}{2g}\frac{L_{q0}^3}{k_3} \tag{2.74}$$

$$\mathbf{H} = -\frac{2gk_3\mathbf{1}_y}{L_{q0}^3}\Delta y \tag{2.75}$$

$$\mathbf{F}_{2y} = -\frac{4\pi}{3}\mu_0\frac{g^2\mathbf{1}_y}{L_{q0}^3}\Delta y \tag{2.76}$$

$$\Delta\mathbf{H}_{qy} = -\frac{4\pi}{3}\frac{g\mathbf{1}_y}{L_{q0}^3}\Delta x \tag{2.77}$$

$$\begin{gathered} k_H = \frac{\Delta H_{qy}}{H} = \frac{4\pi}{3}\frac{g\Delta y}{L_{q0}^3}\frac{L_{q0}^3}{2g\Delta y k_3} = \frac{2\pi}{3k_3} \approx 1.4 \\ \cos\alpha_y = 1/k_H \approx \pm 0.7, \quad \alpha_y \approx \pm 45^{\circ} \end{gathered} \tag{2.78}$$

The analysis results show that disruption of the electrical and magnetic equilibrium inside the quanton in the region of the ultra-microworld of the fundamental length results in automatic disruption of the electrical and magnetic equilibrium of the quantised space-time in the region of the microworld of the elementary particles and in the macroworld. Therefore, the derivation of the Maxwell equations (2.55) and (2.60) for a flat electromagnetic wave, Fig. 2.9 and 2.10, obtained as a result of analysis of electromagnetic polarisation of the quanton, Fig. 2.8, can also be extended to any region of the quantised space-time.

On the other hand, analysis shows that the manifestation of the electrical and magnetic fields in the quantised space-time is associated with the disruption of its electrical and magnetic equilibrium. This means that any electrical or magnetic fields can exist in space due to the electrical and magnetic ionisation of the quantons which play the role of electrical and magnetic dipoles, carriers of fields, and their polarisation results in the pattern of the field.

The field of a flat condenser between the plates and inside them is filled with quantons resulting in the disruption of electrical equilibrium of the space-time in such a manner that the field between the plates is uniform and at the edges it is non-uniform. This can also be found in the magnetic gap of a magnetic circuit. It is now important to note that any configuration of the complex field is described in the statics by the Poisson or Laplace equations because of the internal properties of the orthogonality of the quantised space-time (Fig. 2.5) which has the form in the final analysis of a network of lines of force with equipotentials orthogonal to them.

Faraday and Maxwell attributed a real physical meaning to the lines of force. However, up to now, the actual nature of the lines of force has not been confirmed, regardless of the fact that they have been visualised using iron shavings and other methods. This is because physics can understand the principle of the phenomenon only by penetrating into the region of the ultra-microworld of the quantons, analysing the field on the level of the fundamental length of 10^{-25} m. Only in the EQM theory has it been possible to show that the lines of force as real objects do in fact form as a result of the electrical and magnetic polarisation of the quantised space-time. The simplest form of representation of the lines of force as a real object are the electrical (Fig. 2.6) and magnetic (2.7) strings made from quantons.

2.3.6. Polarisation energy of the quanton

Examining the electromagnetic polarisation of the quantum during the passage of an electromagnetic wave, it was possible to determine the condition (2.34) of constancy of quanton energy. This results in the simultaneous transition of electrical energy to magnetic energy, and vice versa. However, in static polarisation the condition (2.34) is not filled and is determined by the increase of electrical ΔW_e or magnetic ΔW_g energy (2.12) and (2.17) fulfilling the conditions of the electrostatic of magnetic regime:

$$W_q = W_g + W_e \pm \Delta W_e \neq \text{const} \tag{2.79}$$

$$W_q = W_e + W_g \pm \Delta W_g \neq \text{const} \tag{2.80}$$

In the transition regime which is characterised by a very high speed (2.15) for a single quanton the condition (2.34) is fulfilled at $\Delta W_e = \Delta W_g$ and is characterised by the interaction of the components ($-\Delta W_e$) and ($-\Delta W_g$)

$$W_q = W_g - \Delta W_g + W_e + \Delta W_e = \text{const} \tag{2.81}$$

$$W_q = W_e - \Delta W_e + W_g + \Delta W_g = \text{const} \tag{2.82}$$

Possibly, this transition is associated with damped oscillations of the quanton, treating the quanton as a volume electromagnetic resonator.

Since the disruption of the induced equilibrium ($-\Delta W_e$) and ($-\Delta W_g$) in (2.81) and (2.32) is not maintained in the steady regime, ($-W_e$) and ($-W_g$) change to 0, establishing the electrical (2.79) or magnetic (2.80) static field as displacements (2.70) and (2.77) of the charges in the quanton in relation to the equilibrium state. It should be mentioned that a source of the external static field is required for the displacement of the charges (2.70) and (2.77).

The continuous electromagnetic wave is generated by harmonic variation of ΔW_e or ΔW_g for a large group of quantons in some volume of the space which is regarded as the radiation zone. This is realised using the generators of the electromagnetic field and antennae.

2.3.7. Nature of electromagnetic oscillations in vacuum

In section (2.3.4) we analysed the derivation of the Maxwell equations for the electromagnetic wave in vacuum which is reduced, in the final analysis, to a single vector equation (2.55) or to an equivalentequation (2.60). It would appear that this work has been sufficient to understand the principle of wave phenomena taking place in vacuum, regarding the quanton as a real carrier of the electromagnetic field. At the same time, the EQM theory provides additional possibilities for investigating the nature of electromagnetic oscillations in vacuum based on the capacity of the quanton to carry out elementary oscillatory cycles.

In particular, it should be noted that the continuity of the electromagnetic wave is determined by the superposition of the oscillations of the individual quantum during the passage of an electromagnetic wave through the quantised space-time. Consequently, it can be claimed that any electromagnetic field (wave) is quantised in its basis.

The quantised nature of the electromagnetic field becomes especially evident when the frequency of the field in the region of photon radiation is increased, when the electromagnetic radiation has discrete properties and energy is emitted in portions – radiation quanta. This was used as the starting point of the quantum theory in which the classic electrodynamics, supported by the continuity of the electromagnetic field, clashed with the disruption of continuity, with discrete photon radiation [12].

The characteristic feature of the continuous electromagnetic wave is that the intensity of radiation is independent of wavelength. The intensity of radiation of a continuous wave may smoothly change in the entire range of electromagnetic continuous waves by the smooth variation of the parameters **E** and **H**.

Photon radiation is of the discrete nature and its intensity is proportional to radiation frequency. The nature of this phenomenon is not known in modern physics. The introduction of the action quanton h (or $\hbar$) purely empirically by Planck was used as a basis for developing the calculation apparatus of quantum theory but has not helped in studies of its principle.

The assumption on the photon nature of radiation enabled Einstein to determine the equivalence of the mass *m* (or the mass defect Δm) and radiation energy $\hbar v$, which is proportional to frequency ν:

$$\Delta m C_0^2 = \hbar \nu \tag{2.83}$$

Thus, equation (2.83) shows that the nature of phonon radiation differs from that of radio waves, including microwaves. Radio waves are produced by electromagnetic resonators which are artificially produced oscillatory circuits *LC*, where *L* is inductance, *C* is capacitance. In the oscillatory circuit, electrical energy is converted to magnetic energy and vice versa. The discharge of electromagnetic energy from various oscillatory circuits and resonators into space takes place by different mechanisms. However, in the final analysis, the quantised space-time is characterised by the formation of an electromagnetic wave from orthogonal vectors **H** and **E** which is described by the vector product (2.55) for a flat wave.

Resonator systems are not used for producing photon radiation. Einstein showed that photon radiation is based on the mass defect phenomenon (2.83). This is the primary method. All other methods of investigating photon radiation are secondary methods and are not without contradictions.

For example, the radiation of an atomic system is regarded as a jump of the electrical energy of the system in transition of an orbital electron to a lower orbit. However, there is a contradiction in this. A decrease of the distance between the atomic nucleus and the orbital electron at the moment of the jump increases the electrical energy of the system, as the binding energy. If the situation were reversed, the energy of the system would decrease in comparison with the initial energy, and its excess would be transformed to radiation. However, in this case, the energy of the system increases and photon radiation forms at the same time. The removal of this contradiction by the method of re-normalisation of energy is only the removal of contradictions in the calculation variant, it is not the solution of the problem.

The solution of the problem of photon radiation is based on the nature of transfer of the mass defect to electromagnetic radiation. This fundamental problem cannot be solved without combining gravitation and electromagnetism, and this is also investigated in this book. The EQM and Superunification theories describe the electromagnetic nature of gravitation and the mechanism of formation of the mass of an elementary particle as a result of spherical deformation of quantised space-time [22, 23]. In particular, the energy of deformation of the space-time is released as a result of the mass defect of the elementary particle and generates a radiation quantum in the form of a photon.

It is important to understand that, regardless of different nature of the formation of photon radiation and radio waves, the common feature of these two types of radiation is the common carrier – quanton and quantised space-time. However, it can already be asserted that radio waves are characterised by a variable (var) value of displacement Δx (2.70) and Δy (2.77) of the charges in the quanton:

$$\Delta x = \Delta y = \text{var} \tag{2.84}$$

In particular, the variable value of the displacements Δx and Δy of the charges in the quanton leads to a change of the parameters **E** and **H** of the electromagnetic wave and to changes of their intensity which is not directly linked with frequency.

The intensity of photon radiation is proportional to frequency (2.83). This is possible only if the displacements Δx (2.70) and Δy (2.77) of the charges in the quanton, which takes part in the transfer of photon radiation, remain constant

$$\Delta x = \Delta y = \text{const} \tag{2.85}$$

Only if the condition (2.85) is fulfilled, when it is not simple to change the intensity of radiation as a result of the parameters **E** and **H**, there remains a single method of changing the energy transferred by the photon – the method of variation of the frequency (2.83) of the electromagnetic field for the radiation quantum. It can already be assumed that the condition (2.83) is fulfilled for the photon only if the photon occupies a small limited region of the quantised space-time which includes a constant number of quantons, and the condition (2.85) is fulfilled for every quanton. Consequently, inside the region of the space-time limited by the volume of the photon there can only be a certain number of waves determining the discrete nature of photon radiation.

As already mentioned, the nature of photon radiation is associated with the nature of gravitation and is outside the framework of only electromagnetism. On the other hand, photon radiation, like the radiation of radio waves, is linked by its nature with the quanton and the quantised space-time. Therefore, we continue analysis of the properties of the quanton.

It is surprising to see that everything in nature is linked harmonically with the system of knowledge described by the EQM theory and Superunification theory. It would appear that some monopole charges e and g of different nature enter the quanton (Fig. 2.2b) and determine the single substance – electromagnetism. However, if g is formally divided by e, we obtain the speed of light (2.6)

$$C_0 = \frac{g}{e} \tag{2.86}$$

In fact, equation (2.86) has a specific physical meaning. Figure 2.5 shows the model of the quantised space-time which can be regarded as some spatial field with the distributed parameters $\pm e$ and $\pm g$. Because of the presence of the distributed parameters $\pm e$ and $\pm g$, the space-time represents a unique volume waveguide, a medium capable of carrying electromagnetic radiation.

In radioelectronics, electromagnetic radiation is transferred by double-wire lines (or coaxial cables, waveguides) regarded as lines with the distributed *LC* parameters. Drawing an analogy between the distributed parameters *LC* and $\pm e \pm g$, it can be shown that the electrical charge e is an analogue of capacitance C and the magnetic charge g is an analogue of inductance L.

The quanton contains two electrical charges and two magnetic charges (Fig. 2.2 and 2.8). Electrical capacitance C_e of two charges $\pm e$ included in the quanton is determined by the radius r_k of the sphere (2.25) around the nucleus of the monopole charge (Fig. 3), taking into account that $r_k < r_{ex}$, where r_{ex} are the distances between the centres of the charges (sphere r_k is the equipotential surface)

$$C_e = \frac{2e}{\Delta\varphi_e} = 4\pi\varepsilon_0 r_k \tag{2.87}$$

where $\Delta\varphi_e$ is the difference of the electrical potentials between the spheres r_k around the nuclei of monopole charges at $r_k \ll r_{ex}$

$$\Delta\varphi_e = \frac{e}{2\pi\varepsilon_0}\left(\frac{1}{r_k} - \frac{1}{r_{ex} - r_k}\right) \approx \frac{1}{2\pi\varepsilon_0}\frac{e}{r_k} \tag{2.88}$$

Equation (2.87) determines the electrical capacitance of the quanton as a distributed parameter of the quantised space-time. It is interesting to note that the capacitance of the quanton is determined by the radius r_k of the sphere around the nucleus of the electrical monopole and by the electrical constant ε_0. This is noteworthy due to the fact that this makes it possible to calculate constant ε_0 as the electrical parameter of vacuum filling the entire space, including the space between the quantons.

On the other hand, the magnetic monopole charge g (Fig. 2.3) can be characterised by inductance L_g which by analogy with (2.87) is determined by the ratio of $2\mu_0 g$ to the difference of the magnetic potentials $\Delta\varphi_g$ between the spheres r_k around the nuclei of the monopole charges at $r_k \ll r_{gy}$ (Fig. 2.8):

$$L_g = \frac{2\mu_0 g}{\Delta\varphi_g} = 4\pi\mu_0 r_k \tag{2.89}$$

$$\Delta\varphi_g = \frac{1}{2\pi}\frac{g}{r_k} \tag{2.90}$$

Equation (2.89) determines the inductance of the quanton as a distributed parameter of quantised space-time. It is interesting to note that the inductance of the quanton is determined by the radius r_k of the nucleus of the magnetic monopole and magnetic constant μ_0. This is noteworthy due to the fact that it enables us to regard the constant μ_0 as a magnetic parameter of vacuum, filling the entire space, included the space between the quantons.

It should be mentioned that the EQM theory makes it possible to examine for the first time the inductance as some analogue of a magnetic condenser capable of storing magnetic energy in the statics. Consequently, knowing inductance L_g (2.89) and capacitance C_e (2.87), the quantum can be regarded as a volume electromagnetic resonator in which the resonance condition is the quality of the capacitance X_C and inductance X_L resistances:

$$\frac{1}{\omega C_e} = \omega L_g \tag{2.91}$$

Taking into account (2.87) and (2.89), from (2.91) we determine the resonance frequency $\omega = 2\pi f_0$ of electromagnetic oscillations of the quanton

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{L_g C_e}} = \frac{1}{8\pi^2 r_k}\sqrt{\frac{1}{\mu_0\varepsilon_0}} = \frac{C_0}{8\pi^2 r_k} \tag{2.92}$$

Equation (2.92) includes the unknown parameter r_k. This is a very important parameter and can be determined using (2.16) and (2.17)

$$f_0 = \frac{C_0}{L_{q0}} = 4\cdot 10^{33} \text{ Hz} \tag{2.93}$$

The frequency parameter f_0 (2.93) determines the transmission capacity of the quanton in passage of an electromagnetic wave through the quanton with the speed C_0, forming the time delay of $T_0 = 2.5\cdot 10^{-34}$ s at the quanton. If time T_0 is longer than $2.5\cdot 10^{-34}$ s in length L_{q0}, this would result in the mismatch between speed C_0 and frequency parameter (2.93). To avoid this situation, the resonance frequency of the quanton completely coincides with the frequency (2.16) which determines the passage of the electromagnetic wave through the quanton. In particular, the resonant frequency of the intrinsic oscillations of the quanton defines the speed of light in vacuum

$$C_0 = f_0 L_{q0} \tag{2.94}$$

The diameter of the quanton determines the minimum length $\lambda = L_{q0}$ of the electromagnetic wave which can form in vacuum.

Equating (2.92) with (2.93) and determining the radius r_k of the sphere of the equipotential surface around the nucleus of the monopole charge:

$$r_k = \frac{L_{q0}}{8\pi^2} = \frac{0.74 \cdot 10^{-25}}{78.9} = 0.94 \cdot 10^{-27}\,\text{m} \tag{2.95}$$

Substituting (2.95) into (2.87) and (2.89), we determine the capacitance and inductance of the quanton:

$$C_e = 4\pi\varepsilon_0 r_k = \frac{1}{2\pi}\varepsilon_0 L_{q0} = 10^{-37}\,\text{F} \tag{2.96}$$

$$L_g = 4\pi\mu_0 r_k = \frac{1}{2\pi}\mu_0 L_{q0} = 1.5 \cdot 10^{-32}\,\text{H} \tag{2.97}$$

From (2.96) and (2.97) we determine the wave resistance Z_0 of the quanton

$$Z_o = \sqrt{\frac{L_g}{C_e}} = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 377\ \text{ohm} \tag{2.98}$$

Equation (2.96) determines the well-known value of the wave resistance of the vacuum. To the well-known situation we can now add that the wave resistance starts to characterise the vacuum, including of the vacuum inside the quanton, which can be regarded as the wave resistance element $L_g C_e$ with the internal wave resistance Z_0 = 377 ohm.

On the other hand, the wave resistance (2.19) of vacuum is determined by the parameters ε_0 and μ_0. Equation (2.98) does not include the radius r_k (2.95) of the sphere around the charge of the monopole nucleus. However, r_k determines the capacitance (2.96) and inductance (2.97) of the quanton which in turn characterise the resonance parameters of the quanton (2.91). It should be mentioned that the ultra-microworld of the quanton has been described using the characteristics typical of the macroworld, such as capacitance and inductance. These are calculation characteristics for the quanton. In fact, the wave properties of the quantised space-time are characterised by its electrical and magnetic tension. This is the primary fact. Nevertheless, the introduction of the parameters capacitance and inductance of the quanton helps to characterise its resonance properties in conventional terms.

Previously, it was assumed that the nucleus of the monopole quanton should be regarded as a point charge with the size of the order of Planck length 10^{-35} m [22, 23]. This assumption has not been supported by calculations. Calculations carried out using equation (2.94) show that radius r_k of the sphere around the charge of the monopole nucleus is of the order of 10^{-27} m (2.95) which is two orders of magnitude smaller than the quanton diameter of 10^{-25} m. At the same time, it can be assumed that the determined radius r_k (2.95) is nothing else but the upper limit of the radius of the charge of the monopole nucleus which cannot be exceeded. Otherwise, the wave characteristics of the vacuum will not match.

Quanton can be treated as a time delay element T_0 (2.16):

$$T_0 = 2\pi\sqrt{L_g C_e} \leq \frac{L_{q0}}{C_0} \tag{2.99}$$

Equation (2.99) is the formula for matching the parameters of the quanton with vacuum as a waveguide medium. If the parameters $L_g C_e$ exceed (2.96) and (2.97), the electromagnetic wave would not be capable of propagating in vacuum with speed C_0. On the other hand, the actual displacement of the monopole nucleus when the electrical equilibrium is disrupted is determined by the values of the order of 10^{-62} m (2.64). This shows that the monopole nucleus itself is in all likelihood point-shaped, and the radius r_k of 10^{-27} m (2.95) determines some additional sphere which characterises the parameters $L_g C_e$. Therefore, the problem of the radius of the monopole nucleus, as the Planck length (point source), remains unsolved.

In any case, the results of calculations can no longer be associated with the Planck length but we can use the determined parameters $L_g C_e$. Figure 2.12 shows the scheme of substitution of the quanton which includes the oscillatory contour $L_g C_e$ and the sources of electrical W_e and magnetic W_g energies. All this forms a unique resonant element with no analogues in technology. The uniqueness of this resonant element is represented by the fact that in addition to the oscillatory contour $L_g C_e$ it contains two sources of energy of different types which are however equivalent as regards the magnitude of energy. This determines the equilibrium state of the resonant element. The exit from the equilibrium state is takes place by the disruption of the quality of the electrical W_e and magnetic W_g energies (2.79)...(2.82), producing oscillations of the charges and energies inside the quanton.

We examined the oscillatory processes are the quantum during the passage of an electromagnetic wave through the quanton (Fig. 2.8). In the electromagnetic wave the quanton charges carry out oscillations in accordance with the harmonic law (2.37) in relation to the equilibrium state, determining the instantaneous displacements x_e and y_g of the electrical and

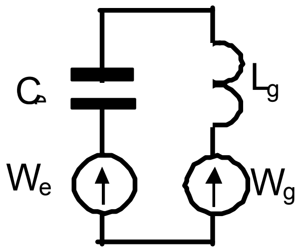


Fig. 2.12. Substitutional scheme of the quanton.

magnetic charges, respectively, for the amplitude displacements Δx (2.70) and Δy (2.77) of these charges:

$$\begin{cases} x_e = \Delta x \cdot \sin \omega t \\ y_g = -\Delta y \cdot \sin \omega t \end{cases} \tag{2.100}$$

The speeds $\mathbf{v}_{echo}$ and $\mathbf{v}_{golf}$ of displacement of the charges are determined by the first derivative of (2.100), and their accelerations $\mathbf{a}_e$ and $\mathbf{a}_g$ by the second derivative at $\mathbf{v} = \mathbf{v}_e = \mathbf{v}_g$ and $\mathbf{a} = \mathbf{a}_e = \mathbf{a}_g$

$$\begin{cases} \mathbf{v}_e = \dfrac{\partial\, x_e}{\partial\, t} = \omega \Delta x \mathbf{1}_x \cos \omega t = \omega \Delta x \mathbf{1}_x \sin(\omega t + \dfrac{\pi}{2}) \\ \mathbf{v}_g = \dfrac{\partial\, y_g}{\partial\, t} = -\omega \Delta y \mathbf{1}_y \cos \omega t = \omega \Delta y \mathbf{1}_y \sin(\omega t - \dfrac{\pi}{2}) \end{cases} \tag{2.101}$$

$$\begin{cases} \mathbf{a}_e = \dfrac{\partial^2 x_e}{\partial\, t^2} = -\omega^2 \Delta x \mathbf{1}_x \sin \omega t \\ \mathbf{a}_g = \dfrac{\partial^2 y_g}{\partial\, t^2} = \omega^2 \Delta y \mathbf{1}_y \sin \omega t \end{cases} \tag{2.102}$$

The equations (2.64) and (2.75) can be written in the following form taking into account (210) and the new coefficients k_x and k_y:

$$\begin{cases} \mathbf{E} \cdot \sin \omega t = k_x \mathbf{1}_x \Delta x \cdot \sin \omega t \\ \mathbf{H} \cdot \sin \omega t = -k_y \mathbf{1}_y \Delta y \cdot \sin \omega t \end{cases}. \tag{2.103}$$

As indicated by (2.103), **E** and **H** are completely identical in phase with the sinusoidal displacement Δx and Δy of the charges in the quanton during the passage of the electromagnetic wave. The accelerations of the charges $\mathbf{a}_c$ and $\mathbf{a}_g$ in (2.102) are also in phase with the changes of **E** and **H** in (2.101). The densities of the displacement currents $\mathbf{j}_e$ and $\mathbf{j}_g$ (4) are determined by the cosinusoidal velocity of displacement of the charges (2.100) and are phase-shifted by the angle $\pi/2$:

$$\begin{cases} \mathbf{j}_e = 2e\rho_o \dfrac{\Delta x \mathbf{1}_x}{\omega} \sin(\omega t + \dfrac{\pi}{2}) \\ \mathbf{j}_g = 2g\rho_o \dfrac{\Delta y \mathbf{1}_y}{\omega} \sin(\omega t - \dfrac{\pi}{2}) \end{cases} \quad (2.104)$$

Comparing (2.103) and (2.104) it should be noted that the vector of density $\mathbf{j}_e$ of electrical current outstrips the vector of the strength **E** of the electrical field of the electromagnetic wave by the phase angle $\pi/2$. This corresponds to the nature of capacitance current. The vector of the density of the magnetic current $\mathbf{j}_g$ lags behind the vector **H** of the strength of the magnetic field of the electromagnetic wave by the phase angle $\pi/2$. This is shown in the graphs in Fig. 2.13. The calculations may be presented in the complex form more efficiently, but in this case it is required to show the nature of elementary electromagnetic cyclic processes and the role of the quanton in the formation of electromagnetic radiation.

In the existing solutions of the wave equations of the electromagnetic field the functions **E** and **H** are described by the cosinusoidal variation law. This is determined by the origin of the cyclic process in the chosen refgerence system.

Finally, we can estimate the amplitude of speed (2.101) and acceleration (2.102) of charges in the quanton in the displacement $\Delta x = 2.3 \cdot 10^{-62}$ m (2.64) for $E = 3 \cdot 10^6$ V/m and the limiting frequency of oscillations of the quanton $4 \cdot 10^{33}$ Hz (2.93)

$$v = \omega \Delta x = 2\pi f_0 \Delta x = 0.6 \cdot 10^{-27}\, \mathrm{m/s}$$
$$a = \omega^2 \Delta x = (2\pi f_0)^2 \Delta x = 1.5 \cdot 10^7\, \mathrm{m/s^2} \quad (2.105)$$

Actually, in the range of superhigh frequency (SH F) for the limiting strength of the field $E = 3 \cdot 10^6$ V/m and the frequency of 10^8 Hz (wavelength

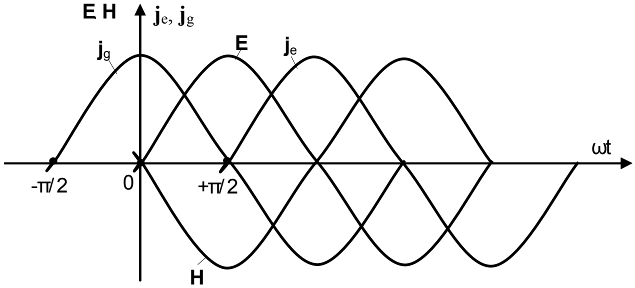


Fig. 2.13. Graphs of the variation of **E** and **H**, $\mathbf{j}_e$ and $\mathbf{j}_g$ in the electromagnetic wave in electromagnetic polarisation of the quanton.

3 cm), the speed of displacement of the charges of the quanton is $v = 1.4 \cdot 10^{-53}$ m/s, acceleration $a = 0.9 \cdot 10^{-44}$ m/s^2. It can be seen that the speed and acceleration of the charges in the quanton are extremely small in the range of actual electromagnetic radiation. Regardless of this, the rate of transfer radiation is very high and equal to the speed of light. However, the increase of the radiation frequency is associated with a large increase of the acceleration (2.105) of the charges in the quanton. This is important for the development of powerful emitters in x-ray and gamma ranges.

2.3.8. Quantisation of the electromagnetic wave

At present, the concepts of the electromagnetic field and the electromagnetic wave are not strictly separated. Figure 2.5 shows the region of the quantised space-time. This static electromagnetic field with a discreteness of 10^{-25} m determines the superstrong electromagnetic interaction (SEI) and the structure of vacuum. The electromagnetic wave in vacuum is associated with the electromagnetic disruption of the equilibrium of the superstrong electromagnetic interaction, i.e., with the disruption of the equilibrium of the static electromagnetic field as a carrier of the electromagnetic wave. As already mentioned, the quantised space-time is an elastic quantised medium (EQM) whose tension is determined by the grid (Fig. 2.5) of the static electromagnetic field. When examining the wave processes, it is natural that the base for any wave is represented by the medium, the elastic quantised medium in the present case.

The presence of the elastic quantised medium with a discreteness L_{q0} (7) suggests that any electromagnetic wave is quantised in its basis. The discovery of the quantum of the space-time (quanton) in 1996 in the EQM theory together with the discovery of the radiation quantum by Planck in 1900 enables us to transfer to the non-formal examination of the quantum phenomena, including quantisation of the electromagnetic wave. The primary factor is the space-time quantum because only the population of the quantons can form both the radiation quantum in the form of a discrete particle-wave in the elastic quantised medium and also a continuous electromagnetic wave.

It may be assumed that the quanton, as an elementary volume resonator (Fig. 2.8), is characterised by the intrinsic resonance frequency of the electromagnetic oscillations of $4 \cdot 10^{33}$ Hz (2.93). As a resonator, the quanton can be highly stable and the frequency of its intrinsic oscillations can be changed only by placing it in a strong gravitational field. However, at the present time we are interested in how the frequency of quantons is adjusted in the entire spectrum of electromagnetic oscillations in weak terrestrial gravity or free vacuum. Radioelectronics shows that the frequency of the electromagnetic resonator can be changed only by changing its parameters. The parameters of the quanton can be changed by a natural method.

At present, the spectrum of electromagnetic oscillations is found in a relatively wide range of frequencies and wavelength: from radiowaves with a frequency of 10^3 Hz (wavelength $3{\cdot}10^5$ m) to gamma radiation with a frequency of 10^{23} Hz (wavelength $3{\cdot}10^{-15}$ m). The resonance frequency of the quanton is of the order of 10^{33} Hz for the wavelength of 10^{-25} m. This means that the resonance parameters of the quanton exceed the parameters of gamma radiation by 10 orders of magnitude. It can be assumed that during excitation the quanton carries out oscillations at the intrinsic resonance frequency represented by high harmonics with a lower frequency along the entire length of the transmitted electromagnetic wave. In this case, the oscillations of all the quantons, included in the restricted volume of the wave, are added and phased in some manner in accordance with the principle of superposition of the fields and form the observed wave whose length is many orders of magnitude greater than the length of the quanton.

However, the simplest explanation is based on the assumption that the quantons can adjust themselves automatically to the required wavelength in merger into wave groups. This follows logically from the analysis of the substitutional scheme of the quanton, Fig. 2.12. It is evident that a group consisting of two quantons (Fig. 2.14a) can be regarded as parallel connection of the quantons with doubling of the capacitance and inductance parameters L_gC_e. Consequently, in accordance with (2.29), the delay time T_0 is doubled. This is in agreement with the time parameters of the electromagnetic wave during its passage through a group consisting of two quantons.

In a general case, a successive chain of n_q quantons has the form of a two-wire line (Fig. 2.14b), consisting of elements L_gC_e, connected in parallel, with either element ensuring the time delay of the signal for the period T_0 (2.99). Wave resistance Z_0 (2.98) of the entire line is equal to the wave resistance of vacuum, 377 ohm. This ensures matching of the passage of the signal with the speed of light C_0 in a wide range of the frequency spectrum of the electromagnetic waves. Most importantly, any electromagnetic signal, in the form of period T or wavelength λ in the entire frequency range can be regarded as equal to the multiple of the number of the quantons n_q

$$\begin{aligned} T &= n_q T_o \\ \lambda &= n_q L_{qo} \end{aligned} \qquad (2.106)$$

Equation (2.106) shows that any electromagnetic signal is quantised. To

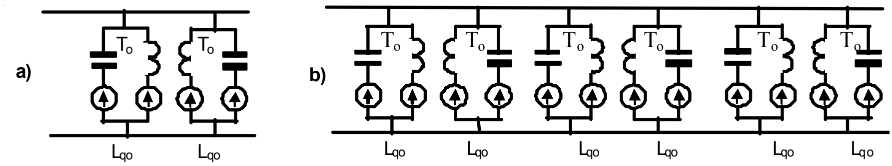


Fig. 2.14. Conventional scheme of substitution of a string of quantons in the form of a two-wire line.

transfer from the signal to a free electromagnetic wave in the quantised space-time, it is necessary to transfer from the substitutional scheme (Fig. 2.14) to analysis of electromagnetic processes in the string consisting of quantons (Fig. 2.15)

Thus, the volume of the quantised space-time has the form of a waveguide region with the distributed parameters of the resonance elements $L_g C_e$ and with the matched wave resistance. These unique properties of vacuum as the quantised structure enable the vacuum to be used as a volume waveguide for the entire spectrum of the electromagnetic waves, adjusted to any wavelength as a result of the merger of quantons into resonance groups of any length and volume. There is an analogy with a stretched string (membrane) when the variation of the length of the string determines its setting to resonance frequency. In the quantised space-time this takes place automatically as a result of including the required number of the quantons in the wave. In this case, the resonance frequency of the group of the quantons is determined by the length of the wave of the quantons taking part in this process.

However, it is necessary provide additional explanation of the basis of the substitutional scheme of the two-wire line (Fig. 2.14). Two conductors in the scheme can be ignored, and it can be explained that the signal is transferred from quanton to quanton through inductance–capacitance links. In a real string the transfer of electromagnetic perturbation from quantons takes place as a result of displacement Δx (2.64) and Δy (2.74) of charges in quantons.

Figure 2.15 shows the average scheme of an electromagnetic string consisting of quantons in the direction Z of wave propagation. It should be mentioned that in transfer from the analysis of the processes in a separately considered quanton to a group of quantons acting in the electromagnetic wave, we are concerned with the statistical indeterminacy of the orientation of the quantons in the string. In fact, equation (2.106) shows that to transfer an electromagnetic wave with the length of, for example, 1 m it is necessary to act upon the wavelength in the group of the order of $n_q = 10^{25}$.

Taking into account the fact that the charges of the monopoles inside a

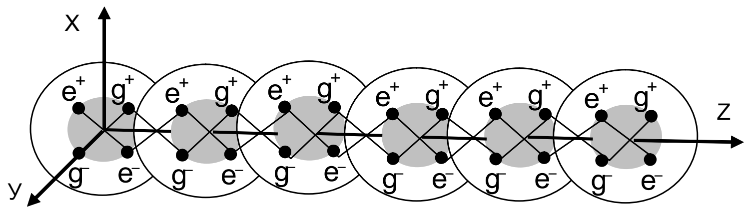


Fig. 2.15. Electromagnetic string consisting of quantons.

quanton are positioned on the tips of the tetrahedron, we introduce the element of randomness into the orientation of the quanton by the electrical and magnetic axes in space (Fig. 2.2). The orientation of the quantons is determined by the interaction of charges of adjacent quantons at the unchanged orthogonality of the electrical and magnetic axes in the quanton. If we select a completely random direction in space, the electrical and magnetic axes of the quantons, being the vectors, form some angle in relation to the selected axis. The statistical law of distribution of these angles of inclination is not yet known. However, taking into account the fact that we are concerned with a very large number of quantons per wavelength, it can be assumed that this angle is governed by the law of normal distribution in relation to some mean angle (mathematical expectation).

The results of determination of coefficient k_E in (2.71) were used to determine the mean angle of orientation of the axes of the quanton $\alpha_x \sim \pm 45°$ in relation to the selected axis. The statistical electromagnetic string cannot be demonstrated visually. Therefore, Fig. 2.15 shows the conventionally averaged electromagnetic string in which the axes of the quantons are inclined under the angle of $\Delta x \sim \pm 45°$ in relation to the Z axis whilst maintaining the orthogonality of the axes inside the quanton. Consequently, the displacements Δx (2.64) and Δy (2.74) of the charges in the large group of the quantons in the string can be regarded as averaged-out projections onto the axes X and Y.

Figure 2.16 shows the formation of a running longitudinal electromagnetic wave in direction Z as a result of longitudinal displacement Δx and Δy of the charges in the wave group of the quantons. The wave group (wave packet) is the group of quantons which takes part in the transfer of a single electromagnetic wave with length λ. For comparison, we should mention Fig. 2.5 which shows the idealised (averaged) orientation of the quantons in a line, perpendicular to the Z axis in Fig. 2.16. In particular, the disruption of the electrical and magnetic equilibrium of the quantised space-time (Fig. 2.5) determines the displacement of the charges (Fig. 2.8) as a result of the wave perturbation of vacuum.

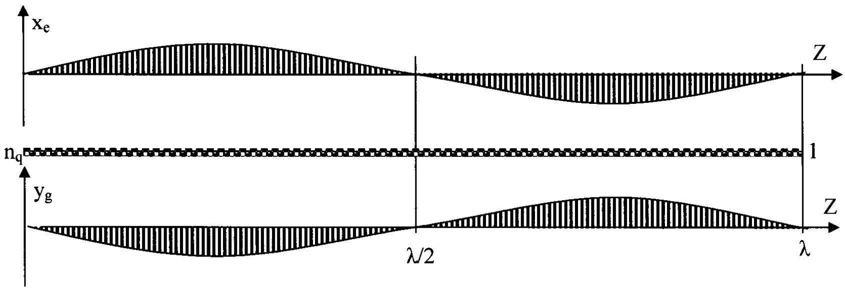


Fig. 2.16. Formation of a running transverse electromagnetic wave in the quantised space-time with quantons taking part.

In the electromagnetic string (Fig. 2.15) the first quanton is linked successively by the superstrong electromagnetic interaction with the subsequent quantons in the string. Therefore, in passage of the electromagnetic wave through the string, longitudinal displacement Δx and Δy of charges in the quanton results in the longitudinal wave displacement of the charges in the entire string, shown in Fig. 2.16. Every longitudinal line segment in the wave denotes the magnitude of displacement of the charges in the quanton, and the entire crosshatched region of the wave shows its discrete quantised structure. The positive region of displacement of the charges in the string denotes their stretching in the quanton, and the negative region denotes the compression in relation to the equilibrium state. The stretching along the X axis corresponds to the compression of the charges on the Y axis, and vice versa.

The propagation of the running wave along the Z axis determines its harmonic character which is described by the sinusoidal law of the variation of the displacement of charges along the way. In fact, if the transverse displacement of the charges in the quanton is described by the harmonic law (2.101), (2.102), (2.103) with respect to time t, the longitudinal propagation of the wave along the length z is also described by a harmonic law and is linked functionally with the transverse displacement of the charges. Consequently, we can write an elementary equation of the harmonic wave, linking displacement x_e and its amplitude Δx with wavelength λ and coordinate z (Fig. 2.16):

$$x_e = \Delta x \sin\left(2\pi \frac{z}{\lambda}\right) \tag{2.107}$$

On the other hand, the displacement x_e of the charges is determined by the harmonic function of time t for the period T (2.100)

$$x_e = \Delta x \sin\left(2\pi \frac{t}{T}\right) \tag{2.108}$$

Equating (2.107) with (2.108), we obtain an elementary wave equation of a flat electromagnetic wave, linking the coordinates of the wave and time

$$\Delta x \sin\left(2\pi \frac{z}{\lambda}\right) = \Delta x \sin\left(2\pi \frac{t}{T}\right) \tag{2.109}$$

The solution of (2.109) is very simple $z = C_0 t$, taking into account that $\lambda = C_0 T$

$$\frac{z}{\lambda} = \frac{t}{T} \quad \text{or} \quad \frac{z}{C_0 T} = \frac{t}{T} \tag{2.110}$$

The wave equation (2.109) can be presented in the differential form, for example, in partial derivatives with respect of t and z of the second order. The second derivative with respect to t is determined in (2.102)

$$\frac{\partial^2 x_e}{\partial t^2} = -\left(\frac{2\pi}{T}\right)^2 \Delta x \sin\left(\frac{2\pi}{T} t\right) \tag{2.111}$$

The second derivative with respect to z is determined from (2.107)

$$\frac{\partial^2 x_e}{\partial z^2} = -\left(\frac{2\pi}{TC_o}\right)^2 \Delta x \sin\left(\frac{2\pi}{\lambda} z\right) \tag{2.112}$$

Taking into account the equivalence of the arguments (2.110) in (2. 111) and (2.112), from (2.110) and (2.112) we obtain the wave equation of the electromagnetic wave in partial derivatives of the second order

$$\frac{\partial^2 x_e}{\partial t^2} = C_o^2 \frac{\partial^2 x_e}{\partial z^2} \tag{2.113}$$

The wave equation (2.113) is equivalent to the Maxwell wave equation (2.56) which was used in the analysis of the flat electromagnetic wave. The wave equation (2.113) is the generally accepted wave equation of the flat electromagnetic wave [34–38], only it is expressed through the displacement of the charges. In electrodynamics, the wave equation of the electromagnetic wave can be derived on the basis of complex transformations of the Maxwell rotor equations. The quantisation of the electromagnetic wave enables us to derive the wave equation (2.113) by elementary methods, retaining the physical meaning of the wave electromagnetic processes in vacuum for the running wave (Fig. 2.16). The solution of (2.112) is represented by the equation (2.109).

The wave equation (2.113) can be represented in the form of a differential equation in partial derivatives of the first order, reducing the order of (2.113):

$$\frac{\partial x_e}{\partial t} = C_o \frac{\partial x_e}{\partial z} \tag{2.114}$$

Equation (2.114) has a physical meaning, for example, for the harmonic function, showing that the sinusoidal transverse displacement x_e (2.108) of the charges inside a stationary quanton with speed $\mathbf{v}_e$ (2.101) transfers this displacement from the quanton to quanton with speed of light C_0 along the electromagnetic string (Fig. 2.15) in the direction of the Z axis, forming a transverse electromagnetic wave (2.107) (Fig. 2.16).

The formation of the wave can be described as consisting of stages (Fig. 2.16). In the first stage of analysis we consider only one quanton oriented in accordance with Fig. 2.8. The Z axis is perpendicular to the plane of the figure and directed to the plane. The quanton is perturbed and its electrical charges oscillate harmonically with displacement x_e (2.108) along the axis X (2.110) with speed $\mathbf{v}_e$ (2.101). In accordance with the EQM theory, the quanton is connected with the quantised space-time and is stationary in relation to it. We now use an artificial procedure and assume that the quanton moves and travels away from the plane of the Fig. 2.8 along the Z axis with the speed of light C_0. During a single period T of oscillations of the quanton, displacement x_e (2.107) of electrical charges forms a sinusoid along the Z axis, determining the wavelength λ (Fig. 2.16).

At the same time, the displacement of the magnetic charges y_g of the quanton along the axis Y produces a sinusoid along the Z axis in the antiphase opposite to the displacement x_e of the electrical charges along the X axis (Fig. 2.16). Taking into account that the electrical and magnetic axes of the quanton in the direction Z are situated in different planes with a distance of $0.34L_{q0}$ between the planes (Fig. 2.2), we determine the time delay $0.34\ T_0$ and the phase shift angle φ_{eg} between the oscillations of the electrical $\pm e$ and magnetic $\pm g$ charges in the quanton:

$$\varphi_{eg} = 2\pi \frac{0.34T_0}{T} \tag{2. 115}$$

$$\begin{cases} x_e = \Delta x \cdot \sin \omega t \\ y_g = -\Delta y \cdot \sin(\omega t - \varphi_{eg}) \end{cases} \tag{2.116}$$

The actual spectrum of the electromagnetic oscillations is situated in the frequency range $T \gg 0.34\ T_0$. Therefore, the phase shift angle φ_{eg} is not taken into account for the actual spectrum of frequencies and it is assumed that the displacements of the electrical and magnetic charges in the real waves are completely in phase in accordance with (2.100).

Subsequently, we consider two quantons connected into a successive group along the Z axis. The charges of the first quanton carry out oscillations in accordance with the law (2.107), and the oscillations of the charges of the second quantum lag in respect of the phase φ_{t0} by time delay T_0

$$x_e = \Delta x \cdot \sin\left(\omega t - \varphi_{t0}\right) = \Delta x \cdot \sin\left(2\pi \frac{t}{T} - 2\pi \frac{T_0}{T}\right) \tag{2.117}$$

For a wave group (packet) consisting of n_q quantons and forming a string along the entire wavelength λ (for example, for λ = 1 m and n_q ~10^{25} particles), the charges of each quanton n in the string carry out oscillations x_{en} with the delay in phase $(n - 1)\varphi_{t0}$ along the wave, starting from the first quanton 1 and ending with the last quanton n_q, where n is the sequence number of the quanton in the wave group (Fig. 2 .16)

$$x_{en} = \Delta x \cdot \sin\left\{\omega t - (n-1)\varphi_{to}\right\} = \Delta x \cdot \sin\left\{2\pi \frac{t}{T} - 2\pi (n-1) \frac{T_0}{T}\right\} \tag{2.118}$$

The entire wave group consisting of n_q quantons with the length λ is placed by the quanton 1 in the origin of the coordinates. The tail of the wave group is situated in the negative region along the X axis. Subsequently, the entire wave group of the quantons, starting with the first quanton 1, is transferred to the oscillatory regime in accordance with the law (2.118) and at the same time it is forced to move along the Z axis with the speed of light C_0. After time T, the wave group occupies the position on the Z axis as shown in Fig. 2.16. The displacements of the charges in the quanton on the graphs are represented by the sinusoidal law with respect to the wavelength λ for both electrical and magnetic charges

$$x_{en} = \Delta x \cdot \sin\left\{2\pi \frac{z}{\lambda} - 2\pi (n-1) \frac{L_{q0}}{\lambda}\right\} \tag{2.119}$$

In fact, the wave group consisting of n_q quantons is stationary in space and occupies the position shown in Fig. 2.16. The external running electromagnetic wave initially excites the last quanton n_q in the wave group and subsequently travels to the first quanton 1, exciting the entire wave group of the quantons in accordance with the law (2.119).

Thus, the EQM theory shows that every electromagnetic wave is the result of electromagnetic excitation of a very large number of the space-time quantons. In fact the electromagnetic wave is quantised. When the electromagnetic wave is found in the macroworld, it appears to be continuous.

The wave equation (2.114) in partial derivatives of the first order determines the relationship between transverse speed $\mathbf{v}_e$ (2.101) of the displacement of the charges and the speed of light C_0 and the parameters of the running wave (2.112)

$$\frac{v_e}{C_0} = 2\pi\frac{\Delta x}{\lambda}\cos\left(\frac{2\pi}{\lambda}z\right) \tag{2.120}$$

At $z = 0$ the equation (2 .120) gives the relationship between the amplitude of speed $\mathbf{v}_e$ and the displacement Δx of charges linking them with the wave parameters λ and C_0

$$\frac{v_e}{C_0} = 2\pi\frac{\Delta x}{\lambda} \tag{2.121}$$

The wave equation (2.113) in partial derivatives of the second order determines the relationship between the acceleration a_c (2.102) and the displacement Δx of the charges, linking them with the wave parameters λ and C_0

$$\frac{a_e}{C_0^2} = \left(\frac{2\pi}{\lambda}\right)^2 \Delta x \sin\left(\frac{2\pi}{\lambda}z\right) \tag{2.122}$$

At $z = \lambda/4$, from equation (2 .122) we obtain the ratio of the parameters of the wave for the amplitude values

$$\frac{a_e}{C_0^2} = 4\pi^2\frac{\Delta x}{\lambda^2} \tag{2 .123}$$

From (2.121) and (2 .123) we obtain another relationship:

$$\frac{v_e}{a_e} = \frac{1}{2\pi}\frac{\lambda}{C_0} \tag{2.124}$$

The wave equations (2.113) and (2.114), written previously for the wave along the Z axis, can be written for the volume wave in the rectangular coordinate system X, Y, Z for the displacements x_e and y_g of the electrical and magnetic charges

$$\frac{\partial^2 x_e}{\partial t^2} = C_0^2\left(\frac{\partial^2 x_e}{\partial x^2} + \frac{\partial^2 x_e}{\partial y^2} + \frac{\partial^2 x_e}{\partial z^2}\right) \tag{2.125}$$

$$\frac{\partial^2 y_g}{\partial t^2} = C_0^2\left(\frac{\partial^2 y_g}{\partial x^2} + \frac{\partial^2 y_g}{\partial y^2} + \frac{\partial^2 y_g}{\partial z^2}\right) \tag{2.126}$$

$$\frac{\partial x_e}{\partial t} = C_0 \left(\frac{\partial x_e}{\partial z}\mathbf{i} + \frac{\partial x_e}{\partial z}\mathbf{j} + \frac{\partial x_e}{\partial z}\mathbf{k} \right) \tag{2.127}$$

$$\frac{\partial y_g}{\partial t} = C_0 \left(\frac{\partial y_g}{\partial z}\mathbf{i} + \frac{\partial y_g}{\partial z}\mathbf{j} + \frac{\partial y_g}{\partial z}\mathbf{k} \right) \tag{2.128}$$

where **i**, **j**, **k** are the unit vectors in the directions *X*, *Y*, *Z*, respectively.

From (2.63) and (2.73) we can write the relationships between the displacement of the charges and the strength of the fields *E* and *H*

$$\begin{cases} x_e = \dfrac{\varepsilon_0}{2e\rho_0} E \\ y_g = -\dfrac{1}{2g\rho_0} H \end{cases} \tag{2.129}$$

Substituting (2.129) into (2.126) and (2.127) we obtain the well-known (in classic electrodynamics) wave equations of the electromagnetic field in partial derivatives of the second order

$$\frac{\partial^2 E}{\partial t^2} = C_0^2 \left(\frac{\partial^2 E}{\partial x^2} + \frac{\partial^2 E}{\partial y^2} + \frac{\partial^2 E}{\partial z^2} \right) \tag{2.130}$$

$$\frac{\partial^2 H}{\partial t^2} = C_0^2 \left(\frac{\partial^2 H}{\partial x^2} + \frac{\partial^2 H}{\partial y^2} + \frac{\partial^2 H}{\partial z^2} \right) \tag{2.131}$$

From the wave equations (2.127) and (2.128) in partial derivatives of the first order we easily obtain the Maxwell equations for the electromagnetic wave in vacuum, taking into account the fact that the speeds of displacement of the electrical and magnetic charges, which are determined by the first derivative with respect to time, are equal to

$$\frac{\partial x_e}{\partial t} = \frac{\partial y_g}{\partial t} \tag{2.132}$$

Into (2.132) we substitute the values from (2.129) and obtain a singular Maxwell equation for vacuum in the vector form

$$\varepsilon_0 C_0 \frac{\partial \mathbf{E}}{\partial t} = -\frac{\partial \mathbf{H}}{\partial t} \tag{2.133}$$

The solution of the singular Maxwell equations (2.133) for vacuum can be presented in a more convenient form of the vector product (2.55)

$$\varepsilon_0\left[\mathbf{C}_0\dot{\mathbf{E}}\right]=-\dot{\mathbf{H}} \tag{2.134}$$

Thus, analysis of the quantisation of the electromagnetic wave makes it possible to obtain, within the framework of classic electrodynamics, the elementary and understandable derivation of the wave equations (2.130), (2.131) and the singular Maxwell equations (2.133), (2.134) of the electromagnetic wave in vacuum. For the first time, the EQM theory explains the reasons for electromagnetic wave processes without using the concept of rotors.

2.3.9. Circulation of electrical and magnetic fluxes in the electromagnetic wave

Analysis of the electromagnetic processes in vacuum shows that the transformation of electricity and magnetism and vice versa, in the electromagnetic wave is based on the unique properties of the quanton as a carrier of unified electromagnetism which enables these transformations to take place. The transformation of electricity into magnetism and vice versa does not require rotor considerations regarding the nature of electromagnetic processes in vacuum.

Nevertheless, the circulation of the vectors of the strength of the electrical and magnetic fields is observed in the electromagnetic wave, and the EQM theory explains for the first time how this takes place.

It should be mentioned that when Maxwell derived his historical equations for the electromagnetic field, he had at his disposal only the Faraday laws of electromagnetic induction and the hydrodynamic analogy with respect to the force tubes of tensioning of electrical and magnetic fields of the aether medium [38]. The electromagnetic induction laws were discovered only for the electrical circuit, including an inductance coil. The prediction of the electromagnetic wave in vacuum was a brilliant foresight by Maxwell and this enabled Hertz to study them in experiments.

The electromagnetic processes in vacuum are causes bt the displacement of the charges in the core of the stationary quanton. The core of the quanton can be compared with the heart whose beating ensures pumping of electrical energy to magnetic, and vice versa. In particular, analysis of the displacement of the charges in the core of the quanton resulted in the derivation of the wave equations (2.130), (2.131) of the electromagnetic field and in derivation of the singular Maxwell equation (2.54), (2.134) for the electromagnetic wave in vacuum.

We shall use the previously discussed results and write the wave equation (2.130) for a spherical electromagnetic wave, propagating along the radius

r and from the origin of the new coordinates X, Y, Z (Fig. 2.17):

$$\frac{\partial^2 E}{\partial t^2} = C_0^2 \frac{\partial^2 E}{\partial r^2} \tag{2.135}$$

$$r^2 = x^2 + y^2 + z^2 \tag{2.136}$$

The order of the derivatives of the equation (2.134) is reduced and the equation is written for the partial derivatives of the vector **E** with respect to time t in radius r, taking into account that the vectors $\mathbf{E} \perp \mathbf{r}$

$$\frac{\partial \mathbf{E}}{\partial t} = C_0 \frac{\partial \mathbf{E}}{\partial r} \tag{2.137}$$

Figure 2.17 shows the increase of the radius r of the wave by the value ∂r as a result of spherical propagation of the wave from the dotted sphere to the continuous sphere

$$\partial r = C_0 \cdot \partial t \tag{2.138}$$

The increase of the strength **E** by the value $\partial\mathbf{E}$ is determined by the partial derivatives (2.137). On the surface of the wave sphere at a large distance from the source which is considerably greater than the wavelength, the electromagnetic field should be regarded as a field of a flat wave when the vector of strength **E** is orthogonal to the vector **r**. Vector $\partial\mathbf{E}/\partial r$ is expanded by the components along the axes X and Y (Fig. 2.17a). In Fig. 2.17b, the triangle of the vectors of increments is enlarged. Vector analysis shows that the given triangle determines the difference of the vectors, describing rot**E** [43]

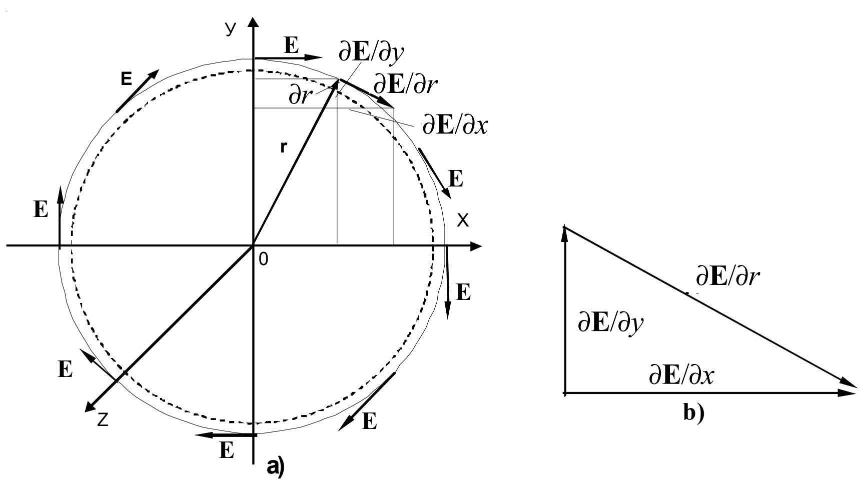


Fig. 2.17. Calculation of the circulation of vector **E** in a spherical electromagnetic wave.

$$\frac{\partial \mathbf{E}}{\partial r} = \frac{\partial \mathbf{E}}{\partial x} - \frac{\partial \mathbf{E}}{\partial y} = \mathrm{rot}\mathbf{E} \tag{2.139}$$

Substituting (2.139) into (2.137) gives the first rotor equation of the electromagnetic wave for the strength vector **E**:

$$\frac{\partial \mathbf{E}}{\partial t} = C_0 \mathrm{rot}\mathbf{E} \tag{2.140}$$

Taking into account the equivalence between the electrical and magnetic processes in the electromagnetic wave, we can write in accordance with (2.140) the second rotor equation of the electromagnetic wave for the strength vector **H**, taking into account that **H**⊥**E**, i.e., it is situated in the orthogonal sections:

$$\frac{\partial \mathbf{H}}{\partial t} = C_0 \mathrm{rot}\mathbf{H} \tag{2.141}$$

$$\mathrm{rot}\mathbf{H} = \frac{\partial \mathbf{H}}{\partial z} - \frac{\partial \mathbf{H}}{\partial y} = \frac{\partial \mathbf{H}}{\partial r} \tag{2.142}$$

Formally, taking (2.133) into account, we can write

$$\varepsilon_0 C_0 \mathrm{rot}\mathbf{E} = -\mathrm{rot}\mathbf{H} \tag{2.143}$$

Replacing in (2.143) the electrical parameters of the rotors by the magnetic ones in (2.140), and the magnetic parameters of the rotor by electrical ones (2.141), we obtain classic Maxwell equations (2.3) for the electromagnetic wave in vacuum

$$\begin{cases} \mathrm{rot}\mathbf{H} = \varepsilon_0 \dfrac{\partial \mathbf{E}}{\partial t} \\ \mathrm{rot}\mathbf{E} = -\mu_0 \dfrac{\partial \mathbf{H}}{\partial t} \end{cases} \tag{2.144}$$

The Maxwell rotor equations (2.144) are valid in the vicinity of the emitter (antenna). In a space-time region away from the emitter, when a free electromagnetic wave has formed, the equations (2.144) loose their physical meaning. The previously mentioned analysis of the electromagnetic perturbation of the quantised space-time shows that in the electromagnetic wave the rotor **H** does not generate **E** and, vice versa, rotor **E** does not generate **H**. This is the case in which the mathematics formally provides an accurate calculation method but does not make it to penetrate into the principle of electromagnetic processes in vacuum. Primary reasons for electromagnetic phenomena in vacuum are hidden in the electromagnetic polarisation of quantons (Fig. 2.8).

In fact, the quantised space-time is a self-organised substance whose behaviour is governed by physical laws based on the very electromagnetic structure of vacuum. In a free electromagnetic spherical wave in vacuum, the variations of the electrical (2.140) and magnetic (2.141) fields take place simultaneously, as shown previously. The electrical and magnetic fields of the wave are self-organised into simultaneous electrical (2.140) and magnetic (2.141) rotors, and the circulation of the strength **E** (and **H**) of these rotors takes place in the sphere of the electromagnetic wave (Fig. 2.17) in orthogonal sections.

The nature of circulation of the vectors of strength **E** and **H** in the sphere of propagation of the electromagnetic wave is explained quite simply by the quantised structure of space-time. For this purpose, the electrical and magnetic components of the quanton are represented in the form of electrical and magnetic dipoles: elementary electrets (+) and magnetics (N) and (s).

Figure 2.18 shows the cross-section of the sphere with elementary dipoles placed on the surface of the sphere. The electromagnetic perturbation of the quantised space-time by the electromagnetic wave results in the disruption of electrical equilibrium of the quantised space-time characterised by the appearance of strength vector **E**. Under the effect of strength vector **E** the electrical dipoles of the quanton try to rotate by their axis along the vector **E**, and the vector **E** tries to close itself through the dipoles of the quanton, circulating in the sphere of the wave and forming rotor **E**.

It should be remembered that this pattern of the circulation of vector **E** in the sphere is a statistically average pattern. In fact, taking into account

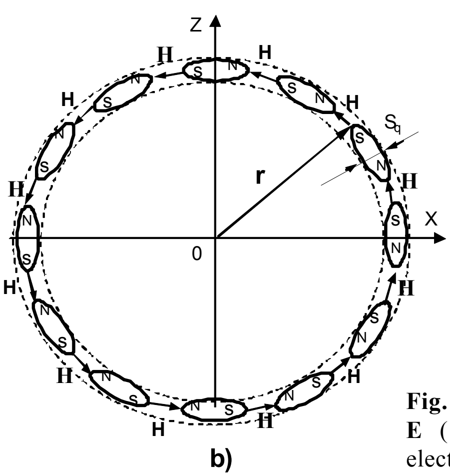


Fig. 2.18. Circulation of the strength of electrical **E** (a) and magnetic **H** (b) fields in the electromagnetic wave.

the small dimensions of the quanton, the number of the quantons taking part in the circulation of vector E is extremely large and they are oriented randomly, resulting only in the disruption of electrical equilibrium of space-time in the wave which is characterised by the averaged parameter of field strength **E**.

Identical considerations also relate to the formation of the strength rotor **H** of the magnetic field circulating in the sphere of the electromagnetic wave (Fig. 2.18b). The only difference is that vector **H** circulates in the cross-section of the sphere, orthogonal to the plane of the circulation section of the strength vector **E** of the electrical field (Fig. 2.19). We can separate two characteristic points **E** and **H**, setting the condition **H**⊥**E**. Taking into account the small dimensions of the quanton, the number of the characteristic points E and B on the wave sphere is extremely large. For any arbitrary coordinate A on the sphere of the wave, there is always coordinate B resulting in the extremely high number of fluxes **E** and **H** on the sphere. This can take place only in the case of the quantised structure of the electromagnetic wave.

Evidently, the circulation of the vectors **E** and **H** in the sphere in the orthogonal sections was detected for the first time in the EQM theory and requires additions to be made in vector analysis. This circulation is not typical of the flows of fluids or gas. The circulation of the magnetic flux around a conductor with a current is characterised by a cylindrical field, not by a spherical one.

Returning to Fig. 2.18, we can separate the elementary 'vortex' closed pipe defined by the cross-section of the quanton S_q. Due to the quantised state, the elementary vortex pipe is characterised by very interesting properties. Its electromagnetic perturbation is transferred by the pipe to the next vortex pipe in the direction of propagation of a spherical wave. Therefore, it may be asserted that the circulation of the strength vector **E** along the length ℓ of the elementary pipe and circulation of the electrical flux Ψ_e through the cross-section of the pipe S_q in its volume V are constants for any elementary vortex pipe, closed on the sphere of the wave

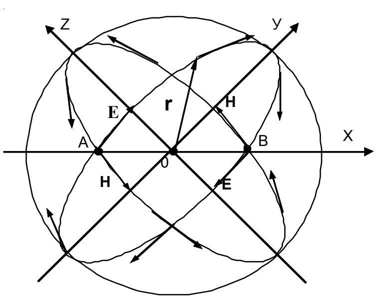


Fig. 2.19. Simultaneous circulation of the vectors **E** and **H** on the sphere of the electromagnetic wave in the orthogonal sections.

$$\oint_{\ell} \mathbf{E} d\ell = 2\pi r E = \text{const} \tag{2.145}$$

$$\oiiint_{v} \Psi_e dV = 2\pi r E S_q = \text{const} \tag{2. 146}$$

These two equations are equivalent. Therefore, we use the simpler expression (2.145) and form an equality for the moduli of two circulation vectors $\mathbf{E}$ and $\mathbf{E}_0$ with respect to the radii r and r_0:

$$2\pi r E = 2\pi r_0 E_0 \tag{2.147}$$

The parameters $\mathbf{E}_0$ and r_0 relate to the nearest zone from the radiation source and they can characterise the radiation source. From (2.147) we determine the nature of variation of the modulus of the strength of the field of the spherical electromagnetic wave, in movement away from the radiation source:

$$E = \frac{r_0 E_0}{r} = \frac{1}{2\pi} \frac{\varphi_{e0}}{r} \tag{2.148}$$

$$\varphi_{e0} = 2\pi r_0 E_0 \tag{2.149}$$

where φ_{e0} is the electrical potential (potential difference), characterising the region of the radiation source, V.

As indicated by (2.148), the strength $\mathbf{E}$ of the electrical field in the spherical electromagnetic wave decreases with the increase of the distance from the radiation source in inverse proportion to the distance $1/r$. This is in agreement with experimental results. However, the resultant dependence (2.148) has not as yet been justified theoretically because the strength of the spherical field, for example, for a point electrical charge (2.44), decreases in inverse proportion to the square of the distance $1/r^2$. It should be taken into account that this potential of the point source decreases on the sphere in inverse proportion to the distance $1/r$. The strength of the electrical field decreases in inverse proportion to the distance $1/r$ for the linear distribution of the charges, forming a cylindrical field.

Consequently, the tension of the spherical electromagnetic wave is changed in relation to the distance from the radiation source in the fashion other than the spherical relationships, propagating on the sphere the cylindrical field circulation of the strength vector. This can be explained quite logically, i.e., by the quantised nature of the electromagnetic wave. Firstly, vector $\mathbf{E}$ of the electromagnetic wave is normal to the propagation radius of the wave, it is not a radial vector, as in the case of the vector $\mathbf{E}$ of the point charge. Secondly, the vector $\mathbf{E}$ of the electromagnetic wave is a statistically averaged-out vector, formed as a result of superposition of the fields of a vast number of quantons, displaced from electrical equilibrium.

If we return to analysis of Fig. 2.18, the elementary vortex pipe produced from quantons, being a statistical category characterised by the rotor (2.140), can merge with the adjacent elementary vortex pipes at the same distance r from the radiation source. In fact, the pipe represents a very narrow cylindrical field (strip). This narrow strip encircles the wave on the sphere and this is the cylindrical section, regardless of the investigated section of the spherical wave. This is the unique property of the vacuum as an elastic quantised medium, which behaves in an inadequate fashion in comparison with the known media when the sphere is encircled by narrow and thin cylinders.

We can analyse in greater detail the processes on the level of the ultra-microworld of quantons, regarding the self-organisation of the elementary vortex pipes as statistical categories of the cylindrical type in the spherical wave. However, now it is important to understand that we are concerned with the unique processes of self-organisation of the elastic quantised medium.

Identical considerations refer to the circulation of the strength vector **H** of the magnetic field along the length ℓ of the elementary pipe and circulation of the magnetic flux ψ_g through the cross-section of the pipe S_q in its volume V, which are constant fine elementary vortex pipe, closed on the sphere of the wave (Fig. 2.18let about):

$$\oint_{\ell} \mathbf{H} d\ell = 2\pi r H = \text{const} \tag{2.150}$$

$$\oiiint_{v} \Psi_g dV = 2\pi r H S_q = \text{const} \tag{2.151}$$

The equations (2.150) and (2.151) are equivalent. Therefore, we use the simpler equation (2.150) and form an equality for the moduli of two circulation vectors **H** and $\mathbf{H}_0$ with respect to the radii r and r_0

$$2\pi r H = 2\pi r_0 H_0 \tag{2.152}$$

The parameters $\mathbf{H}_0$ and r_0 relate to the zone closest to the radiation source, and can characterise the radiation source itself. From (2.152) we determine the variation of the modulus of the strength of the magnetic field of the spherical electromagnetic wave in movement away from the radiation source

$$H = \frac{r_0 H_0}{r} = \frac{1}{2\pi} \frac{\varphi_{g0}}{r} \tag{2.153}$$

$$\varphi_{g0} = 2\pi r_0 H_0 \qquad (2.154)$$

where φ_{g0} is the magnetic potential (potential difference), characterising the region of the radiation source, A.

As shown by (2.153), the strength **H** of the magnetic field, like the strength **E** (2.148) of the electrical field, in the spherical electromagnetic wave decreases with the increase of the distance from the radiation source in inverse proportion to the distance $1/r$. This is well known in electrodynamics and has been verified many times by experiments. However, the reasons for this phenomenon were found for the first time in the EQM theory.

The fact that the strength moduli **E** (2.148) and **H** (2.153) in the spherical electromagnetic wave change in inverse proportion to the distance $1/r$, like the potential of the point charge, was used as a basis for the purely formal introduction of auxiliary functions of scalar $\varphi = \varphi(\mathbf{r}, t)$ and vector $\mathbf{A} = \mathbf{A}(\mathbf{r}, t)$ potentials for the electromagnetic wave which are used widely in calculations in electrodynamics [39–42].

2.3.10. Transfer of energy by the quanton in the electromagnetic wave

The electromagnetic wave cannot form without participation of quantons. In a general form, the energy balance of the quanton is represented in statics by the equations (2.79) and (2.8), and in dynamics by (2.81) and (2.82).

We examine internal energy processes taking place in the quanton if its electrical and magnetic equilibrium is disrupted in the statics through the effect of the external field E (2.63) and H (2.73). The fields E and H are determined by the displacement of the charges Δx and Δy inside the quanton. One of the electrical charges of the quanton is regarded as stationary, and the second charge e is displaced by the value Δx. Taking into account that the displacement Δx is an incommensurably small value in relation to the quanton diameter, work ΔW_e (2.79) for the displacement of the charge e in the field E by the value Δx will have the form of a linear function

$$\Delta W_e = eE\Delta x \qquad (2.155)$$

From (2.63) we obtain the product $e\Delta x$

$$e\Delta x = \frac{\varepsilon_0 E}{2\rho_0} \qquad (2.156)$$

We introduce (2.156) and (2.155) and obtain the variation of electrical energy ΔW_e (2.79) of the quanton in displacement Δx of the electrical charge but their core in statics under the effect of the external field **E**

$$\Delta W_e = \frac{1}{2\rho_0}\varepsilon_0 E^2 \tag{2.157}$$

The volume density of electrical energy in polarisation of vacuum is determined by the sum of energies (2.157) of all quantons included in 1 m^3 of space-time. For this purpose, (2.157) is multiplied by the quantum density of vacuum ρ_0 and we obtain the well-known equation for the electrostatic volume density W_E of the energy of polarisation by the external electrical field of vacuum

$$W_E = \frac{1}{2}\varepsilon_0 E^2 \tag{2.158}$$

We use the same procedure for the change of the magnetic energy ΔW_g (2.80) of the quanton in displacement Δy of the magnetic charge g in the statics under the effect of the magnetic field **H** (2.73), and also volume density W_H of magnetic energy in the statics

$$\Delta W_g = \frac{1}{2\rho_0}\mu_0 H^2 \tag{2.159}$$

$$W_H = \frac{1}{2}\mu_0 H^2 \tag{2.160}$$

The equations (2.157) and (2.159) are the statistically averaged-out energies of the quanton in determination of the volume density of energies (2.158) and (2.159) of vacuum. Under the simultaneous effect of fields E and H on the vacuum, the variation of the quanton energy is determined by the sum of (2.157) and (2.159) and the volume density of the energy of the vacuum by the sum of (2.150) and (2.160).

In disruption of the vacuum by the electromagnetic wave, the energy processes inside the quanton and in the perturbed vacuum are not adequate. The point is that in transfer of the electromagnetic wave the internal edge of the quanton remains constant and the variations of the internal energy of the quanton are manifested externally in the form of simultaneously acting fields **E** and **H**. These fields characterise the energy of electromagnetic polarisation of vacuum which is described by the volume density of electrical (2.150) and magnetic (2.160) energies.

Let us consider the energy processes inside the quanton and outside it in greater detail. In passage of the electromagnetic wave through the quanton, the quanton energy (2.81) and (2.82) remains constant. The variation of the quanton energy in this case is characterised only by a single component: electrical or magnetic which cannot be added up. The electrical component of quantum energy ΔW_e is twice the energy (2.155) because electromagnetic perturbation the total displacement of the charge e is determined by the double amplitude $2\Delta x$

$$\Delta W_e = 2eE\Delta x \tag{2.161}$$

Taking into account (2.156), from (2.161) we obtain the total energy transferred by the quanton in passage of the electromagnetic wave through the quantum. This energy is determined by the electrical component ΔW_e or, by analogy, by the magnetic component ΔW_g

$$\Delta W_e = \frac{\varepsilon_0 E^2}{\rho_0} \tag{2.162}$$

$$\Delta W_g = \frac{\mu_0 H^2}{\rho_0} \tag{2.163}$$

The equations (2.162) and (2.163) show that in accordance with (2.81) and (2.82), the increase of the electrical component (2.162) by the equivalent value reduces the magnetic component (2.163) inside the quanton or, vice versa, the energy of the quanton during the passage of the electromagnetic wave through the quantum remains constant. In the experiments, this is confirmed on the basis of the absence of excess energy in wave electromagnetic processes which are governed by the energy balances (2.81) and (2.82).

However, the external manifestation of the electrical (2.161) and magnetic (2.163) components in the volume of the quantised space-time, in accordance with the laws of electromagnetic induction, is determined by two component of the volume density of energies (2.150) and (2.160) with the same values. The total density of volume energy W_v [J/m^3] of the electromagnetic wave is determined as the sum of its electrical (2.158) and magnetic (2.160) components

$$W_v = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\mu_0 H^2 \tag{2.164}$$

Taking into account the equivalence of the electrical and magnetic components in (2.164), the magnetic component is expressed by the electrical parameters of the field, replacing the modulus of the strength H by the equivalent electrical modulus $\varepsilon_0 C_0 E$ from the singular equation (2.55), (2.134) of the electromagnetic wave in vacuum:

$$W_v = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\mu_0(\varepsilon_0 C_0 E)^2 = \varepsilon_0 E^2 \qquad (2.165)$$

It is convenient to express the volume density of energy (2.165) through two components: electrical and magnetic (2.134)

$$W_v = \varepsilon_0 E^2 = \varepsilon_0 E\left(\frac{H}{\varepsilon_0 C_0}\right) = \frac{EH}{C_0} \qquad (2.166)$$

Equation (2.166) characterises the polarisation energy of 1 m^3 of vacuum in passage of the electromagnetic wave through it. We determine the time t_v of passage of the electromagnetic wave to the depth of the volume h by the section normal to the vector of the speed of light C_0

$$t_v = \frac{h}{C_0} \qquad (2.167)$$

From (2.166) we determine the flux with density **S** (the intensity of the flux) of the electromagnetic energy of the wave in the vacuum passing through the cross-section of 1 m^2 to the depth h in unit time t_v (2.164), writing it in the vector form:

$$\mathbf{S} = \frac{W_v h}{t_v}\mathbf{1}_r = W_v \mathbf{C}_0 = |\mathrm{EH}| \quad \left[\frac{\mathrm{J}}{\mathrm{m^2 s}} = \frac{\mathrm{V \cdot A}}{\mathrm{m^2}}\right] \qquad (2.168)$$

where $\mathbf{1}_r$ is the unit vector in the direction **r** of propagation of the electromagnetic wave with respect to the speed vector $\mathbf{C}_0$.

The equation (2.168) is a Pointing vector derived by an elementary procedure on the basis of the equivalence of the electrical and magnetic components of the electromagnetic wave in the quantised space-time. The Pointing vector determines the intensity of the incident energy flux which in the case of vacuum represents only the reactive energy and the power of the flux, because there is no absorption of energy by the quantised space-time in the absence of matter. Expression (2.168) links the density of the volume energy W_v with the intensity of the flux I**EH**I. The vector product I**EH**I determines the plane of the vectors **E**⊥**H** as normal to the direction of the vector of speed C_0 of propagation of the electromagnetic wave and the direction of the Pointing vector **S** (2.168) [39–42].

The equation (2.168) in the integral form is the Ostrogradskii–Gauss theorem

$$C_0 \int \mathrm{div} W_v dV = \oint EH dS_v \qquad (2.169)$$

If the radiation source is placed inside the volume V, then the closed integral

(2.169) on the surface S_v of the given volume determines the power of the radiation source.

We introduce (2.148) and (2.153) into (2.166) and (2.168). We obtain the function of attenuation of the volume density of energy W_v and flux intensity $\mathbf{S}$ = I**EH**I of the spherical electromagnetic wave with the distance from the power source increasing to **r**

$$W_v = \frac{EH}{C_0} = \frac{r_0^2}{C_0}\frac{E_0 H_0}{r^2} = \frac{1}{4\pi^2 C_0}\frac{\varphi_{e0}\varphi_{g0}}{r^2} \quad (2.170)$$

$$\mathbf{S} = W_v \mathrm{C}_o = |\mathbf{EH}| = \frac{r_0^2|\mathbf{E}_0\mathbf{H}_0|}{r^2} = \frac{1}{4\pi^2}\frac{\varphi_{e0}\varphi_{g0}}{r^2}\mathbf{1}_r \quad (2.171)$$

It can be seen that the volume density of energy W_v (2.170) and flux intensity **S** (2.171) decrease with the increase of the distance from the radiation source in inverse proportion to the square of the distance $1/r^2$. This is a sufficiently verified experimental fact.

The equations (2.170) and (2.171) can be used to estimate the parameters of the emitter. Therefore, for calculations in practice it is convenient to use only one component (electrical or magnetic) which excites the electromagnetic radiation in relation to the type of antenna (electrical or magnetic)

$$W_v = \frac{\varepsilon_0 (r_0 E_0)^2}{r^2} = \frac{\varepsilon_0}{4\pi^2}\frac{\varphi_{e0}^2}{r^2} \quad (2.172)$$

$$\mathbf{S} = \frac{\varepsilon_0 (r_0 E_0)^2}{r^2}\mathbf{C}_0 = \frac{\varepsilon_0}{4\pi^2}\frac{\varphi_{e0}^2}{r^2}\mathbf{C}_0 \quad (2.173)$$

$$W_v = \frac{\mu_0 (r_0 H_0)^2}{r^2} = \frac{\mu_0}{4\pi^2}\frac{\varphi_{g0}^2}{r^2} \quad (2.174)$$

$$\mathbf{S} = \frac{\mu_0 (r_0 H_0)^2}{r^2}\mathbf{C}_0 = \frac{\mu_0}{4\pi^2}\frac{\varphi_{g0}^2}{r^2}\mathbf{C}_0 \quad (2.175)$$

The single-component parameters (2.172)–(2.175) characterise the nearest radiation zone in the region of the antenna. In the formation of the electromagnetic wave, the single-component parameter is divided into two equivalent components: electrical and magnetic, as a result of the effect of the laws of electromagnetic induction in the quantised space-time.

The results can be used to estimate the participation of the superstrong electromagnetic interaction (SEI) in the wave transfer of electromagnetic energy. For this purpose, we determine the value of the variation of the quanton energy ΔW_e (2.155) which takes part in the transfer of electromagnetic energy, expressing the tension modulus of the wave E through the variation of the tension modulus of the quantom ΔE_{qx} (2.70)

$$\Delta W_e = eE\Delta x = e\Delta E_{qx}\Delta x = \frac{4\pi}{3}\frac{e^2}{\varepsilon_0 L_{q0}^3}\Delta x^2 \tag{2.176}$$

From equation (2.12) we determine the binding energy W_v of the electrical charges inside the quanton at $r_{e0} = 0.5\ L_{q0}$

$$W_e = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_{e0}} = \frac{1}{2\pi\varepsilon_0}\frac{e^2}{L_{q0}} \tag{2.177}$$

Dividing (2.176) by (2.177), we determine the extent of participation of the superstrong electromagnetic interaction in the classic electromagnetic interaction in transfer of the electromagnetic wave in vacuum which can be estimated quite satisfactorily by the displacement of the charges $\Delta x = 2.3\cdot 10^{-62}$ m (2.64) for the region of the strong electrical field with the strength of 30 kV/cm

$$\frac{\Delta W_e}{W_e} = \frac{8\pi^2}{3}\left(\frac{\Delta x}{L_{q0}}\right)^2 = 2.6\cdot 10^{-72} \tag{2.178}$$

The result (2.178) is estimated as being of the order of 10^{-72}. This value is extremely small even for the region of strong electrical (electromagnetic) fields in comparison with the density of the energy which was initially accumulated in the form of SEI in the quantised space-time.

Thus, quantisation of the electromagnetic wave enables us to understand the reasons for electromagnetic phenomena in vacuum, determining the nature of exchange processes between SEI and classic electromagnetism. If appears that the well-known parameters of the electromagnetic wave have been estimated from a completely different point of view. It is important to mention the considerable simplification of the calculation procedure developed on the basis of the analysis of the physical model of quantised space-time as a result of its electromagnetic perturbation. The previously mentioned calculations of the electromagnetic processes can be presented in the complex form, but this would complicated understanding the causality of the physical phenomena which is at present the principal task in explaining of the EQM theory.

2.4. Electromagnetic tensioning of vacuum. Strings and superstrings

2.4.1. Elastic quantised medium (EQM)

Since the Maxwell period, only the EQM theory has made it possible to carry out for the first time the analytical derivation of the main equations of the electromagnetic processors in vacuum, describing the nature of the very phenomena and taking into account only the specific features of the electromagnetic structure of vacuum as the elastic quantised medium. The electromagnetic processes in vacuum have been studied experimentally quite extensively and the explanation of their nature is the most efficient confirmation of the validity of the EQM theory. This was not possible prior to the development of the EQM theory.

All the electromagnetic processes in vacuum are the result of the elastic interaction of electricity and magnetism inside the quanton and, on the whole, the elastic electromagnetic tensioning of the quantised space-time. Taking into account the small size of the quantum, the interaction of the charges inside the quanton is determined by colossal forces (2.10)

$$\begin{cases} F_e = \dfrac{1}{4\pi\varepsilon_0}\dfrac{e^2}{r_{e0}^2} = \dfrac{1}{\pi\varepsilon_0}\dfrac{e^2}{L_{q0}^2} = 1.6\cdot 10^{23}\,\mathrm{N} \\ F_g = \dfrac{\mu_0}{4\pi}\dfrac{g^2}{r_{g0}^2} = \dfrac{\mu_0}{\pi}\dfrac{g^2}{L_{q0}^2} = 1.6\cdot 10^{23}\,\mathrm{N} \end{cases} \tag{2.178}$$

In the quantised space-time (Fig. 2.5), the forces (2.178) are balanced by the interaction of every quanton with the entire population of the quantons in the space, establishing the linear laws (2.69) and (2.76) of the variation of force in displacement Δx and Δy of the electrical and magnetic charges inside the quanton in relation to the equilibrium state

$$\mathrm{F}_{2x} = \frac{4\pi}{3}\frac{e^2 1_x}{\varepsilon_o L_{qo}^3}\Delta x = k_x \Delta x = 3\cdot 10^{49}\,\Delta x \tag{2.180}$$

$$\mathrm{F}_{2y} = -\frac{4\pi}{3}\mu_o \frac{g^2 1_y}{L_{qo}^3}\Delta y = k_y \Delta y = 3\cdot 10^{49}\,\Delta y \tag{2.181}$$

where $k_x = k_y = 3\cdot 10^{49}$ N/m is the coefficient of electromagnetic elasticity of vacuum

$$k_x = \frac{4\pi}{3}\frac{e^2}{\varepsilon_0 L_{q0}^3} = 3\cdot 10^{49}\,\frac{\mathrm{N}}{\mathrm{m}} \tag{2.182}$$

The forces (2.180) and (2.181) are elastic forces, similar to the elastic forces of tensioning of the string. The value of the coefficient (2.182) of electromagnetic elasticity of vacuum is very high, of order of 10^{49} N/m. None of the known media has such a colossally high elasticity is vacuum. In particular, the colossal elasticity of vacuum determines the highest rate of propagation of the electromagnetic wave in the vacuum. The elastic displacement of the charges inside the quantum determines the wave electromagnetic processes in the quantised space-time, characterising it as a light-bearing medium.

We can derive a differential dynamics equation which is the analogue of the mechanical system for the equivalent mass m_x and the elastic forces (2.180) (to simplify considerations, Δx is replaced by x)

$$m_x \frac{d^2 x}{d\,t^2} - k_x x = 0 \tag{2.183}$$

Equivalent mass m_x characterises the inertia of the system. Equation (2.183) is the equation of free oscillations of the point mass under the effect of elastic force. The solution of (2.183), makes it possible to link the elastic parameters (2.182) of the quanton as the inertia system with the frequency of its free oscillations (2.15) and (2.16)

$$k_x = m_x \omega^2 = m_x (2\pi f_0)^2 = 4\pi^2 m_x \left(\frac{C_0}{L_{q0}} \right)^2 \tag{2.184}$$

Equation (2.183) characterises the oscillatory system without losses. This relates to the transfer of energy without losses from one quantum to another during the passage of the electromagnetic wave because in nature there are no free quantons isolated from the space-time in nature.

Using equation (2.184), we determine the equivalent of mass m_x of the system taking into account (2.182)

$$m_x = \frac{k_x}{4\pi^2} \left(\frac{L_{q0}}{C_0} \right)^2 = \frac{1}{C_0^2} \frac{e^2}{3\pi L_{q0}} = \frac{W_x}{C_0^2} \tag{2.185}$$

Equation (2.185) fully confirms the principle of equivalence of energy and mass because (2.185) includes the binding energy W_x of the individual charge inside the quanton with the charges of other quantons

$$W_x = \frac{e^2}{3\pi L_{q0}} \tag{2.186}$$

Energy (2.186) is three times smaller than the binding energy of two electric charges inside the quanton and is averaged-out at this time because the exact solution of the problem of interaction of a large group of charges in the volume of quantised space-time has not been obtained as yet. Taking into account that energy W_x (2.186) relates to a single charge, the total averaged-out energy of two electrical charges in the quanton is:

$$W_e = 2W_x = \frac{2e^2}{3\pi L_{q0}} \tag{2.187}$$

The energy processes inside the quantum and between the quantons determined the inertia of energy transfer and the speed C_0 of propagation of transverse electromagnetic perturbations in vacuum. From (2.185) and (2.184) we obtain

$$C_0 = \sqrt{\frac{W_x}{m_x}} = \frac{L_{q0}}{2\pi}\sqrt{\frac{k_x}{m_x}} \tag{2.188}$$

The wave electromagnetic processes in vacuum were studied examined in detail previously. These processes can be investigated from the viewpoint of elastic tensions of electromagnetic strings (Fig. 2.50) in the volume of quantised space-time, introducing the characteristics of the mechanical systems, such as the modulus of transverse shear and the modulus of longitudinal elasticity. Consequently, we can determine the difference (or the absence of difference) between the speeds of the electromagnetic and gravitational waves. However, this is already a completely different problem and, at the moment, it is necessary to analyse the tensioning of the electromagnetic strings.

However, prior to analysing the elastic properties of the electromagnetic string and superstrings, we return to the history of the process. In a letter to Boyle, Newton wrote: ‘I assume that the entire space is filled with aether matter, capable of compression and stretching, with high elasticity...’ [44]. He supported his concept when completing his excellent ‘Origins’ [45]. However, Newton was not capable of formulating exactly the elastic properties of the aether and made only brilliant guesses. The article by Maxwell ‘Aether’ was also based on guesses, in the sense that the ‘aether has elasticity, similar to the elasticity of the solid’ [48]. Lorentz, who understood correctly the concept of the electromagnetic aether, proposed a relatively contradicting idea regarding its properties as a mechanistic aether [6]. Einstein also expressed doubts regarding the aether, replacing it by the concept of the four-dimensional space-time and at the end of his life he believed that there is no emptiness and defended the concept of the unified field [10,11] which was realised in the EQM theory.

Academician Vavilov evaluated the situation quite accurately: ‘...aether should be the arena of gravitational, electromagnetic and optical phenomena. It was not possible to construct a model of the ether corresponding to all these requirements'. However, most importantly, the concept of mechanistic aether did not explain the 'relativity of translational motions' i.e., but they did not explain the fundamental nature of the relativity principle [46].

The elastic structure of the quantised space-time, described in the EQM theory, explains for the first time without contradiction all the fundamental interactions, including the fundamentality of the relativity principle in the absolute space, determining the principle of relative-absolute dualism [22-33]. It has already been shown in this book that the electromagnetic structure of the quantised space-time explains without contradiction and harmonically the nature of electromagnetic processes in vacuum, proving that there is no emptiness in nature. Prior to developing the EQM theory, nobody was capable of describing the structure of vacuum.

Quantised space-time is the elastic quantised medium (EQM) which is the carrier of superstrong electromagnetic interactions (SEI).

2.4.2. Tensioning of the electromagnetic superstring

In the first approximation, the order of forces in 10^{23} N in (2.178) determines the colossal tensioning of the electromagnetic string made of quantons (Fig. 2.15). To determine the tensioning of the string, it is necessary to take into account the effect of charges of elastic quantons. Taking into account the ambiguous orientation of the electrical and magnetic axes of the quantons, the exact solution of this task is associated with considerable mathematical difficulties. However, the statistically average-out answer can be obtained by elementary methods, taking into account the mean angle 45° (2.71) and (2.78) of the slope of electrical and magnetic axes of the quantons in the direction of any electromagnetic string, penetrating the quantised space-time (Fig. 2.15).

The problem is greatly simplified if we consider separately the magnetic and electrical alternating superstrings. In the EQM theory, the electrical and magnetic superstrings represent an infinite chain of alternating electrical and magnetic charges placed in a line with the alternation of polarity. A section of the chain of the alternating charges represents yhe electrical (a) and magnetic (b) string (Fig. 2.20). The electromagnetic superstring in the EQM theory is an infinite chain consisting of quantons which interact with each other by the attraction forces resulting in tensioning of the superstring. A section of the chain made of quantons represents the an electromagnetic string (Fig. 2.15).

Figure 2.20 shows the calculation scheme of the forces of electrical $\mathbf{F}_e$

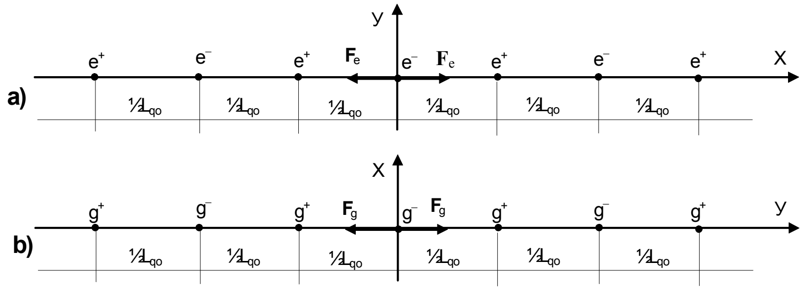


Fig. 2.20. Calculation of the tensioning of alternating electrical (a) and magnetic (b) superstrings.

and magnetic $\mathbf{F}_g$ potentials, acting on the elementary charge e and g inside the electrical (a) and magnetic (b) superstrings. Figure 2.20 is an analogue of Fig. 2.5 on the condition of the same distance between the charges, equal to half the quanton diameter $½L_{q0}$.

The tension of the electrical superstring (Fig. 2.20a) is determined by the pair of electrical forces $\mathbf{F}_e$ acting from the left and right on a test charge, placed in the origin of the coordinates. To calculate force $\mathbf{F}_e$, we determine the strength $\mathbf{E}_e$ of the electrical field in the region of the coordinates which is generated by the charges with alternating signs to the right of the origin of the coordinates along the axis X to infinity. In accordance with the principle of superposition of the fields, strength $\mathbf{E}_e$ is determined by the sum of the fields acting in the region of the coordinates to the right of every charge in only half the superstring. We obtain an infinite series, whose sum is known:

$$\mathbf{E}_e = \frac{\mathbf{1}_x}{4\pi\varepsilon_0}\frac{e}{(0.5L_{q0})^2}\left(1-\frac{1}{2^2}+\frac{1}{3^2}-\frac{1}{4^2}+\cdots\right)=\frac{\mathbf{1}_x}{\pi\varepsilon_0}\frac{e}{L_{q0}^2}\left(\frac{\pi^2}{12}\right)=\frac{\pi}{12\varepsilon_{00}}\frac{e}{L_{q0}^2}\mathbf{1}_x \quad (2.189)$$

From (2.189) we determine the force $\mathbf{F}_e$ which is slightly smaller than (2.179) because of weakening of the field by the second negative charge in the series (2.189). Taking into account the fact that the charge is subjected to the effect of the pair of the forces $\pm\mathbf{F}_e$ from the left and right, we introduce the concept of the alternating unit vector $\pm\mathbf{1}_x$, which balances the effect of the pair of the forces $\pm\mathbf{F}_e$ on the charge in the superstring (Fig. 2.20a)

$$\mathbf{F}_e = \pm e\mathbf{E}_e = \pm\mathbf{1}_x\frac{\pi}{12\varepsilon_0}\frac{e^2}{L_{q0}^2} = \pm 1.4\cdot 10^{23}\,\text{N} \quad (2.190)$$

The same procedure is used to determine the per of tensioning forces $\pm\mathbf{F}_g$, acting on the magnetic charge g in the magnetic superstring (Fig. 2.20b):

$$\mathbf{F}_g = \pm\mu_0 g\mathbf{H}_g = \pm\mathbf{1}_y \frac{\pi\mu_0}{12}\frac{g^2}{L_{q0}^2} = \pm 1.4\cdot 10^{23}\,\mathrm{N} \tag{2.191}$$

The forces $\pm\mathbf{F}_e$ and $\pm\mathbf{F}_g$ were obtained for ideal superstrings and the directions of the axes X and Y do not coincide. In the electromagnetic superstring (Fig. 2.15) the electrical and magnetic superstrings are combined into a single system. Taking into account the statistical scatter of the orientations of the quantum axes, (2.71) and (2.78) were used previously to determine the average angle of inclination of the axes, which was equal to 45°, including in the direction Z, i.e. $\alpha_z = 45°$.

Figure 2.21 shows the flat scheme of the statistically averaged-out electromagnetic superstring in the direction Z. Actually, the superstring has the volume and chirality and twisted in relation to the Z axis. This is determined by the tetrahedral arrangement of the charges in the quantum which prevents arrangement in the single plane (Fig. 2.2).

In the flat model (Fig. 2 .21), the electrical charges of the quantons are situated in the plane XZ, and the magnetic charges in the plane YZ. The region of the coordinates for the axes X and Y is displaced by the displacement of the electrical and magnetic axes in the quanton. Attention should be given to the fact that the projection of the strength E_z of the electrical field on the axis Z is determined by the difference of the vectors **E**, compensating the electrical field in the direction Z. The projections of the strength E_x of the electrical field on the axis X are determined by the sum of the vectors **E**.

This also relates to the magnetic component. The projections of the strength H_z of the magnetic field on the Z axis are determined by the difference of the vectors **H**, compensating the magnetic field in the direction Z. The projections of the strength H_y of the magnetic field on the axis Y are determined by the sum of the vectors **H**. For this reason, the electrical and

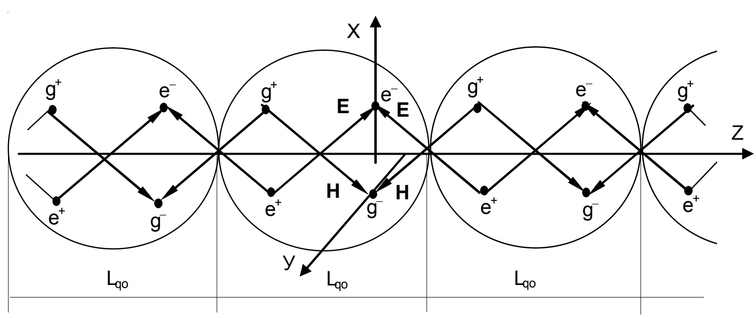


Fig. 2.21. Scheme of the statistically averaged-out electromagnetic superstring.

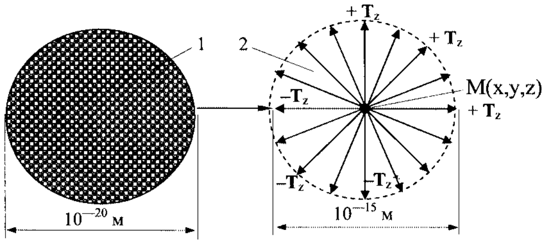


Fig. 2.22. Representation of region 1 of the quantised space-time as a point object M (x, y, z) in the region 2.

magnetic components of the strength of the field in the electromagnetic wave are transverse and situated in the plane normal to the direction of propagation of the wave along the electromagnetic superstring.

We determine the projections of the forces $\pm\mathbf{F}_e$ and $\pm\mathbf{F}_g$ on the Z axis and determine the total force $\pm\mathbf{F}_z$ of tensioning the electromagnetic superstring in the direction Z for the unit alternating vector $\pm\mathbf{1}_z$

$$\mathbf{F}_z = \pm\mathbf{1}_z(F_e + F_g)\cos\alpha_z = \pm\mathbf{1}_z \frac{\pi}{12L_{q0}^2}\left(\frac{e^2}{\varepsilon_0} + \mu_0 g^2\right) = \pm 2\cdot 10^{23}\,\text{N} \qquad (2.192)$$

The value of the tensioning force $\pm\mathbf{F}_z$ (2.192) of the electromagnetic superstring is regarded as the calculated value. We determine the tension $\pm\mathbf{T}_z$ of the electromagnetic superstring as the force $\pm\mathbf{F}_z$ per cross-section S_q of the quantum since the cross-section of the quanton determines the cross-section of the electromagnetic superstring (Fig. 2.15)

$$\pm\mathbf{T}_z = \frac{\pm\mathbf{F}_z}{S_q} = 4\frac{\pm\mathbf{F}_z}{\pi L_{q0}^2} = \frac{\pm\mathbf{1}_z}{3L_{q0}^4}\left(\frac{e^2}{\varepsilon_0} + \mu_0 g^2\right) = \pm 4.65\cdot 10^{73}\,\frac{\text{N}}{\text{m}^2} \qquad (2.193)$$

The alternating tension vector $\pm\mathbf{T}_z$ characterises vacuum as an elastic quantised medium with the discreteness equal to the quanton diameter. Attention should be given to the fact that in the region of the quantum ultramicroworld all the vacuum parameters are characterised by very small dimensions and extremely high forces (2.192) and tensioning of the medium (2.193). It may be shown that vacuum is a virtually incompressible substance and any fluctuations of vacuum to be associated with colossal external forces. It would appear that the usual physical laws with low forces should not be valid in such a substance. It is difficult to imagine an analogue of a continuous stretched net (Fig. 2.5) under the effect of colossal forces similar to (2.190) and (2.191). Such a net could not be used for any action using conventional forces acceptable for the macroworld.

However, the point is that the vacuum is not a continuous medium but a quantised medium. In the non-perturbed condition it is a fully balanced medium in which the tension forces $\pm\mathbf{F}_e$ and $\pm\mathbf{F}_g$ act on the charge from the left and right. Consequently, the force of displacement of the charges inside the quanton is determined by the magnitude of displacement Δx and Δy (2.180) and (2.181) and not by tensioning forces. Taking into account the fact that the displacement of the charges can be very small in magnitude, very small external forces would be required to displace the quantised space from the equilibrium condition. For example, to generate a strength of the electrical field of 30 kV/cm, the displacement of the charge in the quanton is only $2.3\cdot10^{-62}$ m (64). This displacement corresponds to the relatively low force (2.180):

$$\mathbf{F}_{2x} = k_x \Delta x = 0.7\cdot10^{-12}\,\mathrm{N} \tag{2.194}$$

Thus, the vacuum is a unique medium which is characterised by both colossal tension (2.193) and by the capacity for very low forces acting in vacuum (2.194). Force (2.194) is already a derivative force of the equilibrium state of the vacuum determined by the discrete tension (2.193), where the linking term in the string is the elementary charge of the quanton (Fig. 2.20).

2.5.3. Tension tensor in vacuum

The presence of colossal tension $\mathbf{T}_z$ (2.193) makes it possible to use the methods of tensor analysis for the analysis of non-equilibrium forces in the quantised space-time [37, 34]. The specific feature of the quantised space-time is that the super strongelectromagnetic interaction (SEI) acts in the region of the ultra-microworld of the quantons, and this interaction characterises the vacuum space as a highly heterogeneous and anisotropic substance. However, in transition to the region of the microworld of the elementary particles and the macroworld, the quantised space-time is already perceived as a homogeneous and isotropic medium. This is explained by the operation of statistical laws which are determined by the high concentration of the quantons in the volume of space.

We separate a spherical volume of the quantised space-time with the diameter of the order of 10^{-20} m, i.e., up to 10 times greater than the quanton diameter L_{q0}. For the region of the microworld of the elementary particles, the diameter of 10^{-20} m is up to 10^5 times greater than the diameter of the elementary particle 10^{-15} m, and can be regarded as a point object $M(x, y, z)$. In this case, we are concerned with the relativity of perception of the quantised space-time in physical processes. It may be assumed that the concept of relativity in the EQM theory is considerably wider than the relativity of straight and uniform motion.

The relative special feature of quantised space-time is that at any point of space M (x, y, z) the tension forces $\pm\mathbf{T}_z$ (2.193) are balanced in any arbitrary direction governed by spherical symmetry and form a tension field $\pm\mathbf{T}_z$ uniform in all directions (Fig. 2.22).

If a spherical shell is cut out from the quantised space-time (Fig. 2.23a), it may be seen that the shell is subjected to the effect of tension forces on both the external and internal side. In the non-perturbed vacuum, the tension forces on the external side are fully compensated by the tension forces on the internal side of the shell, ensuring the equilibrium of space-time.

The tension, acting in the direction normal to the unit surface dS of the spherical shell from the external side will be denoted by $\mathbf{T}_{n1}$, and from the internal side $\mathbf{T}_{ns}$. Consequently, the resultant of all forces $\Sigma\mathbf{F}$, acting on the shell, will be determined by the difference of the forces $\mathbf{F}_1$ and $\mathbf{F}_2$ on the internal and internal sides of the shell, which are determined by the integral of the surface S of the shell for the function of the tensions $\mathbf{T}_{n1}$ and $\mathbf{T}_{n2}$:

$$\sum\mathbf{F}=\mathbf{F}_1-\mathbf{F}_2=\oint_S\mathbf{T}_{n1}dS-\oint_S\mathbf{T}_{n2}dS=\oint_S(\mathbf{T}_{n1}-\mathbf{T}_{n2})dS=\oint_S\Delta\mathbf{T}_n dS \qquad (2.195)$$

As already mentioned, the quantised space-time is a universal medium in which both the small forces (2.194) can and also colossal stresses $\mathbf{T}_z$ (2.193) can operate or be absent. Consequently, it may be assumed that tension $\mathbf{T}_{n1}$ is the intermediate tension in the range $0 < \mathbf{T}_{n1} < \mathbf{T}_z$ (2.193).

Integral (2.195) is of considerable importance in the EQM theory, and determines the effect of unbalanced forces of the electrical, magnetic in gravitational fields in the quantised space-time, and also their equilibrium condition. The difference of the tensions $\mathbf{T}_{n1}$ and $\mathbf{T}_{n2}$ determines the 'jump' of tension $\Delta\mathbf{T}_n$. If there is no jump of the tension on the surface of the sphere S (Fig. 2.23a) i.e., $\Delta\mathbf{T}_n = 0$, it can be assumed that there is nothing happening in this quantised space-time, i.e., no electrical, magnetic or gravitational perturbation is found in the vacuum, and only one tension at $\mathbf{T}_z$ (Fig. 2.22).

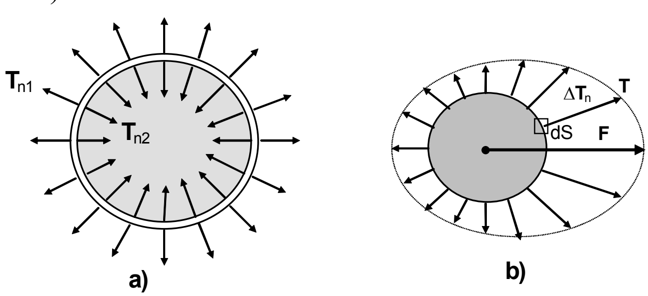


Fig. 2.23. Effect of tension on the spherical shell (a) and the formation of the spherically unbalanced force F (b).

As shown previously, all electrical, magnetic in electromagnetic processes in vacuum are linked only with the displacement of the charges inside the quanton and this results in the disruption of the equilibrium of the quantised space-time without disruption of the quantum density of the medium. In this case, the volume of the quanton remains constant and also there was no change in the concentration of the quantons in the unit volume of the space.

Gravitational perturbation is characterised by the disruption of the quantum density of the medium in the absence of displacement inside the quanton charges in relation to the equilibrium state. More accurately, the charges are displaced not only at the moment of the changes of the gravitational field when the uniform tension or compression of the quanton is associated with the variation of its volume without disrupting its electrical and magnetic equilibrium. In the presence of the gravitational perturbation, the concentration of the quantons in the unit volume of space changes.

The theory of gravitation is strongly linked with the deformation of the quantised space-time and is also investigated in this book. The tasks formulated in this chapter in solving the problems of electromagnetic phenomena in vacuum have been fulfilled. Further investigations are linked with the nature of gravitation as an electromagnetic phenomenon determined by the deformation of the quantised space-time and the interaction of electromagnetism with matter.

Therefore, without discussing the underlying phenomena in the quantised space-time, we examine the general manifestation of tensions in the quantised space-time through the elements of tensile analysis and its application to several aspects of static electromagnetism in interaction with matter.

Returning to analysis of (2.195), we specify two main groups of the interactions:

$$\sum \mathbf{F} = 0, \quad \Delta\mathbf{T}_n > 0 \tag{2.196}$$

$$\sum \mathbf{F} > 0, \quad \Delta\mathbf{T}_n > 0 \tag{2.197}$$

The first group (2.194) characterises the spherically symmetric systems (Fig. 2.23a). If $\mathbf{T}_{n2} > \mathbf{T}_{n1}$, then the jump of the tension $\Delta\mathbf{T}_n$ at the interface is directed into the bulk of the sphere and compresses the latter. Spherical compression of the quantised space-time increases the quantum density of the medium inside the sphere as a result of extension of the sphere on the external side of the interface. This interaction results in the generation of mass as a result of spherical deformation of the quantised space-time. The gravitational interaction is investigated in greater detail in chapter 3.

If the sphere contains (Fig. 2.23a) a free electrical charge, polarisation of vacuum results in the formation of a gradient of the displacement of electrical charges inside the quantons in the radial direction r, generating effects in the space-time of the spherical electrical field. The sphere with thickness Δr shows a jump of tension $\Delta \mathbf{T}_n$ and also a jump of strength and difference of the potentials. If the gradient is regarded as a continuous function in the theory of vector analysis, in the EQM theory it is shown that every gradient is quantised on the basis of the discreteness of space-time.

The second group (2.197) characterises the formation of unbalanced force **F** as a result of the non-symmetrical distribution of tension jumps $\Delta \mathbf{T}_n$ on the sphere (Fig. 2.23a). This perturbation characterises the already anisotropic medium whose properties change depending on direction.

In a general case, we can separate the vector of a tension jump $\Delta \mathbf{T}$ (or, to simplify considerations, vector **T**) which is directed under an angle to the interface as a result of complicated interactions in the quantised space-time. In a number of cases this leads to the formation of the unbalanced momentum of forces M (Fig. 2.24).

We examine the perturbation of vacuum in the conditions of disruption of spherical symmetry, shown in Fig. 2.23b in the rectangular coordinate system. The area dS is specified on the surface of the compressed sphere at an arbitrary point, and the tension vector normal to this area and the surface of the sphere is denoted by **T**. In the rectangular coordinate system, the tension **T** can be expanded with respect to the axes (x, y, z) into three vectors $\mathbf{T}_x$, $\mathbf{T}_y$, $\mathbf{T}_z$.

To describe the anisotropic media (Fig. 2.23b), the three previously mentioned vectors $\mathbf{T}_x$, $\mathbf{T}_y$, $\mathbf{T}_z$ are no longer sufficient because the properties of each vector depend on the direction in which these properties are investigated. In the rectangular coordinate system, there are three additional

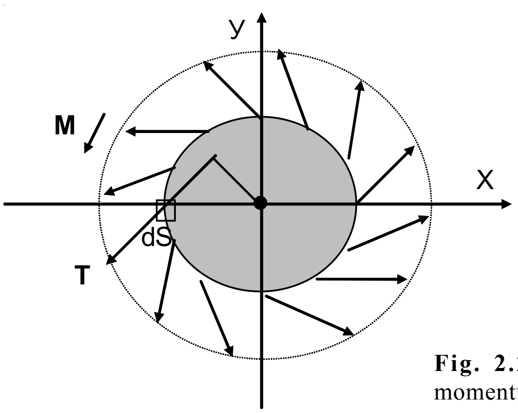


Fig. 2.24. Formation of the unbalanced momentum M.

directions denoted by the unit vectors **i**, **j**, **k**. Consequently, writing $\mathbf{T}_x$, $\mathbf{T}_y$, $\mathbf{T}_z$ on the unit vectors **i**, **j**, **k**, we obtain a system of equations for the tension tensor **T**:

$$\begin{cases} \mathbf{T}_x = \mathbf{i}T_{xx} + \mathbf{j}T_{yx} + \mathbf{k}T_{zx} \\ \mathbf{T}_\mathrm{y} = \mathbf{i}T_{xy} + \mathbf{j}T_{yy} + \mathbf{k}T_{zy} \\ \mathbf{T}_\mathrm{z} = \mathbf{i}T_{xz} + \mathbf{j}T_{yz} + \mathbf{k}T_{zz} \end{cases} \quad (2.198)$$

The components of the tensor **T** (2.198) is represented by the matrix:

$$\mathbf{T} = \begin{vmatrix} T_{xx} & T_{xy} & T_{xz} \\ T_{yx} & T_{yy} & T_{yz} \\ T_{zx} & T_{zy} & T_{zz} \end{vmatrix} \quad (2.199)$$

To transfer from the surface tension forces to volume forces acting on every local small volume dV, the density of the volume force is denoted by vector **f** and, using the Gauss theorem, we write a relationship between the surface tension forces of the vacuum field and the volume forces acting inside the defined volume:

$$\mathbf{F} = \oint_S \mathbf{T}\, dS = \int_V \mathbf{f}\, dV \quad (2.200)$$

The Gauss theorem (2.200) can be used to reduce the surface tension forces to volume forces acting inside the specified region, expressing the unbalanced resultant force **F** as a modulus with respect to the axes (x, y, z) through the corresponding components of the tension tensor **T** (2.199) [37]

$$F_x = \oint_S T_{xn} dS = \int_V \left(\frac{\partial T_{xx}}{\partial x} + \frac{\partial T_{xy}}{\partial y} + \frac{\partial T_{xz}}{\partial z} \right) dV \quad (2.201)$$

where T_{xn} is the normal component of T_x in the investigated point on the surface of the sphere.

By analogy, we determine the differential relationships between the density of the volume forces along the three axes (x, y, z) and the components of the tension tensor **T** (2.199)

$$\begin{cases} f_x = \dfrac{R_x}{V} = \dfrac{\partial T_{xx}}{\partial x} + \dfrac{\partial T_{xy}}{\partial y} + \dfrac{\partial T_{xz}}{\partial z} \\ f_y = \dfrac{R_y}{V} = \dfrac{\partial T_{yx}}{\partial x} + \dfrac{\partial T_{yy}}{\partial y} + \dfrac{\partial T_{yz}}{\partial z} \\ f_z = \dfrac{R_z}{V} = \dfrac{\partial T_{zx}}{\partial x} + \dfrac{\partial T_{zy}}{\partial y} + \dfrac{\partial T_{zz}}{\partial z} \end{cases} \tag{2.202}$$

Thus, the interpretation of the perturbations of the quantised space-time by the elements of tensor analysis shows that the quantised space-time is an elastic medium which can be regarded as an analogue of some solid whose properties greatly differ from the molecular solid of substance matter.

The equilibrium condition of the spherically symmetric system is determined by the fact that the surface tension forces in projection on any of the axes should be equal to zero

$$\begin{cases} \dfrac{\partial T_{xx}}{\partial x} + \dfrac{\partial T_{xy}}{\partial y} + \dfrac{\partial T_{xz}}{\partial z} = 0 \\ \dfrac{\partial T_{yx}}{\partial x} + \dfrac{\partial T_{yy}}{\partial y} + \dfrac{\partial T_{yz}}{\partial z} = 0 \\ \dfrac{\partial T_{zx}}{\partial x} + \dfrac{\partial T_{zy}}{\partial y} + \dfrac{\partial T_{zz}}{\partial z} = 0 \end{cases} \tag{2.203}$$

In analysis of the rotational perturbation of the quantised space-time it is important to determine the field of perturbing forces in relation to the point or axis of rotation (Fig. 2.24). Mechanics shows that momentum **M** is determined by the vector product of force **F** by vector of **r** from the centre of rotation to the point of application of force, i.e. **M** = [**Fr**]. In transition to the volume forces, the expression for moment **M** is determined by the integral:

$$\mathbf{M} = \int_v [\mathbf{f}\,\mathbf{r}]dV \tag{2.204}$$

We examine moment M_x (2.204) in relation to the x axis in the plane y–z, taking forces f_y and f_z into account (2. 202). It can be seen that the momenta of the forces in relation to the X axis are directed to different sides, and the total moment M_x is determined as the difference of the partial moments along the axes

$$M_x = \int_V \left(f_z y - f_y z\right) dV \tag{2.205}$$

Into (2.205) we substitute from (2.202)

$$M_x = \int_V \left\{ \left(\frac{\partial T_{zx}}{\partial x} + \frac{\partial T_{zy}}{\partial y} + \frac{\partial T_{zz}}{\partial z} \right) y - \left(\frac{\partial T_{yx}}{\partial x} + \frac{\partial T_{yy}}{\partial y} + \frac{\partial T_{yz}}{\partial z} \right) z \right\} dV \tag{2.206}$$

After transformations of (2.206), we finally obtain [137]

$$M_x = \oint_S \left(yT_{zn} - zT_{yn} \right) dS + \int_V \left(T_{yz} - T_{zy} \right) dV \tag{2.207}$$

Equation (2.207) determines the moment of rotation (Fig. 2.24) as a result of the effect of surface tension and volume forces determined by the disruption of the spherical symmetry of the quantised space-time. Evidently, for the spherically symmetric system of the tensions, the components of the tension tensor in (2.207) are equal to each other and the system is fully balanced in relation to any axis of rotation.

As an example, we investigate the effect of elastic tensioning of the quantised space-time on the surface of a dielectric sphere placed in a heterogeneous electrical field formed by a system of sources with different polarity (Fig. 2.25a). The electrical polarisation of the sphere results in the formation of forces which determine the resultant force **F** (2.192) as the difference of tensions $\mathbf{T}_{n1}$ and $\mathbf{T}_{n2}$ on the external and internal sides of the sphere surface, unified over the entire surface. In a general case $\mathbf{T}_{n1}$ and $\mathbf{T}_{n2}$ are expressed as $\mathbf{T}_1$ and $\mathbf{T}_2$.

In electricity theory, the tensor $\mathbf{T}_1$ of the surface tension of electrical forces is determined by man components and [37]:

$$\mathbf{T}_1 = \varepsilon_0 \varepsilon_1 \begin{vmatrix} E_{1x}^2 - \frac{1}{2}E_1^2 & E_{1x}E_{1y} & E_{1x}E_{1z} \\ E_{1y}E_{1z} & E_{1y}^2 - \frac{1}{2}E_1^2 & E_{1y}E_{1z} \\ E_{1z}E_{1x} & E_{1z}E_{1y} & E_{1x}^2 - \frac{1}{2}E_1^2 \end{vmatrix} \tag{2.208}$$

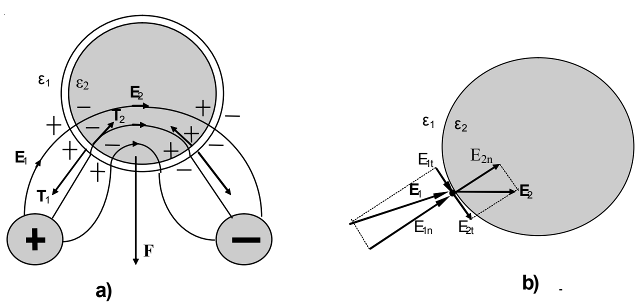


Fig. 2.25. Tensions of a heterogeneous electrical field at the interface of two media (a) and the fraction of the lines of force of the strength *E* of the electrical field (b).

The tensor is represented in the vector form on the external $\mathbf{T}_1$ and internal $\mathbf{T}_2$ sides of the interface:

$$\mathbf{T}_1 = \varepsilon_0\varepsilon_1\left(E_{1n}\mathrm{E}_1 - \tfrac{1}{2}\mathrm{n}E_1^2\right) \tag{2.209}$$

$$\mathbf{T}_2 = \varepsilon_0\varepsilon_2\left(E_{2n}\mathrm{E}_2 - \tfrac{1}{2}\mathrm{n}E_2^2\right) \tag{2.210}$$

where E_n is the normal component of the vector **n** of strength **E**; ε_1 is the relative dielectric permittivity of the medium on the external side; ε_2 is the relative dielectric permittivity of the sphere.

It is well known that the vector of the strength **E** of the electrical field at the interface of the media 'jumps' only for the normal components E_{2n} and E_{1n}, and its tangential components E_{2t} and E_{1t} do not change (Fig. 2.25b):

$$\begin{aligned} E_{2n} &= \frac{\varepsilon_1}{\varepsilon_2} E_{1n} \\ E_{2t} &= E_{1t} \end{aligned} \tag{2.211}$$

Taking into account (2.211), from 2.25b we obtain:

$$E_2^2 = \left(\frac{\varepsilon_1}{\varepsilon_2}\right)^2 E_{1n}^2 + E_{1t}^2 \tag{2.212}$$

Substituting (2.209) and (2.210) into (2.195) taking (2.212) into account, we obtain the resultant force **F**

$$\mathbf{F} = \oint_S (\mathbf{T}_1 - \mathbf{T}_2)\,dS = \oint_S \varepsilon_0\varepsilon_1 E_{1n}(\mathbf{E}_1 - \mathbf{E}_2) - \frac{\varepsilon_0}{2}\oint_S \left(1 - \frac{\varepsilon_1}{\varepsilon_2}\right)(E_{1n}E_{2n} - E_{1t}E_{2t})\,\mathbf{n}\,dS \tag{2.213}$$

Analysis of (2.213) shows that under the condition $\varepsilon_1 < \varepsilon_2$ the force **F** is directed into the region of the maximum strength of the field, as shown in Fig. 2.25. Conversely, under the condition $\varepsilon_1 > \varepsilon_2$, the force **F** is directed in the opposite direction, and the sphere is displaced from the region with the maximum strength. If $\varepsilon_1 = \varepsilon_2$, then the force $\mathbf{F} = 0$.

The same analysis was carried out for the force **F** acting on a sphere made of a magnetic material and placed in a heterogeneous magnetic field, with the identical magnetic parameters:

$$\mathbf{F} = \oint_S (\mathbf{T}_1 - \mathbf{T}_2)\,dS = \oint_S \mu_0\mu_1 H_{1n}(\mathbf{H}_1 - \mathbf{H}_2) - \frac{\mu_0}{2}\oint_S \left(1 - \frac{\mu_1}{\mu_2}\right)(H_{1n}H_{2n} - H_{1t}H_{2t})\,\mathbf{n}\,dS \tag{2.214}$$

Thus, the analysis shows that all the perturbations of the quantised space-time are described for the medium subjected to elastic perturbations.

2.5. Conclusions for chapter 2

New fundamental discoveries of the space-time quantum (quanton) and superstrong electromagnetic interaction (SEI) determine the electromagnetic structure of quantised space-time.

The quanton is a complicated weightless particle which includes four charges – quarks: two electrical (+1e and –1e) and two magnetic (+1g and – 1g) linked by the relationship $g = C_0 e$.

The quanton is the carrier of electromagnetism, space and time, and a carrier of strong electromagnetic interaction. The process of electromagnetic quantisation of space is associated with filling of its volume with quantons. The quanton diameter determines the discreteness of the quantised space-time of the order of 10^{-25} m.

When analysing the electromagnetic perturbation of the quantised space-time, the nature of electromagnetic phenomena, the laws of electromagnetic induction, Maxwell equations and Pointing vector have been described for the first time.

The electromagnetism of quantised space-time is fully symmetric and determines the transfer of electromagnetic energy in accordance with the Maxwell equations. The nature of rotors in the electromagnetic wave has been determined.

It has also been shown that as we move deeper, initially into the region of the microworld of elementary particles and the atomic nucleus (~10^{-50} m) and subsequently into the region of the ultra-microworld (~10^{-25} m) of the quantised space-time, we encounter higher and higher energy concentrations. The energy capacity of the quanton is colossal and estimated at 10^{73} J/m^3. This is sufficient to generate a universe as a result of a big bang in activation of 1 m^3 of vacuum.

It has also been found that the electromagnetic perturbation of the vacuum is described by a simple equation: $\Delta x = -\Delta y$ which can be expanded into the main equations of the electromagnetic field in vacuum. The displacement from the equilibrium deposition of the electrical Δx and magnetic Δy charges – quarks inside the quanton disrupts the electrical and magnetic equilibrium of the quantised space-time. Real bias currents were found in the electromagnetic wave.

Inside the quantised space-time we can find an electromagnetic string or a superstring of quantons which determines the colossal tension of the quantised space-time. Taking into account the fact that the quanton is a volume elastic element similar to some extent to an electronic clock specifying the rate of electromagnetic processes and time, the quantum not only combines electricity and magnetism but, being a space-time quantum, it combines the space and time into a single substance: quantised space-time.

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