DIALECTICAL VIEW OF THE WORLD

The Wave Model
(Selected Lectures)

George P. Shpenkov

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Lecture 1

Fundamental Flaws of Quantum Mechanics

1. Introduction

In this Lecture we will analyze Schrödinger's equation which was created for the description of motion at the microlevel. To that time physicists have come to the conclusion that motion at the atomic level has the wave nature. However, for unknown reason, the well-known ("classical") wave equation describing arbitrary periodic processes running in space and time has not been taken into consideration for solving the above problem. Instead of this, an obscure equation designed by Schrödinger representing by itself actually a distorted form of the wave equation was accepted as a result for this aim.

Originally our analysis of the foundations of quantum mechanics, based on Schrödinger's equation, was considered in a book [1] and further it was repeated in a series of specific publications. We will rely, in particular, on three papers [2-4] reproducing their content in a main part without essential changing in the given Lecture.

Schrödinger's approach gave rise to abstract phenomenological constructions which do not reflect the real picture of microworld. Despite the fact that this approach exhausted itself completely, it remains the basis for modern theories closely related initially with quantum mechanics. Things reached a crisis point; therefore, the comprehensive analysis of the foundations of quantum mechanics, first of all Schrödinger's equation and complex Ψ-functions entering in this equation, is the urgent point of physics. We intend to focus on such features of Schrödinger's wave equation, which were not discussed earlier and for this reason are unknown for many.

Schrödinger's equation is commonly regarded as one of the postulates of quantum mechanics (QM). However, the time is ripe for clarifying the *physical meaning* of the equation. Does it exist generally? It is necessary in order to understand the origin of numerous contradictions and faults inherent in QM based mainly on the given equation.

Schrödinger's equation appeared in the years of a wild blooming of formalism, which was represented, first of all, by positivism, machism, pragmatism, and other philosophical

trends, denying the objective world [1]. Arbitrary mathematical constructions (in the spirit of a free play on notions) were the characteristic result in physics from these philosophical currents. By virtue of this, a reasonable logic was absent or insignificant in such constructions. Schrödinger, a representative of those years, designed his equation following the spirit of aforementioned ideological trends in physics. Nevertheless, we should give Schrödinger his due, because the positivistic style did not satisfy him. He had a propensity for actual realism, and was restrained in regarded to new fashion trends. But he was under the influence of that time. Schrödinger's mathematical model is currently represented in the form of generalized and extended equations, including the relativistic invariant of them, *etc*.

In the 1920's, Schrödinger's equation began to be regarded as a major achievement of scientific thought. It became the basis for lectures on atomic physics in universities. The common opinion is that Schrödinger's equation (in view of its modifications considered in modern QM and QED) proved its validity by the conformity of its solutions with vast amounts of experimental data and the co-ordination with general physical notions.

Now, at the beginning of the 21st century, let us look at the events of those years once more and give an objective estimate of the past.

In the first decades of the 20th century, classical mechanics met with problems in the description of motion at the microlevel, creating the necessity to develop equations of motion *on the basis of wave concepts*. The first step was made by Schrödinger, who introduced the wave function $\hat{\Phi}$, which is in general complex, the complexity being denoted here by the sign ^ above the symbol. At that time, the meaning of the wave function was not clearly understood. It was represented in the form of a product $\hat{\Phi} = \hat{\psi}(x, y, z)e^{i\omega t}$ of a spatial function $\hat{\psi}(x, y, z)$ and a time factor $e^{i\omega t}$, where $\omega = W / \hbar$, with W being energy.

On the basis of optical analogies [5], Schrödinger built the wave, as he assumed, equation for the spatial function:

$$\frac{\partial^2 \hat{\psi}}{\partial x^2} + \frac{\partial^2 \hat{\psi}}{\partial y^2} + \frac{\partial^2 \hat{\psi}}{\partial z^2} + \frac{2mE}{\hbar^2}\hat{\psi} = 0 \tag{1}$$

or

$$\Delta\hat{\psi} + k^2\hat{\psi} = 0, \tag{2}$$

where

$$k = \pm\sqrt{\frac{2mE}{\hbar^2}} \tag{3}$$

is the function substituted the constant wave number k in the ordinary (true) *wave equation* having the same form as Eq. (2); E is the kinetic energy of the electron, presented as the difference between total energy W and potential energy U depending on x, y, z coordinates. Schrödinger assumed (and this assumption is generally accepted now), that the wave motion

of the electron was around a nucleus with charge *Ze*. In terms of radius $r = \sqrt{x^2 + y^2 + z^2}$, the potential energy is

$$U = -\frac{Ze^2}{4\pi\varepsilon_0 r}. \tag{4}$$

The condition (4) imposed on Schrödinger's equation a definite type of solution with the wave number *k* dependent on coordinates. But all experience in physics points to the fact that wave number remains a constant or varies only insignificantly in space, both over large volumes of cosmic space, and at the subatomic level, because $k = \frac{2\pi}{\lambda} = \frac{\omega}{c}$. A field potential does not exert influence on the definite frequency of the wave interaction ω, *which bonds the wave system in a single whole*, and on the wave speed *c* in any practical way. So Schrodinger's variable wave number should be questioned, because the potential function cannot influence the basic frequency and the wave speed or, consequently, the wave number.

Schrödinger was unable to identify too correct boundary conditions to specify the otherwise indefinite wave function. When he first began to study these questions, he noticed that a simplification to "no" boundary conditions seemed necessary [6]. But not having been sufficiently schooled in mathematics, he could not understand how fundamental oscillations could occur without boundary conditions. He later wrote that a more complicated form of coefficients (containing *U*(*x*, *y*, *z*)) must provide information that is usually given by boundary conditions. Unfortunately, he was mistaken in this, because the potential function actually destroys the wave equation.

We are interested in disclosing fundamental errors which were laid in the foundation of quantum mechanics. Therefore, for clearness and simplicity, we will not use here the operator formalism, dominated currently in quantum mechanics, as far as possible.

2. Schrödinger's fundamental errors

Indeed, the wave function $\hat{\psi}(x, y, z)$ is presented in the form of the product of radial $R_{n,l}(r)$, polar $\Theta_{l,m}(\theta)$, and azimuth $\hat{\Phi}_m(\varphi)$ factors:

$$\hat{\psi} = R_{n,l}(r)\Theta_{l,m}(\theta)\hat{\Phi}_m(\varphi) \qquad \text{or} \qquad \hat{\psi} = R_{n,l}(r)\hat{Y}_{l,m}(\theta,\varphi), \tag{5}$$

where

$$\hat{Y}_{l,m}(\theta,\varphi) = \Theta_{l,m}(\theta)\hat{\Phi}_m(\varphi) \tag{6}$$

denotes the polar-azimuth function.

For the radial factor the potential function *U*(*x*, *y*, *z*) from (4) implies the differential equation

$$\frac{d^2R_{n,l}(r)}{dr^2}+\frac{2}{r}\frac{dR_{n,l}(r)}{dr}+\left[\frac{2m}{\hbar^2}\left(W+\frac{Ze^2}{4\pi\varepsilon_0 r}\right)-\frac{l(l+1)}{r^2}\right]R_{n,l}(r)=0\,. \qquad (7)$$

The solution of (7) for $R_{n,l}(r)$ is a functional series which in general diverges; *i.e.*, $R_{n,l}(r)\to\infty$ for some *r*. Addressing this problem, Schrodinger together with H. Weyl (German mathematician, 1885-1955) found the condition under which the series terminates with a finite number of terms and finite values of $R_{n,l}(r)$ for all *r*. The condition is that the electron total energy *W* has a numerical value expressible with infinite mathematical accuracy in the form

$$W=\frac{Z^2e^2}{8\pi\varepsilon_0 a(\kappa+l+1)^2}\,, \qquad (8)$$

where *a* is the first Bohr radius and $(\kappa+l+1)=n$ is the *principal quantum number* with κ-term on which infinite functional series of $R_{n,l}(r)$ solutions was artificially limited. It follows that any tiny variation of electron energy, for example at the level $\Delta W=10^{-137}W$, results again in $R_{n,l}(r)\to\infty$. Thus, the condition (8) is a mathematical manipulation far removed from reality. Moreover, the uncertainty principle – the basis of quantum mechanics – excludes any such accuracy.

Further, the wave function (5) is complex. Misunderstanding of the nature of the imaginary part of complex numbers has generated definite difficulties. These have not been solved, but only bypassed, by formally eliminating the azimuth factor from the wave function. This move predetermined the introduction of the modulus squared of the wave function as the wave density of probability for distribution of electron mass and charge in the space surrounding the nucleus of the atom. Until now, it has been assumed that the electron charge is distributed throughout the intra-atomic space. But at the same time, it follows from the potential function (4) used in Eq. (2) that the electron charge is concentrated in a point. This is a logical conflict.

Note too that the modulus squared $|\hat{\psi}|^2=\hat{\psi}\hat{\psi}^*$ is not itself a solution to the wave equation. Such a "small item" did not attract attention at that time. Instead, $|\hat{\psi}|^2$ was interpreted as fundamental. This allowed the "phase" aspect of the wave function to be ignored, and it allowed $|\hat{\psi}|^2$ to be interpreted as a probability density, the integral $\int|\psi|^2 dxdydz=1$ determining the unit probability that the electron is located in the intra-atomic space. As a result, only the appearance of a solution to the boundary conditions problem, but not the solution itself, was generated.

Understanding the conditionality of such an interpretation, Schrödinger, noted in 1952 [6] that "*We must agree that our concept of material reality is more fuzzy and indefinite than*

it was many years ago. We know plenty of the interesting things and every day we learn new details. However, we are unable to construct a clear picture, easily imagined, with which all physicists could agree. Physics is experiencing a deep ideological crisis". Only the basic sense of his expressions has been appreciated until now. The subsequent development of quantum mechanics eloquently points to the fact that the interpretation of the wave function was a problem for physicists, and it still remains so, although many researchers understand its conditional character.

It is assumed that the modulus squared of the wave function determines an "electron density", closely related to the electron potential function (4). However, a formal introduction of the potential function in Schrödinger's equation does not quite mean that the polar-azimuth distribution (6) (Table 1) (graphs of them are shown in Fig. 4 of L. 3, Vol. 5) has a relation to electrons.

Table 1. Reduced polar-azimuth functions $\tilde{Y}_{l,m}(\theta,\varphi)$

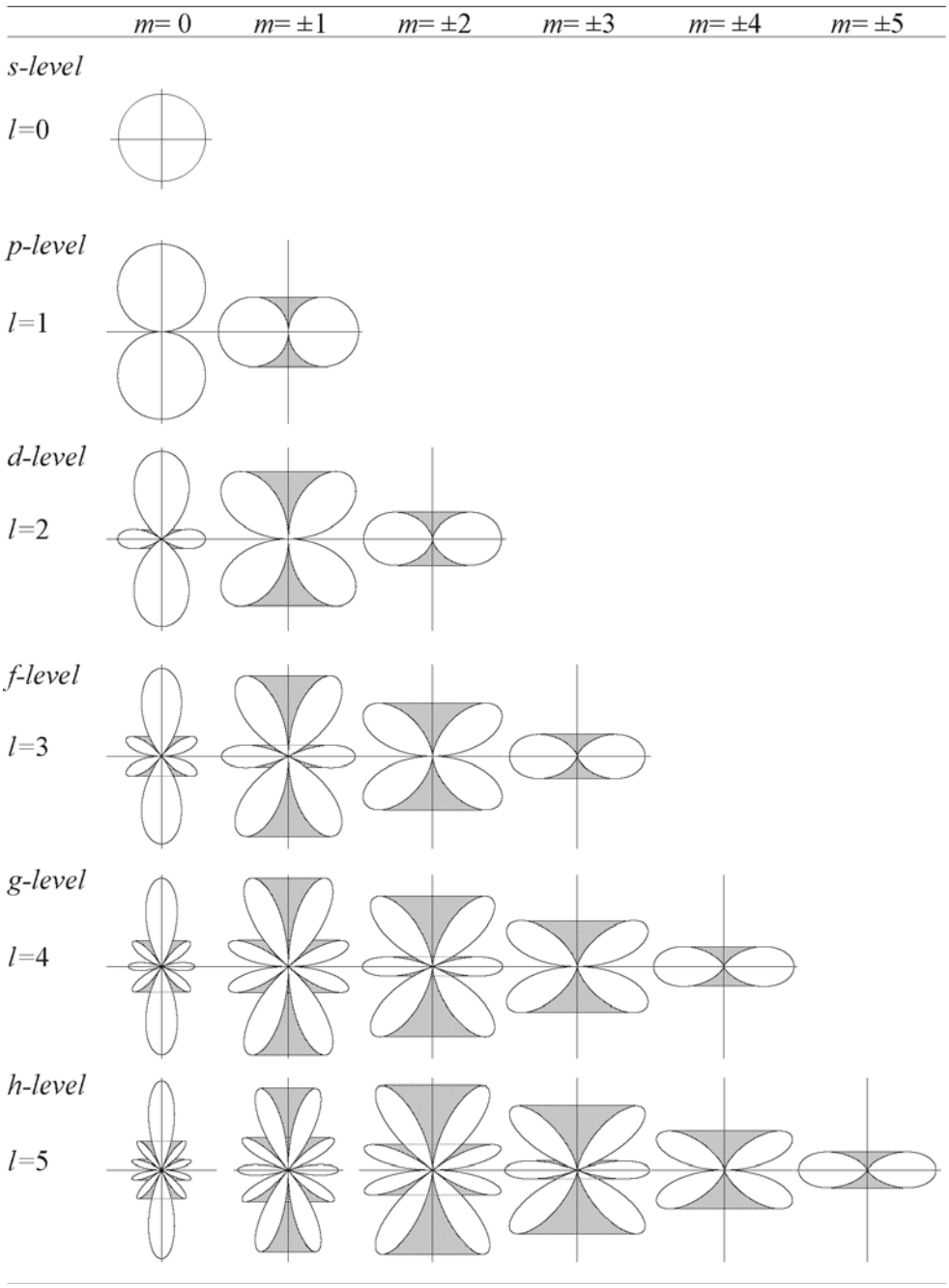
l	m	$\tilde{Y}_{l,m}(\theta,\varphi)=\tilde{\Theta}_{l,m}(\theta)\hat{\Phi}_m(\varphi)$	l	m	$\tilde{Y}_{l,m}(\theta,\varphi)=\tilde{\Theta}_{l,m}(\theta)\hat{\Phi}_m(\varphi)$
0	0	1			
1	0	$\cos\theta$	5	0	$\cos\theta\,(\cos^4\theta - 10/9\cos^2\theta + 5/21)$
	±1	$\sin\theta\exp(\pm i\varphi)$		±1	$\sin\theta\,(\cos^4\theta - 2/3\cos^2\theta + 1/21)\exp(\pm i\varphi)$
2	0	$\cos^2\theta - 1/3$		±2	$\sin^2\theta\cos\theta\,(\cos^2\theta - 1/3)\exp(\pm 2i\varphi)$
	±1	$\sin\theta\cos\theta\exp(\pm i\varphi)$		±3	$\sin^3\theta\,(\cos^2\theta - 1/9)\exp(\pm 3i\varphi)$
	±2	$\sin^2\theta\exp(\pm 2i\varphi)$		±4	$\sin^4\theta\cos\theta\exp(\pm 4i\varphi)$
3	0	$\cos\theta\,(\cos^2\theta - 3/5)$		±5	$\sin^5\theta\exp(\pm 5i\varphi)$
	±1	$\sin\theta\,(\cos^2\theta - 1/5)\exp(\pm i\varphi)$			
	±2	$\sin^2\theta\cos\theta\exp(\pm 2i\varphi)$	6	0	$\cos^6\theta - 15/11\cos^4\theta + 5/11\cos^2\theta - 5/231$
	±3	$\sin^3\theta\exp(\pm 3i\varphi)$		±1	$\sin\theta\cos\theta\,(\cos^4\theta - 10/11\cos^2\theta + 5/33)\exp(\pm i\varphi)$
4	0	$\cos^4\theta - 6/7\cos^2\theta + 3/35$		±2	$\sin^2\theta\,(\cos^4\theta - 6/11\cos^2\theta + 1/33)\exp(\pm 2i\varphi)$
	±1	$\sin\theta\cos\theta\,(\cos^2\theta - 3/7)\exp(\pm i\varphi)$		±3	$\sin^3\theta\cos\theta\,(\cos^2\theta - 3/11)\exp(\pm 3i\varphi)$
	±2	$\sin^2\theta\,(\cos^2\theta - 1/7)\exp(\pm 2i\varphi)$		±4	$\sin^4\theta\,(\cos^2\theta - 1/11)\exp(\pm 4i\varphi)$
	±3	$\sin^3\theta\cos\theta\exp(\pm 3i\varphi)$		±5	$\sin^5\theta\cos\theta\exp(\pm 5i\varphi)$
	±4	$\sin^4\theta\exp(\pm 4i\varphi)$		±6	$\sin^6\theta\exp(\pm 6i\varphi)$

As a pure mathematical function, (6) is not related to the electron potential function (4) (or to any other one either), and $\hat{Y}_{l,m}(\theta,\varphi)$ is independent of boundary conditions. It was shown in L. 3 of Vol. 5, polar-azimuthal functions define the angular disposition of nodes and antinodes of standing spherical waves in space in the corresponding wave spherical shells. Thus, they have nothing in common with electron orbitals ascribed to them unfoundedly in quantum mechanics.

In the first publications, the functions $\hat{Y}_{l,m}(\theta,\varphi)=\Theta_{l,m}(\theta)\hat{\Phi}_m(\varphi)$ were presented as graphs mainly as cross-sections of their modulus squared in the planes passing through *Z*-, *Y*-, and *X*-axes (see, for example, Fig. 2.2.17 in [7]). Actually, their modules graphs are the

surfaces of rotation of these functions about the polar *Z*-axis, as it is presented here in Table 2. As a result, attention was focused on the distribution of so-called "electron density" (electron "orbitals") around different axes lying in the planes of these cross-sections, all of which, without exception, were presented in a cigar-shaped form. However, the later is correct only at *m*=0. In the other cases ($m \neq 0$), such representation leads to gross errors.

Table 2. Sections of surfaces of rotation - diagrams of the modulus $\left|\hat{Y}_{l,m}(\theta,\varphi)\right|$.



Sometimes, the modulus squared of real components of the complex function is implicitly used. However, by tradition, the corresponding graphs in the equatorial plane are presented in the cigar-shaped form, not always rightly.

Polar-azimuth graphs represent the surfaces of rotation around only the polar *Z*-axis; hence, they cannot be treated as volumetric objects in the "electron density" form. An imaginary rotation of the cross-sections of polar diagrams around their axes of symmetry (lying in planes of these cross-sections) states a few polar axes of an atom that is nonsense: a physical system, as whole, can have only a general polar axis of rotation.

Let us consider this question in detail. Polar-azimuth functions are presented in Table 2 (for simplicity, coefficients of functions to the higher powers have been taken to be equal to unity).

Since distribution of the modules of the wave function is qualitatively the same as the distribution of its modules squared, we will consider only the distribution of modules. On the basis of the data in Table 1, the corresponding graphs of polar-azimuth modules $\left|\hat{Y}_{l,m}(\theta,\varphi)\right|$ are drawn in Table 2 (drawings of $\left|\hat{Y}_{l,m}(\theta,\varphi)\right|^2$ can be found, for example, in [8]).

Graphs $\left|\hat{Y}_{l,m}(\theta,\varphi)\right|$ for $m = 0$ have the cigar-shaped form (with additional tori of collateral maxima, beginning from $l = 2$), and in the other cases, when l and $m = 1, 2,...$, they represent toroidal surfaces of rotation of the cigar-shaped cross-sections. Thus, the modulus of a polar-azimuth function is characterized by main and collateral extremes. They indicate polar coordinates (angles θ) of extremal values of $\psi(x, y, z)$ *on the corresponding spheres* of radial factors of the function.

The simplest graph of $|\psi(x, y, z)|$ occurs at $l = 0$ and $m = 0$ (Fig. 1). Extremes of the $|\psi|$-function are on a sphere, which we present conditionally by the spherical layer-vicinity enveloping the spherical extremum.

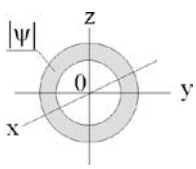


Fig. 1. Distribution of domains of the maximum of the wave function modulus at $l = 0$ and $m = 0$ in the spherical space-field; O is the origin of coordinates; $|\psi|$ is the spherical layer-vicinity of the maximum.

It follows from the *p*-distribution of $|\psi|$-function, that for $l = 1$ and $m = 0$ two polar maxima $\Omega_{l,1}, \Omega_{l,2}$ are found at the spherical (radial) shell; they are presented in Fig. 2 by *spherical shells of a small radius*.

Such an image of the distribution cannot be interpreted as the distribution of *electron density* since, as was mentioned above, the polar-azimuth function (6) is independent of any physical contents (parameter).

At l = 2, m = 0, the d-distribution of the $|\psi|$-function (Fig. 3) has at the radial shell two other polar maxima $\Omega_{l,1}, \Omega_{l,2}$ and a ring of the collateral maximum at the equator. This distribution cannot be referred to electron density either.

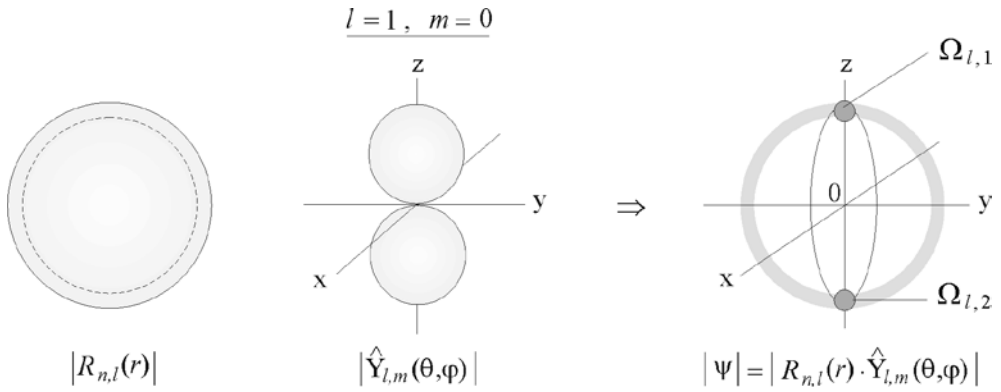


Fig. 2. Distribution of domains of maxima of the wave function modulus $|\psi|$ at l = 1 and m = 0 in the spherical space-field of an atom. $|R_{n,l}(r)|$ is the spherical layer-vicinity of the maximum of the radial factor (an internal surface of the radial spherical layer is presented by a dash circumference); $|\hat{Y}_{l,m}(\theta,\varphi)|$ is the surface of the modulus of the polar-azimuth factor; $\Omega_{l,1}, \Omega_{l,2}$ are locations of polar maxima of $|\psi|$.

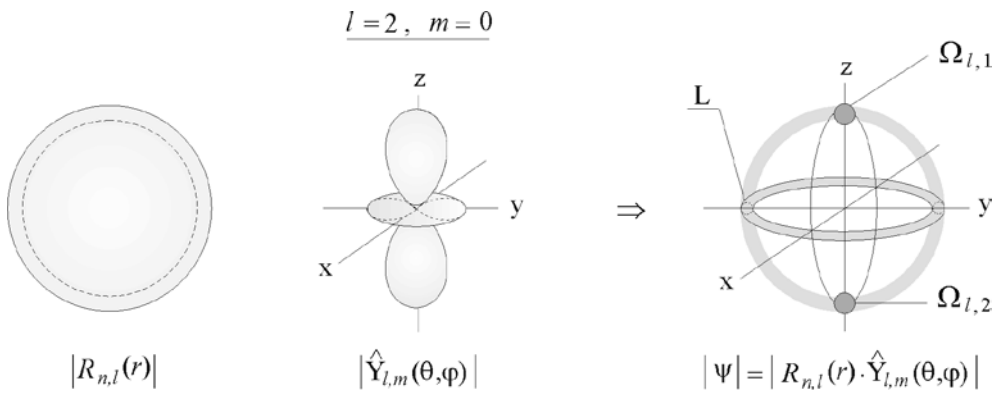


Fig. 3. Distribution of domains of maxima of the wave function modulus $|\psi|$ at l = 2 and m = 0 in the spherical space-field of an atom; $\Omega_{l,1}, \Omega_{l,2}$ are locations of the polar maxima of $|\psi|$; L is the annular equatorial location of the collateral maximum of the wave function modulus.

At l = 3 and m = 0 (Fig. 4), we have the next pair of polar maxima $\Omega_{l,1},\Omega_{l,2}$ and two rings of collateral maxima of middle latitudes. Correspondingly, at l = 4 and m = 0, we arrive also at two polar maxima $\Omega_{l,1},\Omega_{l,2}$, but at three rings of collateral maxima. One ring is at the equator and two other, defined by the angles $\theta_1 = 49^0 6' 23''.78$ and $\theta_2 = 130^0 53' 36''.22$, are in the middle latitudes.

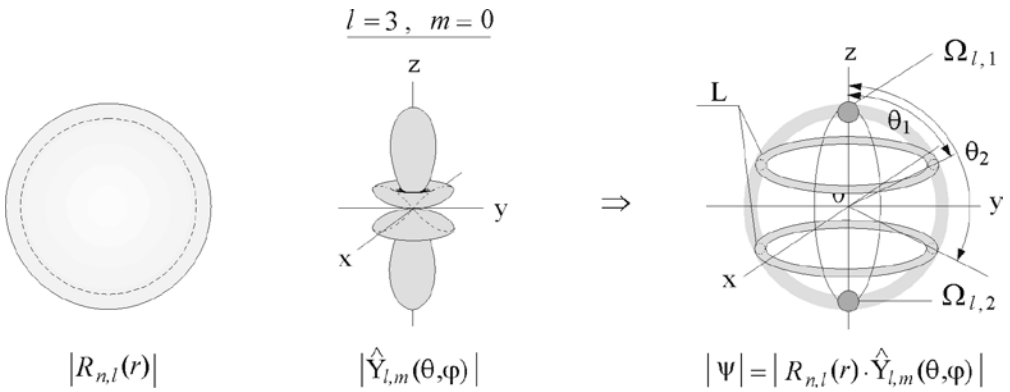


Fig. 4. Distribution of domains of maxima of the wave function modulus $|\psi|$ at l = 3 and m = 0 in the spherical space-field of an atom; $\Omega_{l,1},\Omega_{l,2}$ are locations of the polar maxima of $|\psi|$; L is the annular locus (of middle latitudes) of collateral maxima of the wave function modulus; $\theta_1 = 63^0 26' 5''.82$, $\theta_2 = 116^0 33' 54''.18$.

Finally, at l = 5 and m = 0, we have one more pair of polar maxima $\Omega_{l,1},\Omega_{l,2}$ and four rings of collateral maxima. The first pair of rings, nearest to the poles, is defined by the angles $\theta_1 = 40^0 5' 17''.11$ and $\theta_4 = 139^0 54' 42''.89$. The second pair is defined by the angles $\theta_2 = 73^0 25' 38''.32$ and $\theta_3 = 106^0 34' 21''.68$. And so forth.

At l = 2, m = ±1, the d-distribution of the $|\psi|$-function (Fig. 5) is characterized by two rings of main maxima (at the spherical shell, in the domain of middle latitudes). At l = 2, m = ±2, the d-distribution of the $|\psi|$-function (Fig. 6) is represented by one ring of the main maximum.

It is also possible to analyze other distributions. But in all cases at $m \neq 0$ (in accord with the strict interpretation of quantum mechanical solutions of Eq. (2) in terms of $|\psi|$ or $|\psi|^2$ that leads to the same result), we have *rings* of main and collateral maxima *at the radial spherical surfaces*. However, we do not have cigar-shaped volumes (cut out from the figures of rotation along the z-axis) that are commonly used in quantum mechanics.

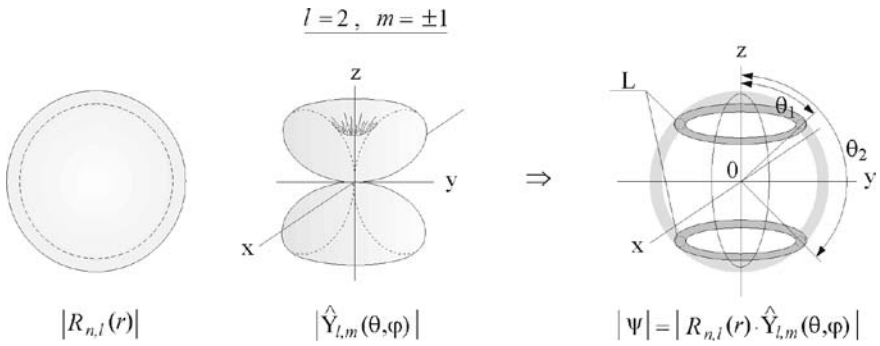


Fig. 5. Distribution of domains of maxima of the wave function modulus $|\psi|$ at l = 2 and m = ±1 in the spherical space-field of an atom; L is the annular locus (of middle latitudes) of main maxima of $|\psi|$; $\theta_1 = 45^0$ and $\theta_2 = 135^0$.

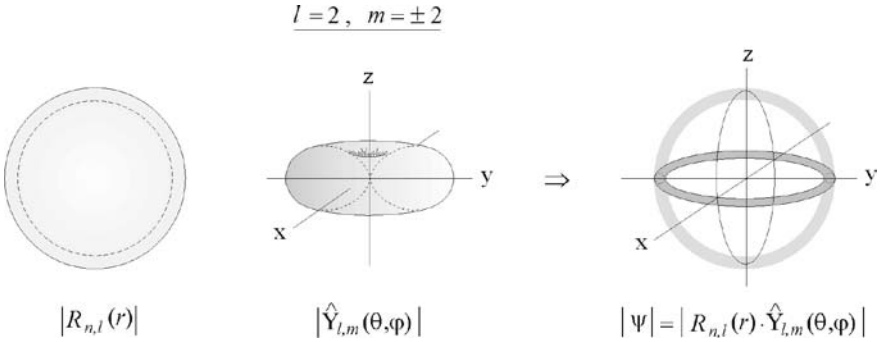


Fig. 6. Distribution of domains of the maximum of the wave function modulus $|\psi|$ at l = 2 and m = ±2 in the spherical space-field of an atom; L is the equatorial ring of the main maximum of $|\psi|$.

We considered the distribution of the modulus of the wave function, selecting only extremes in a spherical space-field, where most probably the matter (particles constituent of an atom, *etc*.) must be localized. Because nobody knows what kind of particles are there, we will call them *X*-particles.

The image of distribution of *X*-particles in a spherical wave space-field was given above in strict correspondence with solutions of Schrödinger's equation (2) and David Bohm's interpretation of the modulus squared of the wave function [9].

In full agreement with the ideology accepted by quantum mechanics, the modulus squared $|\hat{\psi}|^2$ (or the modulus $|\hat{\psi}|$ that leads to the same result) of the wave function has been taken into consideration. Hence, the above-presented analysis is, generally speaking, the analysis of semisolutions of the basic equation of quantum mechanics (2), since quantum mechanics does not give solutions for $\hat{\psi}$. The important conclusions that must be emphasized are as follows.

1) Because the *s*-state (Fig. 1) is characterized by spherical symmetry, quantum mechanics attributes a similar symmetry to the hydrogen atom.

First, what relation all the above solutions have, in general, to the hydrogen atom? From where does it follow?

Second, even if we will agree with such a supposition as to the relation of the *s*-state to *H*-atom, nevertheless, the spherical symmetry of the hydrogen atom is a myth. *The hydrogen atom, as a paired proton and electron, does not possess the spherical symmetry* that defines corresponding angular and magnetic moments. Moreover, the proton in turn has the discrete structure with the polar axis of symmetry [10] that manifests itself in the fine and superfine structure of nucleon spectra, *etc*.

2) Every radial shell of atoms with the wave number $m = 0$ is represented by two polar maxima and rings of collateral maxima, which means that these shells are *characterized by the axis of the infinite-fold symmetry*. The main and collateral maxima-rings at $m \neq 0$ give the same infinite-fold symmetry. But, such symmetry cannot form the discrete atomic spaces. Hence, solutions obtained do not reflect the discrete feature of matter.

Thus, *quantum mechanics solutions*, in their modern form, *contradict reality* because, on the basis of these solutions, the existence of crystal substances-spaces is not possible.

3) It is a principle as well that the wave function itself is always characterized by three arguments: ρ, θ, and φ (in the spherical polar frame of reference), independently of its use in concrete cases to describe different wave processes. Therefore, it is impossible to agree with such a mathematical operation by which the *azimuth angle* φ *is "cut off"* from the wave function, because the definite information, which implies the wave equation and the function itself, is rejected as a result.

4) Introduction of the potential function (4) in the wave equation, which results in dependence of the wave number *k* on the Coulomb potential, *generates divergences* that do not have a physical justification. They are eliminated in an artificial way.

5) In a theory of wave processes and oscillations, mutually conjugated parameters *U* and *V* (as for example, electric and magnetic vectors *E* and *H*) represent, usually, in the form of complex function $\hat{\Psi} = U + iV$. And a question about a meaning of $\hat{\Psi}$ does not arise because functions *U* and *V* have, in accord with their definitions, a definite physical meaning. Quantum mechanics does not separately consider the second ("imaginary") member in the complex wave function because the nature of "imaginary" numbers is unknown for it.

6) In modern computer programming languages, there exists a command "FORWARD" by which it is possible to offer a procedure without a concrete physical filling of it, anticipating events. In this sense, Schrödinger's equation (2) is a logical formation similar to the directive "FORWARD", which accepts the real-science filling only after definition of the wave function on the basis of initial notions, independent of the wave equation.

Unfortunately, as we see, the initial concepts have been incorrectly introduced by quantum mechanics, which resulted in the questionable atomic model commonly used now.

3. Schrödinger's radial "solutions"

Turn again to Schrödinger's equation. In the initial variant, the equation had the following form:

$$\Delta\Psi + \frac{2m}{\hbar^2}\left(W + \frac{e^2}{4\pi\varepsilon_0 r}\right)\Psi = 0. \qquad (9)$$

Its structure had a quite artificial character, and rested upon the operator and variational methods. The wave Ψ–function satisfying the wave equation (9) is represented as the product of the spatial and time factors:

$$\Psi = R(r)\Theta(\theta)\Phi(\varphi)T(t) = \psi(r,\theta,\varphi)T(t), \qquad (10)$$

The spatial factor $\psi(r,\theta,\varphi) = R(r)\Theta(\theta)\Phi(\varphi)$ is the *complex* amplitude of the wave function, because

$$\Phi_m(\varphi) = C_m e^{\pm im\varphi}. \qquad (11)$$

The multiplicative form of the amplitude ψ–function allows dividing of Schrödinger's equation (9) into the equations of the radial $R(r)$, polar $\Theta_{lm}(\theta)$, and azimuth $\Phi_m(\varphi)$ functions:

$$\frac{d^2R}{dr^2} + \frac{2}{r}\frac{dR}{dr} + \left(\frac{2m}{\hbar^2}\left(W + \frac{Ze^2}{4\pi\varepsilon_0 r}\right) - \frac{l(l+1)}{r^2}\right)R = 0, \qquad (12)$$

$$\frac{d^2\Theta_{l,m}}{d\theta^2} + ctg\theta\frac{d\Theta_{l,m}}{d\theta} + \left(l(l+1) - \frac{m^2}{\sin^2\theta}\right)\Theta_{l,m} = 0, \qquad \frac{d^2\Phi_m}{d\varphi^2} - m^2\Phi_m. \qquad (13)$$

An equation for the time component of Ψ is $\frac{d^2T}{dt^2} = -\omega^2 T$; its simplest solution is $T = e^{\pm i\omega t}$.

The equations for $\Theta(\theta), \Phi(\varphi)$, and $T(t)$ were known in the theory of wave fields. Hence, these equations presented nothing new. Only the radial equation (12) was new. Its solution turned out to be divergent. However, Schrödinger together with H. Weyl (1885-1955, German mathematician), contrary to the logic and all experience of theoretical physics, artificially cut off the divergent power series of the radial function $R(r)$ at a κ-th term. This allowed them to obtain the radial solutions, which, as a result of the cut off operation, actually were the fictitious solutions. For hydrogen-like atoms, the radial function has the following form

$$R_{\kappa l} = N_{\kappa l} e^{-\rho/(\kappa+l+1)} \left(\frac{2\rho}{\kappa+l+1} \right)^{l} L_{\kappa}^{2l+1} \left(\frac{2\rho}{\kappa+l+1} \right), \tag{14}$$

where $\rho = r/a$, $a = a_0/Z$, a_0 is the Bohr radius; $L_{\kappa}^{2l+1}\left(\frac{2\rho}{\kappa+1+l} \right)$ is Laguerre polynomial of the power κ, that power being simultaneously the parameter of cutting off the divergent series; and

$$N_{\kappa l} = \frac{2}{(\kappa+1+l)^2} \sqrt{\frac{\kappa!}{(\kappa+1+2l)!}} \cdot \left(\frac{1}{a} \right)^{3/2} \tag{15}$$

is a normalizing multiplier.

Since the radial equation (12) contained the energy of interaction of the electron with the nucleus, $-Ze^2/4\pi\varepsilon_0 r$, it was natural to expect that Eq. (12) would "give out" this energy as a result of the solution under the definite conditions. Indeed, the formal cutting off leads to the discrete series of values of the total electron energy

$$W = -\frac{Ze^2}{8\pi\varepsilon_0 a_0 (\kappa+l+1)^2} = -\frac{Ze^2}{8\pi\varepsilon_0 a_0 n^2}, \tag{16}$$

where the sum $n = \kappa + l + 1$ (equal to 1, 2, 3, …) was called the *main quantum number*.

The formula (16) creates the illusion of a solution to the problem. Actually, in a strictly scientific sense, we deal here with the plain mathematical adjustment to Bohr postulates. The radial solution (14) for the hydrogen-like atom, after replacing $\kappa + l + 1$ with *n*, takes the form

$$R_{nl} = N_{nl} e^{-\rho/n} \left(\frac{2\rho}{n} \right)^{l} L_{n-l-1}^{2l+1} \left(\frac{2\rho}{n} \right), \tag{17}$$

where

$$N_{nl} = \frac{2}{n^2} \sqrt{\frac{(n-l-1)!}{(n+l)!}} \cdot \left(\frac{1}{a} \right)^{3/2} \tag{18}$$

and

$$L_{n-l-1}^{2l+1} \left(\frac{2\rho}{n} \right) = \frac{1}{(n-l-1)!} e^{2\rho/n} \left(\frac{2\rho}{n} \right)^{-(2l+1)} \frac{d^{n-l-1}}{d(2\rho/n)^{n-l-1}} \left\{ e^{-2\rho/n} \left(\frac{2\rho}{n} \right)^{l+n} \right\}. \tag{19}$$

With use of the accepted designations, Schrödinger's Ψ-function (10) is presented as

$$\Psi = R_{nl}(r)\Theta_{lm}(\theta)\Phi_m(\varphi)T(t) = \psi_{nl}(r,\theta,\varphi)T(t), \tag{20}$$

where

$$\psi_{nl}(r,\theta,\varphi) = R_{nl}(r)\Theta_{lm}(\theta)\Phi_m(\varphi). \tag{21}$$

Let us begin an analysis of Schrödinger's equation from the aforementioned radial solution.

Schrödinger's radial equation (12) contains only the wave number *l*. The number κ has an auxiliary character. Accordingly, the radial function should be presented in the form $R_l(\rho,\kappa)$. Taking into consideration these remarks, Schrödinger's elementary Ψ-function (20) can be rewritten as

$$\Psi_{lm,\kappa} = \psi_{lm,\kappa}(\rho,\theta,\varphi;\kappa)T(t) = R_l(\rho;\kappa)\Theta_{lm}(\theta)\Phi_m(\varphi)T(t), \tag{22}$$

where

$$\psi_{lm,\kappa}(\rho,\theta,\varphi;\kappa) = R_l(\rho;\kappa)\Theta_{lm}(\theta)\Phi_m(\varphi) \tag{23}$$

is the spatial $\psi_{lm,\kappa}$-function.

According to the QM conception, the extremes of the radial functions R_{nl} define the radii of shells of the most probable states: $r = a\rho_{nl,\max i}$, where *i* is the number of the root of the extremum. However, for the overwhelming number of cases, ***these roots are not equal to the integers squared***, *i.e.*, $\rho_{nl,\max i} \neq n^2$ (where *n*=1, 2, 3, …), and hence, ***they deny the cutting off condition*** (16). Such roots define the energetic levels that do not exist in Nature:

$$W = -\frac{e^2}{8\pi\varepsilon_0 a\rho_{nl,\max i}}. \tag{24}$$

For example, the radial function $R_{3,0}$, corresponding to the numbers $\kappa = 2$ and $l = 0$ ($n = 3$) is

$$R_{3,0} = \frac{2}{81\sqrt{3}} e^{-\rho/3}(27 - 18\rho + 2\rho^2). \tag{25}$$

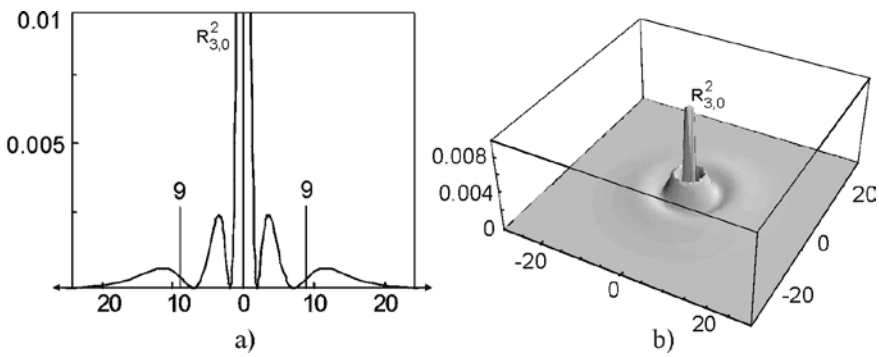


Fig. 7. The density of hypothetical probability of *s*-state, $R^2_{3,0}$, for Schrödinger's Ψ-function with the parameters, $n = 3$ and $l = 0$; (a) one-dimensional, (b) two-dimensional.

One-dimensional and two-dimensional graphs of the radial component of density of probability $R_{3,0}^2$, as a function of the distance along the radius ρ, are presented in Fig. 7.

The radial function squared, $R_{3,0}^2$, has the maximum in the origin of coordinates. There are also two smaller maxima, defining the two shells of the most probable localization of the electron (if we will strictly follow the QM interpretation of Ψ-function). Extremes of the radial function are as follows:

$$\rho_{3,0,\max 1} = 0, \qquad \rho_{3,0,\max 2} = 3.531370333, \qquad \rho_{3,0,\max 3} = 11.46862697. \qquad (26)$$

At the same time, according to the cut-off condition, only the radius $\rho = 3^2 = 9$ defines the stationary shell of the electron corresponding to this function. Two vertical lines in Fig. 7a, at the distance equal to 9 from the coordinate origin, indicate its location. As we see, there is no maximum (shell) of such radius among extremes of $R_{3,0}^2$! It is no wonder that the radial function $R_{3,0}$ is "ignorant". It does not "know" that it represents by itself the reduced function (obtained as a result of the cut off operation) and, therefore, it cannot defines anything here, including "the most probable localization of the electron".

Thus, according to the condition (16), energetic "levels" (states) (24) must not exist. If we suppose that they exist, then these *levels must formally transform the radial function into a divergent functional series* because Eq. (24), where $\rho \neq n^2$ (n = 1, 2, 3,…), does not satisfy the cut-off condition (16) where $\rho = n^2$. Such an absurdity appeared because of the artificial and invalid cutting off of the power series.

The quantum numbers of Schrödinger's equation are usually compared with the quantum numbers in Bohr-Sommerfeld's generalized theory of the hydrogen atom. Between 1913 and 1926, the Bohr-Sommerfeld's theory took roots in minds; as a result, the superficial resemblance of its quantum numbers to those of Schrödinger's equation was groundlessly used by founders of QM.

As an analog of the azimuth number m, the magnetic number m of Bohr-Sommerfeld's theory was accepted. The number l plays the role of the azimuth number n_φ, which defines (along with the main quantum number n) the smaller half-axis of the elliptical electron orbit $b = a_0 n n_\varphi$. The larger half-axis of the orbit a, defining the electron's total energy on the orbit, in Bohr-Sommerfeld's theory, depends only on the main quantum number n: $a = a_0 n^2$. Such a formal juxtaposition must mean that the wave function in Schrödinger's equation (9) contains elliptical orbits in the form of "electron clouds". All these definitions are the fruit of fantasy. In fact, Schrödinger's equation describes only the *circular* orbits, but not mystic clouds-orbitals. If we assume that the electron's motion can be the elliptic one, then such orbits must pierce the shells of the stationary states. Accordingly, when an electron recedes from H-atom, moving along a stationary elliptic orbit, it must absorb energy, at the transition from one shell

to another, and, at the approaching to *H*-atom, it must emit energy of the same value. The energetic transitions within the orbit will be determined by irrational numbers that are not observed in reality. Apart from this, such strange orbits cannot be regarded as stationary.

4. The wave number *k*

We can assume that, at the initial stage of his work, of course, Schrödinger could not do without the ordinary wave equation, describing arbitrary periodic processes running in space and time:

$$\Delta\Psi - \frac{1}{\upsilon_0^2}\frac{\partial^2\Psi}{\partial t^2} = 0\,. \tag{27}$$

Presenting the Ψ-function in the form $\Psi = \psi(x, y, z)e^{i\omega t}$, where $\psi(x, y, z)$ is its amplitude (a complex magnitude, in a general case), we obtain

$$\Delta\Psi = \frac{1}{\upsilon_0^2}\frac{\partial^2\Psi}{\partial t^2} = -\frac{\omega^2}{\upsilon_0^2}\Psi = -k^2\Psi\,.$$

Hence, the wave equation (27) can also be presented as

$$\Delta\Psi + k^2\Psi = 0\,, \tag{28}$$

where $k = \frac{\omega}{\upsilon_0} = \frac{2\pi}{\lambda} = \frac{1}{\lambda\!\!\!^{-}}$ is the wave number of the field. Comparing Eqs. (28) and (9), we find what the wave number *k* in Schrödinger's equation is:

$$k = \sqrt{\frac{2m}{\hbar^2}\left(W + \frac{e^2}{4\pi\varepsilon_0 r}\right)}\,. \tag{29}$$

This means that the ***wave number*** in Schrödinger's radial equation is a ***quantity that varies continuously in the radial direction***. Is it possible to image a field where the wave number, and hence the frequency, changes from one point to another in the space of the field? Of course, it is not possible. ***Such wave objects do not exist in Nature***!

The wave number *k* is a constant parameter of wave objects. It can take a definite series of discrete values depending only on the boundary conditions. According to the cut-off condition (16), the wave number (29) is defined by the following formula:

$$k = e\sqrt{\frac{Zm}{2\pi\varepsilon_0\hbar^2}\left(\frac{1}{r} - \frac{1}{2an^2}\right)}\,. \tag{30}$$

From this it follows that the wave number k is a real number only under the condition $r < 2an^2$. Therefore, one should mention the limiting sphere of wave processes in the atom. The radius of the sphere is equal to the doubled radius of n-th Bohr orbit (orbital):

$$r_{\max} = 2r_n = 2an^2 . \tag{31}$$

In a case where the wave number k also takes imaginary values, the field will not be a wave field, and hydrogen-like atoms will be surrounded, beyond their spheres of the radius $r_{\max}$, with the field of the *aperiodic* structure. However, this completely contradicts reality. Thus, a limiting sphere bounds around the Schrödinger atom. Beyond the sphere, it is impossible to speak about the structure and wave properties of the atom.

Accordingly, the ***normalizing factors of radial functions have a conditional character***, because they are determined by the integrals with an upper limit of integration, equal to *infinity* but not to the limiting radius (31). These remarks are valid also for formulae of averaged values, as, *e.g.*, an average value of inverse distances, defined by the integral

$$\left\langle \frac{1}{r} \right\rangle = \int_0^\infty R_{nl}^2 r dr = \left(\frac{Z}{a_0} \right) \frac{1}{n^2} . \tag{32}$$

This is also another reason why this expression is incorrect. As a matter of fact, the radial functions R_{nl} define the shells of the most probable values of radii in accordance with the quantum mechanical interpretation of the wave function. These radii form a ***discrete series***, which ***cannot be averaged***, as it is impossible to average an inverse series of distances. Indeed, suppose we need to know the mean wavelength of a hydrogen atom spectrum, for example, the Balmer series. Of course, we can calculate it, but it is a meaningless operation, because such an averaged wave does not exist in Nature.

In spite of all fittings, the mean radius of an electron orbit,

$$\langle r \rangle = \int_0^\infty R_{n,l}^2 r^3 dr = a \frac{3n^2 - l(l+1)}{2} , \tag{33}$$

is not proportional to n^2. Moreover, the radial spheres define the orbits of the most probable states; therefore, the radii of stationary electron orbits are constant within the corresponding spheres. Thus, the averaging (33) has no meaning.

Let us turn now to Schrödinger's initial report, where Schrödinger's equation (9) was first derived on the basis of the operator and variational methods. We will consider this in an elementary form. Any material object is characterized by the kinetic and potential energies which define its total energy

$$E = \frac{p^2}{2m} + U\,. \tag{34}$$

We introduce the scalar dimensionless Ψ-function, complex in general; its field gradient is the momentum of the microparticle, defined by the equation

$$\mathbf{p} = i\hbar\left(\frac{\partial\Psi}{\partial x}\mathbf{e}_x + \frac{\partial\Psi}{\partial y}\mathbf{e}_y + \frac{\partial\Psi}{\partial z}\mathbf{e}_z\right) = i\hbar\nabla\Psi\,, \tag{35}$$

where $\hbar$ is some elementary action, needed for realization of the law of equality of dimensionalities of the left and right parts in Eq. (35); i is the imaginary unit. Inasmuch as, in a general case, the Ψ-function is complex, components of the momentum are also, in general, complex. However, their real parts (by definition) represent the ordinary projections of the momentum along the coordinate axes. Thus, the real part of the complex momentum defines the momentum of the microparticle:

$$\mathbf{p} = \mathbf{Re}(i\hbar\nabla\Psi). \tag{36}$$

Relying on the expression (35), we can represent the energy (34) in the following way

$$E = -\frac{\hbar^2}{2m}\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right)\Psi + U\,,$$

or

$$E = -\frac{\hbar^2}{2m}\Delta\Psi + U\,. \tag{37}$$

Let us now introduce operators of the total and potential energies, $\hat{H}$ and $\hat{U}$, according to the following expressions:

$$E = \hat{H}\Psi\,, \qquad U = \hat{U}\Psi\,. \tag{38}$$

Substituting E and U, in Eq. (37), with these operator expressions, we will have

$$\hat{H}\Psi = -\frac{\hbar^2}{2m}\Delta\Psi + \hat{U}\Psi\,. \tag{39}$$

or

$$\Delta\Psi + \frac{2m}{\hbar^2}(\hat{H} - \hat{U})\Psi = 0\,. \tag{40}$$

In a case of a hydrogen-like atom, we seek the field of such a Ψ-function for which the following equalities must exist:

$$\hat{H} = W\,, \qquad \hat{U} = -Ze^2/4\pi\varepsilon_0 r\,. \tag{41}$$

As a result, if we accept $Z = 1$, we arrive (as Schrödinger assumed) at the wave equation for the electron in the *H*-atom (9). Taking into consideration the expression (29), we deduce Eq. (9) to the standard form (28), $\Delta\Psi + k^2\Psi = 0$.

Where is the blunder of principle in the above derivation of (9)? As is known, ***any wave equation is the equation of mass processes***. It describes the result of the interaction of particles and subparticles in space, from which the waves arise. Wave mass processes represent the ***kinematic level of motion***, or the ***level of superstructure***, below which is the ***level of interaction***, or the ***level of basis***.

Because of this, Schrödinger's equation is ***unable to describe the motion of a single electron***. In spite of this, at that time, physicists groundlessly ascribed to Schrödinger's equation a nonexistent aptitude (unnatural for wave equations in principle); they assumed it must describe the motion of the single electron in the hydrogen atom. This was a gross blunder.

The introduction of potentials, or potential energies of an interaction, into kinematic wave equations, means a lack of understanding of discriminate differences between the ***dynamic basis of wave; i.e., the level of mass coordinated interaction, and the level of superstructure of wave, i.e., the ordered kinematic motion***.

Thus, the divergence of the power series of the radial function in Schrödinger's equation is the effect of ***mixing the kinematic and dynamic levels of motion***, which were formally (incorrectly in essence) joined together in Schrödinger's equation.

5. Wave equation of a string

For confirmation of the above analysis, let us present one more example concerning the wave field of a homogeneous string of the length *l*, fixed at both ends. Every point of the string is defined by the coordinate *z*, and the state of its motion at time *t*, by the displacement from the equilibrium, and the motion itself, by the complex Ψ-function

$$\Psi(z,t) = x(z,t) + iy(z,t), \tag{42}$$

The Ψ-function satisfies the wave equation

$$\Delta\Psi - \frac{1}{\upsilon_0^2}\frac{\partial^2\Psi}{\partial t^2} = 0. \tag{43}$$

Here, $\Delta = \partial^2/\partial z^2$ is the one-dimensional Laplacian operator; υ_0 is the wave speed in the string defined by the following expressions:

$$\upsilon_0 = \sqrt{\frac{T_S l}{M}}, \qquad T_S = E\frac{\Delta l}{l}S, \tag{44}$$

where T_S is the tension, M is the mass, E is Young modulus, Δl is the lengthening, and S is the area of the cross-section of the string.

The "real" component of the complex displacement $\mathrm{Re}\,\Psi(z,t) = x(z,t)$ is called the *potential displacement*, and the "imaginary" component $\mathrm{Im}\,\Psi(z,t) = y(z,t)$, the *kinetic displacement*. The conjugated displacements make it possible to describe more completely the wave field of the string, as the *potential-kinetic wave field*. An elementary solution of the wave equation is defined in the form of the product of the string's space displacements, represented by the function $\psi(kz)$, and the time function $T(\omega t)$:

$$\Psi(z,t) = \psi(kz)T(\omega t), \tag{45}$$

where $k = \frac{\omega}{\upsilon_0} = \frac{2\pi}{\lambda}$ is the wave number, and ω is the circular frequency of oscillations.

The existence of two spaces-fields (45) allows representation of the wave equation of the superstructure (43) through equations of the space and time of the superstructure:

$$\Delta\psi + k^2\psi = 0, \tag{46}$$

$$\partial^2 T/\partial t^2 = -\omega^2 T. \tag{47}$$

These equations define two elementary plane-polarized transverse waves, travelling towards each other.

The kinetic energy of any atom of the string, at *the level of the* ***wave basis*** of the field, can be presented in the following forms (details are in [1]):

$$\varepsilon_k = \frac{1}{2}h_1\nu_1 = \hbar\omega_1 = \frac{1}{2}\hbar_1\omega_1 = \frac{m\upsilon_0^2}{2}, \tag{48}$$

where

$$\hbar = \frac{m\upsilon_0 l}{2\pi} = \frac{1}{2}\hbar_1 = \frac{1}{2}m\upsilon_0\lambda\!\!\!^{-}_1 \tag{49}$$

is the wave action of an atom during the transmission of an excitation along the whole length $l = \frac{n}{2}\lambda$ of the string, it is the action at the level of the wave basis; $h_1 = m\upsilon_0\lambda_1$; $n = 1, 2, 3, \ldots$; m is the mass of an atom of the string. On this basis, the wave number squared k^2 [in (46)] can be presented in the following form:

$$k^2 = \frac{\omega^2}{\upsilon_0^2} = \frac{2m\varepsilon_k}{\hbar^2}. \tag{50}$$

Then the amplitude equation for the wave motion of the string (46) takes the form of Schrödinger's equation:

$$\Delta\psi + \frac{2m\varepsilon_k}{\hbar^2}\psi = 0\,. \tag{51}$$

Introducing some potential energy of interaction of atoms $\varphi(z)$ (that, unconditionally, is inadmissible for the wave equation; we have stated that already) and designating the total energy of oscillations of an atom of the string in a cross-section *S* by the letter *W*, we can write:

$$\varepsilon_k = W - \varphi(z)\,. \tag{52}$$

On the basis of such a "generalization", the wave number becomes

$$k = \frac{\omega}{\upsilon_0} = \sqrt{\frac{2m\varepsilon_k}{\hbar^2}} = \sqrt{\frac{2m}{\hbar^2}\left(W - \varphi(z)\right)} \tag{53}$$

and, corresponding to it, the frequency of the wave field of the string becomes

$$\omega = \upsilon_0\sqrt{\frac{2m}{\hbar^2}\left(W - \varphi(z)\right)}\,. \tag{54}$$

Both become functions of the coordinate *z* of points of the string, $k = k(z)$ and $\omega = \omega(z)$. Actually, the wave number *k* is the constant quantity, defining some frequency of the wave field ω, *which bonds the wave system in a single whole*.

According to such a "generalization", all points of the string must oscillate with different frequencies. The absurdity of the above-described formal "deduction" of the relation (53) is clear and no sane physicist will agree with the "generalized" wave equation of the string in the form that follows:

$$\Delta\psi + \frac{2m}{\hbar^2}\left(W - \varphi(z)\right)\psi = 0\,. \tag{55}$$

The falsity and senselessness of such a formal generalization-derivation (as is actually also realized in Schrödinger's equation (9) is obvious.

6. Physical meaning of Ψ-functions

Let us elucidate now the true physical meaning of wave Ψ-functions.

We can present Eq. (28) in the form of the product of Ψ-function by the operator binomial as

$$(\Delta + k^2)\Psi = 0\,. \tag{56}$$

Because the Ψ-function is unequal to zero, we obtain the operator equation for the simplest value of the operator Δ (regarding Δ as a variable operator magnitude): $\Delta + k^2 = 0$. Solving this quadratic equation, we have

$$\Delta = -k^2\,, \qquad \text{and} \qquad \nabla = -i\mathbf{k}\,, \tag{57}$$

since $\Delta = \nabla^2$. In the wave Ψ-field, the momentum (35) of an arbitrary particle takes the form

$$\mathbf{p} = i\hbar\nabla\Psi = \mathbf{k}\hbar\Psi\,, \tag{58}$$

or, in the scalar form,

$$p = i\hbar\nabla\Psi = k\hbar\Psi\,. \tag{59}$$

What does this equality represent by itself? Any physical parameter *P* (of an arbitrary physical wave field) has its own fundamental wave measure, or a period-quantum P_q. Using this quantum, the value of a parameter *P* can be presented by the quantitative relative Ψ-measure:

$$\Psi = P / P_q\,. \tag{60}$$

In a general case, the parameter *P* is the complex quantity

$$P = p_k + ip_p\,. \tag{61}$$

Let us agree to call the "real" part of Eq. (61) the "kinetic" component, and the "imaginary" part, the "potential" component of the *P*-parameter (the usefulness of this terminology is justified in [1]).

By virtue of this, Ψ-*measure* of the zero physical dimensionality will be a *complex wave function* with the argument,

$$i(\omega t - \mathbf{kr}) = i(\omega t - k_x x - k_y y - k_z z)\,, \tag{62}$$

which indicates that the quantitative measure of the *P*-parameter is changing in space and time. The presence in (62) of the imaginary unit *i* is not casual. It simplifies calculations and has a deep philosophical meaning [1, 11]. The argument (62) meets general physical principles.

Thus, the *wave structure of any physical parameter P* is presented by the following scalar measure:

$$P = P_q\Psi[i(\omega t - k_x x - k_y y - k_z z)]\,. \tag{63}$$

If P is the momentum, then Eq. (59) can be written as

$$p = k\hbar\Psi[i(\omega t - k_x x - k_y y - k_z z)]. \tag{64}$$

The *relative elementary harmonic measure*

$$\Psi = \Psi_m \exp[i(\omega t - k_x x - k_y y - k_z z)] \tag{65}$$

of any parameter P satisfies the differential equations with: 1) the spatial partial derivatives of the second order

$$\frac{\partial^2\Psi}{\partial x^2} = -k_x^2\Psi\,, \qquad \frac{\partial^2\Psi}{\partial y^2} = -k_y^2\Psi\,, \qquad \frac{\partial^2\Psi}{\partial z^2} = -k_z^2\Psi\,, \tag{66}$$

or

$$\Delta\Psi = -(k_x^2 + k_y^2 + k_z^2)\Psi = -k^2\Psi\,, \tag{67}$$

and 2) the partial time derivative of the second order

$$\frac{\partial^2\Psi}{\partial t^2} = -\omega^2\Psi\,. \tag{68}$$

Equations (67) and (68) form the ***wave equation of the harmonic Ψ-function*:**

$$\Delta\Psi - \frac{1}{\upsilon_0^2}\frac{\partial^2\Psi}{\partial t^2} = 0\,. \tag{69}$$

Obviously, the sum of elementary measures constitutes the measure of the general character; therefore, we assume that Eq. (69) also defines the wave field of the measure of an arbitrary parameter. Because in any point under the steady-state wave motion the product of its spatial (amplitude) $\psi(\mathbf{kr})$ and time $T(\omega t)$ components represents Ψ-function, the wave equation (69) therefore falls into the amplitude and time equations:

$$\Delta\psi + k^2\psi = 0 \qquad \text{and} \qquad \frac{\partial^2 T}{\partial t^2} = -\omega^2 T\,.$$

The constant parameters, k and ω, are determined on the basis of boundary conditions. Since these equations describe Ψ-measures of arbitrary physical parameters, the difference of their wave structure comes down to the difference of kinematic types of the corresponding wave fields. The basic wave fields are the plane, cylindrical, spherical, and complicated (spherical-cylindrical) fields. Therefore, these fields, to an equal degree, successfully describe not only the atomic structure, but also the structure of megaobjects that is demonstrated in [1].

7. Conceptual unfoundedness of hybridization

The quantum mechanical concept of hybridization is based on mixing the "real" and "imaginary" parts of complex wave functions. The erroneousness of such an operation resulted in the invention of electron configuration of atoms was analyzed in [3]. We reproduce a part of this analysis here undiscussed yet in these Lectures.

The most of physicists and chemists are aware that quantum mechanics (QM) with the group-theory approach [12] to atomic systems elucidate theoretically atomic and molecular structure and the nature of Mendeleev's periodic law. This belief in reality of an abstract-mathematical image of an atom, imposed by the modern Standard Model of elementary particles, lies in the base of the above view.

Hitherto nobody has come into the question on validity of a pure mathematical artificial manipulation with "real" and "imaginary" parts of spherical wave functions (called atomic orbitals), consisting in creating linear combinations of them (mixing, for short), which lay in the base of the construction of QM atomic model. The legality of linear combinations of wave functions is stated by one of the fundamental principles of QM – the superposition principle. This manipulation led, thus, to the invention of "*electron configuration*" of atoms and promoted on this basis to the development of quantum mechanics and quantum chemistry.

The pure mathematical operation (linear combination) with real and imaginary parts was called *hybridization of atomic orbitals*. Quantum mechanics introduced this notion in spite of the obvious fact that the hybridization contradicts first of all to the main postulate of QM on the probabilistic interpretation of wave functions.

Let us give at the beginning a few examples, cited from the world-wide university textbooks and monographs, which show how deeply hybridization took roots in the foundation of quantum mechanics and quantum chemistry.

1. The authors, J.N. Murrell, S.F.A. Kettle, and J.M. Tedder, of the book "*Valence Theory*" [13] teach that the azimuth functions of the form $\exp(\pm im\varphi)$ have such an imperfection that *they cannot be presented in real space*. However, it is possible to obtain the real functions, which are solutions of the equation $\nabla^2\psi + \frac{8\pi^2 m}{h^2}\left(E + \frac{e^2}{r}\right)\psi = 0$, if one uses *linear combinations of spherical harmonics* with the same quantum number *l*. Operating by this way, it is possible to obtain the functions as, for example,

$$\frac{1}{\sqrt{2}}(Y_{1+1} + Y_{1-1}) = \frac{\sqrt{3}}{2\sqrt{\pi}}\sin\theta\cos\varphi, \qquad (70)$$

where

$$Y_{1\pm1} = \frac{\sqrt{3}}{2\sqrt{2\pi}} \sin\theta e^{\pm i\varphi}. \tag{71}$$

Further they state that since $\sin\theta\cos\varphi$ expresses an angular dependence of *x*-component of the radius-vector **r** (they mean the equalities: $x = r\sin\theta\cos\varphi$, $y = r\sin\theta\sin\varphi$, and $z = r\cos\theta$), the linear combination (70) is termed the p_x*-atomic orbital*.

2. R.L. Flurry in "*Quantum Chemistry*" [14] writes that for the qualitative description of chemical bonds, it is convenient to express the wave functions $R_{nl}(r)\Theta_{lm}(\theta)e^{\pm im\varphi}$ in the *real form* if one takes linear combinations of degenerated functions, which correspond to the values + *m* and – *m* of the magnetic quantum number *m*:

$$\psi^{(1)}_{nlm} = \frac{1}{2}(\psi^{+}_{nlm} + \psi^{-}_{nlm}) = R_{nl}(r)\Theta_{lm}(\theta)\cos m\varphi, \tag{72}$$

$$\psi^{(2)}_{nlm} = \frac{1}{2i}(\psi^{+}_{nlm} - \psi^{-}_{nlm}) = R_{nl}(r)\Theta_{lm}(\theta)\sin m\varphi, \tag{73}$$

where

$$\psi^{+}_{nlm} = R_{nl}(r)\Theta_{lm}(\theta)e^{im\varphi}, \qquad \psi^{-}_{nlm} = R_{nl}(r)\Theta_{lm}(\theta)e^{-im\varphi}. \tag{74}$$

The angular dependence of these functions, *e.g.*, for $|m| = 1$, shows that the function $\psi^{(1)}_{nlm}$ is directed along the *x*-axis and the function $\psi^{(2)}_{nlm}$, along the *y*-axis in Cartesian coordinates. However, he notes that for these functions *m* is not already *the right quantum number* (although $|m|$ is the *right quantum number*) because every of these functions represents the combination of the functions with quantum numbers + *m* and – *m*.

3. E. Cartwell and G.W.A. Fowels write (in "*Valency and Molecular Structure*", Sect 4.6. *Angular functions* $Y(\theta,\varphi)$" [15]) that mathematical expressions for solutions of the wave equation contain complex functions which cannot be easy presented in a graphical form. This is why, and *in order to deal with the real solutions, chemists prefer linear combinations of these functions* presented in the form of "polar" diagrams (which are permissible solutions to the wave equation as well). Although, it is impossible to ascribe to the functions, obtained in that way, the definite values of *m*.

4. In the book "*Molecular Structure and Dynamics*" [16] by W.H. Flagare, we find the following instructions: because of impossibility to present orbitals in the complex space, one should realize "*the transition from the complex basis into the real one by the following formulas of matrix transformation*":

$$\left(p_x\, p_y\, p_z\right) = \left(Y_{1-1} Y_{11} Y_{10}\right) \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & i & 0 \\ 1 & i & 0 \\ 0 & 0 & \sqrt{2} \end{pmatrix}, \tag{75}$$

$$\left(d_{xy}\, d_{x^2-y^2}\, d_{xz}\, d_{yz}\, d_{z^2}\right) = \left(Y_{2-2} Y_{22} Y_{2-1} Y_{21} Y_{20}\right) \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & i & 0 & 0 & 0 \\ 1 & -i & 0 & 0 & 0 \\ 0 & 0 & +1 & i & 0 \\ 0 & 0 & -1 & i & 0 \\ 0 & 0 & 0 & 0 & \sqrt{2} \end{pmatrix}\text{”} \tag{76}$$

5. The “*angular parts of the wave function Y_{lm} of the hydrogen atom*”, presented in the explicit form with the corresponding linear combinations (on the right) in “*The Molecular Structure Theory*” by V.I. Minkin, B.Ya. Simkin, and R.M. Minaev [17], have the form:

$$s \;\rightarrow\; Y_{00} = \frac{1}{\sqrt{4\pi}}\;; \tag{77}$$

$$p_z \;\rightarrow\; Y_{10} = \frac{\sqrt{6}}{2\sqrt{2\pi}} \cos\theta\,;$$

$$p_y \;\rightarrow\; Y_{1-\bar{1}} = \frac{\sqrt{6}}{2\sqrt{2\pi}} \sin\theta \sin\varphi\,, \qquad \frac{1}{i\sqrt{2}}\left(Y_{11} - Y_{1\bar{1}}\right);$$

$$p_x \;\rightarrow\; Y_{1+1} = \frac{\sqrt{6}}{2\sqrt{2\pi}} \sin\theta \cos\varphi\,, \qquad \frac{1}{\sqrt{2}}\left(Y_{11} + Y_{1\bar{1}}\right);$$

$$d_{z^2} \;\rightarrow\; Y_{20} = \frac{\sqrt{10}}{4\sqrt{\pi}} \left(3\cos^2\theta - 1\right);$$

$$d_{xz} \;\rightarrow\; Y_{2+1} = \frac{\sqrt{15}}{2\sqrt{\pi}} \sin\theta \cos\theta \cos\varphi\,, \qquad \frac{1}{\sqrt{2}}\left(Y_{21} + Y_{2\bar{1}}\right);$$

$$d_{yz} \;\rightarrow\; Y_{2-\bar{1}} = \frac{\sqrt{15}}{2\sqrt{\pi}} \sin\theta \cos\theta \sin\varphi\,, \qquad \frac{1}{i\sqrt{2}}\left(Y_{21} - Y_{2\bar{1}}\right);$$

$$d_{x^2-y^2} \;\rightarrow\; Y_{2+2} = \frac{\sqrt{15}}{4\sqrt{\pi}} \sin^2\theta \cos 2\varphi\,, \qquad \frac{1}{\sqrt{2}}\left(Y_{22} + Y_{2\bar{2}}\right);$$

$$d_{xy} \;\rightarrow\; Y_{2-\bar{2}} = \frac{\sqrt{15}}{4\sqrt{\pi}} \sin^2\theta \sin 2\varphi\,, \qquad \frac{1}{i\sqrt{2}}\left(Y_{22} - Y_{2\bar{2}}\right)\text{”}$$

Let us analyze the meaning of the above cited texts.

First, it is not so difficult to realize that the concept of mixing (hybridization), accepted in QM relying on the superposition principle, disagrees with the main postulate of QM about the

probabilistic interpretation of the wave functions. Actually, all presented above manipulations express an elementary simple thing, just *usage and mixing of real and imaginary terms* of the space factor $\hat{\psi}$ of the wave function $\hat{\Psi} = \hat{\psi}(r,\theta,\varphi)e^{i\omega t}$:

$$\mathrm{Re}\,\psi_{nlm} = R_{nl}(r)\Theta_{lm}(\theta)\cos m\varphi\,, \tag{78}$$

$$\mathrm{Im}\,\psi_{nlm} = R_{nl}(r)\Theta_{lm}(\theta)\sin m\varphi\,. \tag{79}$$

While the hypothetical electron density, determined in quantum mechanics as $e|\psi_{nlm}|^2$, excludes from the probabilistic analysis $\mathrm{Re}\,\psi_{nlm}$ and $\mathrm{Im}\,\psi_{nlm}$. Recognizing the difficulty in the interpretation of complex quantities, quantum mechanics assumes that the *physical sense has only the modulus squared of the wave function*

$$\psi_{nlm}\psi^*_{nlm} = \mathrm{Re}^2\,\psi_{nlm} + \mathrm{Im}^2\,\psi_{nlm} = R_{nl}(r)^2\Theta_{lm}(\theta)^2\,. \tag{80}$$

This operation has cost one dear – it made away with the azimuth component $\Phi_m(\varphi)$ deleting it from the wave function $\psi_{nlm} = R_{nl}(r)\Theta_{lm}(\theta)\Phi_m(\varphi)$ [2]. In spite of this, simultaneously, QM tacitly accepted (under the term the atomic orbitals with "*incorrect magnetic numbers*") to use for the "qualitative" analysis the squares of $\mathrm{Re}^2\,\psi_{nlm}$ and $\mathrm{Im}^2\,\psi_{nlm}$.

Thus, a phrase "*the transition from the complex basis into the real one…*" [16] is curious. It means that, in essence, it costs nothing to easily leave the world of imaginary shades and to enter in the real world. It is very strange because it contradicts the basic concept of quantum mechanics on the *probabilistic interpretation* of the wave function Ψ, introduced in order to get rid of unreal ("imaginary") components.

Second, a statement about orientation of the functions $\psi^{(1)}_{nlm} = R_{nl}(r)\Theta_{lm}(\theta)\cos m\varphi$ and $\psi^{(+)}_{nlm} = R_{nl}(r)\Theta_{lm}(\theta)\sin m\varphi$ along the *x*- and *y*-axes, respectively [13], is incorrect as well because any atomic system in spherical polar coordinates has only one axis of symmetry, namely the polar *z*-axis.

Third, "real" functions $\Theta_{11}(\theta)\cos\varphi$ and $\Theta_{11}(\theta)\sin\varphi$ (p_x- and p_y-orbitals, see Fig. 8) are linear combinations of complex functions $\Theta_{11}(\theta)e^{\pm im\varphi}$. The mixing of these complex functions, contained "real" and "imaginary" quantities, together, as it has been done in quantum mechanics, is inadmissible, just like *it is impossible, e.g., to mix together the electric and magnetic fields* and then to ascribe to the obtained mixture the properties inherent only in the electric field (or, *vice versa*, only magnetic).

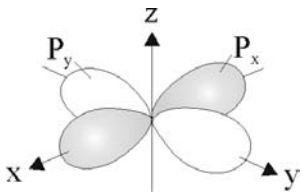


Fig. 8. The p_x – and p_y – orbitals of quantum mechanics.

Thus, the hybridization as a *mathematical mixing* of qualitatively opposite properties unrealizable in Nature should not been to be accepted. It is merely a mathematical trick used by creators of QM at the earliest stage of its building because of the ignorance of the physical meaning of complex wave functions.

8. Groundlessness of mixing the real and imaginary terms

Thus, it is not so difficult to come to the conclusion that all above mentioned strange mathematical operations are directed to the one goal, namely implicitly to legalize the probabilities

$$dw_r = (\mathrm{Re}\,\psi)^2\, dV \qquad \text{and} \qquad dw_i = (\mathrm{Im}\,\psi)^2\, dV\,; \tag{81}$$

while from the beginning, QM distinguishes only one differential of probability which is expressed by the equality

$$dw = |\psi|^2\, dV\,. \tag{82}$$

As a result, we have an interesting relation, which has never been discussed and which nobody has tried even to notice:

$$dw = |\psi|^2\, dV = dw_r + dw_i\,. \tag{83}$$

The question arises: what do the probabilities dw_r and dw_i (and their bond with the originally postulated probability dw) mean?

The mathematical operations, which gave rise *s*-, *p*-, and *d*-orbitals, were directed to an implicit usage not only real but also "imaginary" components of complex wave functions $\hat{\psi} = \psi_r + i\psi_i$. At that, constant factors of the functions are determined on the basis of the following normalization conditions:

$$\int_0^{\pi} \Theta_{l,m}^2 \sin\theta d\theta = 1, \qquad \int_0^{2\pi} \psi_{r,m}^2 d\varphi = 1; \qquad \int_0^{2\pi} \psi_{i,m}^2 d\varphi = 1. \tag{84}$$

Since Max Born introduced the probabilistic interpretation of the wave function [18], till now the "imaginary" parts, regarded as unreal quantities, did not have a firm physical

interpretation. Let us cite Born's explanation: "*The reason for taking the square of the modulus is that the wave function itself* (*because of the imaginary coefficient of the time derivative in the differential equation*) *is a complex quantity, while quantities susceptible of physical interpretation must of course be real*" [18, p.142].

Before "piling up" the "real" and "imaginary" parts of the complex wave function, it is necessary to think about how they are related. What does it mean imaginary? Already their names, "real" and "imaginary", say that we deal with the *qualitatively opposite properties* of wave fields and objects. Such properties are unquestioned at the description of all other physical processes and phenomena.

Actually, nobody will add a potential function (*e.g.*, potential energy) to the corresponding kinetic function (kinetic energy) and then call the resulting sum the potential function (potential energy). It is meaningless. But why similar operations are the norm in QM (and, hence, in quantum chemistry)?

For example, a complex resistance of the *RLC* electric circuit has the following form

$$Z = R + i(X_L + X_C) = R + i\left(L\omega - \frac{1}{C\omega}\right). \tag{85}$$

It is impossible to imagine that someone could regard the "imaginary resistances", iX_L and iX_c, as unreal quantities. Naturally, the "real" and "imaginary" resistances are qualitatively opposite but *real* features. Such is the dialectics of electric circuits. The complex resistance by itself is contradictory just like other phenomena in Nature.

A "real" resistance R is an element of the dispersion of energy at the atomic level, whereas the "imaginary" resistances, positive iX_L and negative iX_c, are the elements accumulating, correspondingly, kinetic and potential energies of the subatomic level (of "electromagnetic field").

When we are interested in an amplitude value of current, the relation between current and amplitude of voltage is determined by means of the modulus of the total resistance:

$$I_m = \frac{U_m}{|Z|} = \frac{U_m}{\sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}}. \tag{86}$$

And the modulus of power of the dispersion of energy depends on the modulus squared of the total resistance:

$$N_m = I_m^2 R = \frac{U_m^2 R}{|Z|^2} = \frac{U_m^2 R}{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}. \tag{87}$$

Of course, the description of the wave field of *H*-atom on the basis of complex numbers is more complicated than the description of the simplest circuits. However, one should understand that the "real" and "imaginary" components of the polar-azimuth function express *qualitatively different wave states* of atoms and their structural units (like the active and reactive resistances in electric circuits or like the "electric" (longitudinal) and "magnetic" (transversal) fields, *etc*.). Unfortunately, it was not realized in quantum mechanics. As a result, the "real" and "imaginary" terms of the Ψ-function are regarded in QM erroneously as qualitatively similar. Accordingly, the complicated orbitals built on the basis of mixture of the "real" and "imaginary" components (*i.e*., mathematical mixture of physically immiscible) became the basis for the construction of QM models of atoms and molecules.

Let us analyze the above stated from the pure philosophical point of view, repeating the corresponding concepts considered earlier in previous Lectures of Vol. 1.

A spirit of extreme abstraction, based on ideology of chance and indeterminacy, has permeated quantum mechanics. It does not favor uncovering the real spatial structure of microobjects. This abstract approach does not endure the rigorous critique. In his time Hegel has noted that scientific abstraction must be the beginning and the elements, from which the concrete images of phenomena and states of nature must be developed; in opposite case we deal with abstractionism, which is far from the true science.

In Nature chance and necessity, definiteness and indeterminacy form symmetrical pairs of polar opposite properties of the Universe. Therefore, description of phenomena in microworld must not be reduced only to probability and indeterminacy.

In accord with dialectical logic, foundation of which was laid by Hegel, to every affirmative judgment Yes, *e.g*., chance, possibility, definiteness, concreteness, discreteness, symmetry, *etc*., corresponds the symmetrical polar opposite judgment No: necessity, reality, indeterminacy, abstractiveness, continuity, asymmetry, *etc*.

The symmetry of polar properties, expressed by the binary dialectical judgment Yes – No, is the base of *dialectical model* of the Universe, which rests on the basic law of dialectical logic, namely the law of affirmation-negation (the Yes – No law) [11]. With this, there is no clear boundary between Yes and No: properties Yes continuously and discontinuously (discretely) turn to opposite properties No.

Dialectical symmetry of polar properties of the Universe is a result of the formation of the Universe as Being from Non-Being with the zero measure. From the metaphysical point of view Non-Being is merely a mathematical emptiness, whereas from dialectical point of view Non-Being is another existence of Being in the uttermost unstable state of the highest degree of continuity, which transients into its opposition – Being. With that, the zero measure of Non-Being remains the same measure for Being. This is why to an arbitrary set Yes always corresponds, in the whole, the equal and opposite quantity No. From this it originates the

symmetry of opposite properties of the Universe as Being. Being and Non-Being always go alongside, their fields-spaces intersect.

By virtue of the above stated it is obvious that we should speak with the Universe on the language of dialectical symmetry of oppositions.

So that to the property of motion Yes = *relative* responds the symmetrical property No = *absolute* [10]. The nodes of standing wave have as their oppositions, the antinodes. Etc.

Aristotle's *formal logic*, the logic of only Yes or only No, is unable of principle to overcome the one-sided view about Nature and therefore cannot correctly describe Nature, whereas Hegel's *dialectical logic* with the law Yes – No is able to do it.

The formal logic excludes the joining of Yes and No. This is why the modern physics is *forced* to operate by the law of dialectical logic Yes – No in implicit form.

Symmetrical opposite properties of processes and objects of Nature demand for their description the introduction of the numerical field of the symmetrical structure Yes – No as well, *i.e.*, with the opposite algebraic properties, because only such a numerical field enables to express exactly the dialectical judgment Yes – No [19 - 21].

Thus if for the formal logic and metaphysics it is sufficient the common (mono) numerical field, for the dialectical logic and dialectical philosophy (the philosophy of symmetrical structure of the Universe) it is necessary the symmetrical (binary) numerical field. Complex numbers represent a particular case of the binary numerical field of dialectics, in which both constituents are real quantities.

Dialectics and essential principles of the binary numerical field were considered in detail in Vol. 1 of the Lectures.

9. Conclusion

Foundations of the theory, quantum mechanics, developed for the description of physical phenomena at the atomic and molecular levels, were analyzed. The basic equation of quantum mechanics, Schrödinger's equation, is similar in form to the general (classical) wave equation. For the spatial function $\hat{\psi}(x, y, z)$, they have the form (2): $\Delta\hat{\psi} + k^2\hat{\psi} = 0$.

However, being identical in form, these equations differ in contents because of the following reasons:

1) The factor k^2 in the *general wave equation* is the *fundamental constant*. In particular, for atomic spaces

$$k = \frac{\omega_e}{c}, \tag{88}$$

where ω_e is the definite fundamental frequency of the atomic and subatomic levels, $\omega_e = 1.869162559 \times 10^{18}\, s^{-1}$ (see (1), L. 1 of Vol. 2), *which bonds the wave system in a single whole*, *c* is the speed of light.

In *Schrödinger's equation*, having the same form (2), instead of the constant wave number *k*, there is the strange *variable quantity*,

$$k = \pm\sqrt{\frac{2m(W-U)}{\hbar^2}}\,, \tag{89}$$

in which $U(x,y,z) = -\dfrac{Ze^2}{4\pi\varepsilon_0 r}$ is the "*potential energy of the electron in the field of a nucleus, depending on electron coordinates*". The above function for electron's potential energy is based on a nuclear model of atoms and on a supposition that between the nucleus and the electrons in atoms it takes place the Coulomb kind of interactions. As a result, as it was shown in this Lecture, under the substitution *k* with (89), Eq. (2) ceases to be wave.

2) As assumed creators of QM, *Schrödinger's equation* (2) "describes" the motion of the electron around an atomic nucleus with the charge *Ze*.

In contrast, the *general wave equation* describes the structure of atomic space regarded as the discontinuous part of the wave space.

Therefore, *solutions* of the wave equation of space and *solutions* of the quantum mechanics equation for electrons, being identical both in form (2), *are different* in contents: they describe different phenomena and, hence, they have different meaning.

Quantum mechanics does not use directly its own solutions, as is done in realistic science. Instead it operates with the squared modulus of the wave function. With this, the hypothesis (accepted in QM as one of its principal postulates) that considers the squared modulus of the wave function as the measure of probability is not justified. This extraordinary illogical act allows one to drop "*an imaginary part*" of the wave function, which is believed conventionally to "*have no physical meaning*". However, a tradition is not a proof. In his time, Leibniz wrote, "*A complex number is a fine and wonderful refuge of the divine spirit, as if it were an amphibian of existence and nonexistence.*" Unfortunately, creators of quantum mechanics have neglected this insight. In the past, negative numbers were also named "*imaginary*", because they were considered to be unreal quantities "*smaller than nonexistence*". But in the course of time, emotions cooled and the "imaginary" negative numbers turned into real ones. However, the square root of a negative number today remains "*imaginary*". The above mentioned problems have been solved by the authors of the works [10, 19]; they were considered already in Lectures of Vol. 1 (see also [21]).

Groundlessness of one of the key concepts of modern physics, namely *hybridization* [4], was revealed convincingly enough, and the physical meaning of the wave $\hat{\Psi}$-function has

been elucidated. It was considered in Vol. 5 that polar-azimuthal constituents of the wave function $\hat{\Psi}$, potential and kinetic, being solutions of the ordinary wave equation (just as Schrödinger's wave equation too) in spherical polar coordinates define the *angular spatial coordinates*, respectively, of *nodes* and *antinodes* of standing spherical waves. They have nothing in common with electron orbitals ascribed to them unfoundedly by creators of QM.

The mixing objects ("orbitals") in QM are actually the *qualitatively opposite real features*, potential and kinetic constituents of the wave function (*nodes* and *antinodes* of standing spherical waves). The erroneousness of the concept of *hybridization* should be clear understandable because of the natural unquestionable impossibility of real mixing of physically immiscible (*nodes* with *antinodes*). Really, we cannot mix qualitatively different (polar) oppositions such, e.g., as: material and ideal, quantity and quality, form and contents, motion and rest, cause and effect, past and future, absolute and relative, wave and quantum, *etc*. Since the hybridization is in the base of the quantum mechanical atomic model (and, hence, quantum chemistry), the above fact naturally calls in question, whether these theories correctly describe reality? As can be seen, they do it (to put it mildly) incorrectly, but, strictly speaking, they are in no way reflect reality.

Obviously, a denial of the legality of "hybridization" amounts to a denial of the superposition principle related to the basic concepts of quantum mechanics. Hence, the validity of the QM atomic model again casts the reasonable doubt.

As we have seen, the numerous contradictions and blunders of the abstract mathematical model, put forward by Schrödinger and inherent in QM, do not endure critique. However, relying on the postulate on the impossibility to imagine a clear spatial structure of microobjects at the atomic and subatomic levels, QM theorists continue developing this model. Such a *status quo*, unfortunately, still exists in physics. Apparently, all revealed faults of QM, including stressed here, are not yet known for wide scientific community.

Any theory initiates an experiment originated from this theory; therefore the experiment very often "confirms" such a theory, to a certain degree, although this theory maybe does not reflect reality completely (see, for example, the sad situation fully formed with the notion of electron spin [22, 23]). This is why theorists must not ignore the fact (noted in his time by Bohr [24]) that the correspondence of any theory with the experiment does not quite mean that the given theory is true and uniquely possible. And what is more, the possibilities of modern mathematics are so impressive that it can present any abstract figment of an imagination as a profound theory and fit it to the experiment.

Thus, basing on the results of the undertaken comprehensive analysis, we have the firm ground to state that QM *incorrectly* describes physical phenomena, including the structure of atoms.

In view of the omnipresent character of QM, at the present stage of development of science, in particular of atomic physics and atomic technologies, it increases the definite

danger of the further existence of QM in science, as the theory in the highest degree distortedly describes the World. This is most important, as in the course of many decades, the opinion, in which QM perfectly describes the microworld, has been propagated and strengthened in the consciousness of people.

Technology deals with real material objects and we live in a real world; accordingly, our knowledge about nature must also be concrete and truly reflect reality, as far as possible. In particular, the development of nanotechnology, where dimensions of devices tend towards magnitudes comparable with atomic sizes, requires as early as possible knowing the *real spatial* structure of atoms. However, it is not an objective of modern physics because of the domination of the Standard Model, including the theory of QM.

Judging by the arguments presented in this Lecture, Schrödinger's equation is false and has significance only from the point of view of history of the philosophical and logical errors of the past. Therefore, all generalized and extended variants of the equation, including relativistic, *etc*., are too erroneous.

The cardinal errors have transformed QM, based on Schrödinger's equation, into a great caricature about the world of real wave processes while the extensive publicity created an illusion as if mankind deals with a great theory. In fact, a phenomenological theory, with the definite fitting of it to the experiment, was built as a result. The QM, being abstract-mathematical theory that *based on a series of the invented axioms*, as much significantly distorted the real picture of the microworld that it became the world of theoretical monsters and quantum chaos, but not the world of real images.

It makes sense to remind in conclusion that a new atomic theory, principal elements of which were considered in detail in Vol. 5 of the Lectures, is *based* on recognizing, as an axiom, the wave nature of all objects and phenomena in the Universe (that undoubtedly corresponds to reality) and on reality, following from this axiom, of the description them by the *general wave equation*. The credibility of the *shell-nodal* or *multi-center* (or *molecule-like*) atomic model, developed on the basis of the above axiom, is confirmed by the fact that it explains a large body of experimental facts of physics which were impossible to explain in the framework of the theory of quantum mechanics. The QM is based on *numerous abstract-mathematical* (*invented*) *axioms* one of which is Schrödinger's equation.

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Lecture 2

The Notions of Temperature, Boltzmann and Avogadro Constants

1. Introduction

The Shell-Nodal Atomic Model (SNAM) and the Dynamic Model of Elementary Particles (DM) explain the *wave structure* and *behavior* of matter at the atomic and subatomic levels. These theories, resting on a concept on the wave nature of everything in the Universe, which lays as a postulate in their basis, allow understanding many unknown sides of the phenomena as well as misunderstood (or insufficiently deep understandable) properties of matter.

One of the fundamental properties of a body or environment is their temperature. This parameter reflects an energetic state of a system being its measure. According to the strict thermodynamic definitions, the temperature *T* expresses the relationship between the change of internal energy *U*, or enthalpy *H*, and the change of entropy *S* of a system:

$$T = \left(\frac{\partial U}{\partial S}\right)_V, \qquad \text{or} \qquad T = \left(\frac{\partial H}{\partial S}\right)_P. \tag{1}$$

In statistical mechanics that makes theoretical predictions about the behavior of macroscopic systems on the basis of statistical laws governing its component particles, the relation of energy and absolute temperature *T* is usually given by the inverse thermal energy

$$\beta = \frac{1}{k_B T}. \tag{2}$$

The physical parameter k_B, called the Boltzmann constant, equal to the ratio of the molar gas constant R and the Avogadro constant N_A,

$$k_B = \frac{R}{N_A} \quad (J \cdot K^{-1}), \tag{3}$$

plays a crucial role in the relation (2). Since $R = 8.3144621\, J \cdot mol^{-1} \cdot K^{-1}$ and $N_A = 6.02214129 \cdot 10^{23}\, mol^{-1}$, hence, $k_B = 1.3806488 \cdot 10^{-23}\ J \cdot K^{-1}$, according to the modern data.

The Boltzmann constant defines also the relation between absolute temperature and the kinetic energy of molecules of an ideal gas.

The product $k_B T$ is used in physics as a scaling factor for energy values in molecular scale (sometimes it is used as a pseudo-unit of energy), because many processes and phenomena depend not on the energy alone, but on the ratio of energy and $k_B T$.

For a thermodynamic system at an absolute temperature *T*, the thermal energy carried by each microscopic "degree of freedom" in the system is of the order of $\frac{k_B T}{2}$.

Determination of N_A, and hence k_B, was one of the most difficult problems of chemistry and physics in the second half of the 19th century. The constant N_A was (and still is) so fundamental that for its verifying and precise determination every new idea and theory appeared in physics are at once used. More accurate definition of the value of N_A involves the change of molecular magnitudes and, in particular, the change in value of an elementary charge. The latter is related with N_A through the so-called “Helmholtz relation”, $N_A e = F$, where *F* is the Faraday constant, the fundamental constant equal to $96485.3365(39)\ C \cdot mol^{-1}$.

Many eminent scientists have devoted definite periods of their life to study of this problem: beginning from I. Loschmidt (1866), Van der Vaals (1873), S. J.W. Rayleigh (1871), *etc*. in the 19th century, and continuing in the 20th century, beginning from Planck (1901), A. Einstein and J. Perrin (1905-1908), Dewer (1908), E. Rutherford and Geiger (1908-1910), I. Curie, Boltwood, Debierne (1911), and many others.

In history of physics, the Boltzmann constant has undergone constant changes. We show here for comparison only two values of N_A, in particular, obtained by Planck, on the basis of his famous black body radiation formula [1], and the modern accepted value [2]:

$$N_A \approx 6.16 \cdot 10^{23}\, mol^{-1} \qquad \text{(Planck, 1901)} \tag{4}$$

$$N_A = 6.02214129(27) \cdot 10^{23}\, mol^{-1} \qquad \text{(2010 CODATA)} \tag{5}$$

The difference is quite essential. The main reason for this, on our mind, is the following. There are no reliable direct experimental methods for the precise determination of the

Avogadro constant. The only direct method for the determination of N_A, based on study of the Brownian motion, has a low accuracy; therefore, it is not used at present.

One of the modern *indirect* methods is based on the calculation of N_A from the density ρ of a pure (and free of defects) crystal, its relative atomic mass M, and the cell length d, determined from x-ray methods. Finally, the accepted recommended value of N_A (5) depends on a series of measured parameters related to the structure of matter. A most probable and self-consistent set of the constants N_A, obtained by different methods, that best fits all reliable data is found by statistical methods.

Calculations of N_A (4) based on Planck's radiation formula

$$r_\nu = \frac{2\pi\nu^2}{c^2}\frac{h\nu}{e^{\beta\cdot h\nu}-1}, \tag{6}$$

where r_ν is the energetic spectral luminosity of atomic space, were carried out at the time when a newborn theory, set forth first by Planck, was under doubts and not yet been accepted. Accordingly, no one paid serious attention to the value N_A (4) obtained by Planck at that time.

From our point of view, the determination based on (6) deserves special attention. The matter is that the above formula does not contain quantities related to the parameters of the structure of matter, as against to the case of an indirect determination with use of modern diffraction methods.

In a case of the determination of N_A on the basis of the WM, SNAM and DM, which we will consider further in this Lecture, we deal with the direct (similar to Planck's) calculation of N_A from the theoretical formula. At this it proven to be that the calculated quantity practically completely coincides with the value (4) originally obtained from Planck's formula.

In light of the said above and because obtained results in the WM shed new light on the nature of k_B and the temperature, it makes sense to present them for public discussion. The more so as a series of fundamental unsolved questions of physics already found their answers in the framework of the SNAM and DM. We relate to them, in particular, the nature of mass and charge of elementary particles, the role of c^2 in the famous formula for energy of particles, $E=mc^2$. The SNAM and DM have revealed an internal spatial structure of individual atoms, explained from a new point of view the nature of the Lamb shift (without use of the notion of virtual particles) and the anomalous magnetic moment of an electron, and a number of other phenomena [3]. Therefore, we have all grounds to trust to the results obtained in the WM concerning the derivation of N_A, and to the conclusion about the nature of k_B and the absolute temperature.

For this reason, as one of the topical issues certainly deserving attention, a new insight, originated from the shell-nodal atomic model and the dynamic model of elementary particles,

into the aforementioned notions relevant to the absolute temperature was taken for consideration in the given Lectures,. We will show here that a quantum of average energy of a nucleon at the level of the so-called *meson frequency* ω_0 is close, in value, to the Boltzmann constant k_B. The number of such quanta, equal in value to the absolute temperature, defines the relative potential-kinetic nucleon energy of a system. This means that the temperature, as the potential-kinetic energy, according to the revealed peculiarity, is the alternating wave magnitude and is *negative* for the relative potential energy and *positive* for the relative kinetic energy.

The Boltzmann and Avogadro constants derived on a new basis (the WM) are presented in terms of other fundamental physical constants. Therefore, we should regard these constants of the obtained resulting values as *fundamental*, because just they, compared with the values of the same constants accepted in modern physics, are the *derivatives of truly fundamental constants*.

Thus, the subject of the present Lecture is to show in detail, within the notions of the WM, the process and results of reconsideration of the common view on some aspects related to the aforementioned physical constants. We will begin first from reminding the nature of the notion of *meson frequency*, which is used at the derivation of k_B presented below.

2. Characteristic frequency of the H-atomic level

According to the DM (see Lectures of Vol. 2 and 3), elementary particles remind pulsating spherical microobjects (pulsating compaction of space), whose mass has associated character. Wave interaction of the particles, more correctly exchange of matter-space-time, is realized on the fundamental frequency of exchange inherent in the atomic and subatomic levels:

$$\omega_e = 1.869162534 \cdot 10^{18}\ s^{-1}. \qquad (7)$$

In dependence on the character of exchange, we distinguish associated masses in the *longitudinal exchange* (at motion-rest in the cylindrical field of matter-space-time), the associated masses in the *transversal exchange* (transversal oscillations of the wave beam), and the associated masses in the *tangential exchange* (at motion-rest in the cylindrical space-field).

Associated masses *m* and *characteristic* frequencies ω are related, in accordance with the DM, by the fundamental dependence:

$$m\omega = q,$$

where *q* is the *exchange* charge, the rate of mass exchange. This means that the spectra of masses and corresponding characteristic frequencies are interconnected. Remind, the elementary quantum of the rate of mass exchange (electron charge) is $m_e\omega_e = e$.

Accordingly, at the rate of mass exchange realized by the elementary quantum *e*, the equality $m\omega = m_e\omega_e$ must be respected.

Consider the derivation of the spectrum of associated masses (taken from Lecture 12, Vol. 3) playing the role in the *longitudinal exchange*, related with the spectrum of corresponding characteristic frequencies. This derivation leads to the masses of particles, constituents of atoms, as, for example, π-mesons, μ-mesons, γ-quanta, *etc*. This consideration will help understanding the concept discussed here, related with the structure of nucleons.

Motion-rest in the cylindrical field of matter-space-time can be presented, at a part of the axial line of length *dz* (Fig. 1), (in the simplest case) by the equation of exchange:

$$\rho_z dz \frac{\partial^2 \Psi}{\partial t^2} = -\frac{\partial F}{\partial z} dz\,, \qquad (8)$$

where ρ_z is the linear density of mass, Ψ is the axial displacement, and F is the power of exchange.

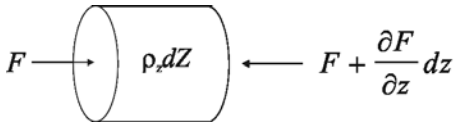

Fig. 1. A graph of power of the elementary longitudinal exchange.

Let *w* will be the density of energy of *basis*, and *p* is the density of energy of *superstructure*. In a linear approximation, the relative change of energy is

$$\frac{pS\partial z}{wS\partial z},$$

where $wS\partial z$ is the energy of an elementary differential volume $S\partial z$, and $pS\partial z$ is its change.

Assuming that the relative change of energy of exchange is equal to the relative linear change of the elementary volume of space-field, $\frac{pS\partial z}{wS\partial z} = \frac{F\partial z}{wS\partial z} = -\frac{\partial \Psi}{\partial z}$, we obtain $F = -wS\frac{\partial \Psi}{\partial z}$. As a result, the equation of exchange (8) takes the form

$$\frac{\partial^2 \Psi}{\partial t^2} = \frac{wS}{\rho_z}\frac{\partial^2 \Psi}{\partial z^2} \qquad \text{or} \qquad \frac{\partial^2 \Psi}{\partial z^2} = \frac{\rho_z}{wS}\frac{\partial^2 \Psi}{\partial t^2}.$$

(9)

An element of a beam is $\partial z = c\partial t$; hence,

$$\frac{\partial^2 \Psi}{\partial t^2} = \frac{wS}{\rho_z c^2}\frac{\partial^2 \Psi}{\partial t^2} \tag{10}$$

and

$$c = \sqrt{\frac{wS}{\rho_z}}. \tag{11}$$

If we consider the exchange with the density of energy at the level of Young's modulus *E*, then

$$c = \sqrt{\frac{ES}{\rho_z}}. \tag{12}$$

and

$$\omega = kc = k\sqrt{\frac{ES}{\rho_z}}, \tag{13}$$

where $k = \frac{2\pi}{\lambda}$ is the wave number, which takes a series of discrete values.

Let us determine now the characteristic spectrum of frequencies. For the hard-facing alloys, Young's modulus lies approximately within $600 - 680\,GPa$. We select, in the capacity of a calculated magnitude, the characteristic value 654.9, which satisfies the metrological spectrum, $M = 2^k \cdot 3^l \cdot 5^m \Delta$ (see Lecture 6, Vol. 1), on the basis of the fundamental measure – quantum-period $\Delta = 2\pi \lg e$ [3] (the cardinal number is $2^3 \cdot 3 \cdot 5^{-1}\Delta$):

$$\mathrm{E} = 6.549 \cdot 10^{11}\,Pa. \tag{14}$$

Let the remaining parameters are equal to:

$$l = 2\pi r_0, \qquad \rho_l = m_e / l, \qquad S = \pi r_0^2, \tag{15}$$

where $r_0 = 0.52917720859 \cdot 10^{-8}\,cm$ is the Bohr radius, $m_e = 9.10938215(45) \cdot 10^{-28}\,g$ is the electron mass.

Under above conditions, the formula for the characteristic spectrum of frequencies (13) takes the form

$$\omega = 4\omega_0 \cdot r_0 k, \tag{16}$$

where

$$\omega_0 = \frac{\pi}{2}\sqrt{\frac{Er_0}{2m_e}} = 6.85091084 \cdot 10^{15}\ s^{-1} \approx \frac{\omega_e}{272.88}. \tag{17}$$

The frequency ω_0 is bound up with the fundamental frequency ω_e (7) by the following characteristic ratio:

$$\frac{\omega_e}{\omega_0} = 272.8103045 \approx 272.8752708 = 2\pi \lg e \cdot 10^2 . \tag{18}$$

Frequency of the fundamental tone ω_0 is the *characteristic frequency* of the *H*-atomic level. If $l = n\lambda$, then $r_0 k = n$ and

$$\omega_n = 4\omega_0 \cdot n \approx \Delta \cdot 10^{16} n \ s^{-1} . \tag{19}$$

The spectrum of frequencies (19) defines the spectrum of associated masses of elementary particles:

$$M_n = \frac{e}{\omega_n} = \frac{e}{4\omega_0} \cdot \frac{1}{n} = \frac{68.5\, m_e}{n} , \tag{20}$$

where

$$e = 1.702691582 \cdot 10^{-9} \ g \cdot s^{-1} \tag{21}$$

is the elementary *exchange charge* or an *elementary quantum of the rate of mass exchange* (electron charge for brevity, its value and dimensionality follow from the DM).

If $l = n\frac{\lambda}{2}$, then $r_0 k = \frac{1}{2} n$ and

$$\omega_n = 2\omega_0 \cdot n , \qquad M_n = \frac{e}{\omega_n} = \frac{e}{2\omega_0} \cdot \frac{1}{n} = \frac{137\, m_e}{n} . \tag{22}$$

At last, for $l = n\frac{\lambda}{4}$, it follows that $r_0 k = \frac{1}{4} n$ and

$$\omega_n = \omega_0 \cdot n , \qquad M_n = \frac{e}{\omega_n} = \frac{e}{\omega_0} \cdot \frac{1}{n} = \frac{274\, m_e}{n} . \tag{23}$$

For $n = 1, 2, 3, 4,$ we have

274 m_e	$\Rightarrow$	π-meson
137 m_e	$\Rightarrow$	γ-quantum
91.3 m_e	$\Rightarrow$	ρ-lepton
68.5 m_e	$\Rightarrow$	g-lepton

(24)

Two g-leptons form a γ-quantum, and three g-leptons compose a μ-meson:

$$205.5\, m_e \qquad \Rightarrow \qquad \mu\text{-meson.} \tag{25}$$

Because at $n = 1$, a particle of the mass $M_1 = 274 m_e$ is the π-meson, we call the frequency ω_0 the *meson frequency*. This *characteristic frequency* of the *H*-atomic level will be used now at the derivation of k_B.

3. The Boltzmann constant and absolute temperature

As was mentioned in Introduction, the physical parameter k_B of the dimension $J \cdot K^{-1}$ was introduced in science as the ratio (3) under the name the *Boltzmann constant*; and its value accepted at present [2] is

$$k_B = 1.3806488 \cdot 10^{-23}\ J \cdot K^{-1}. \tag{26}$$

The product k_B with the absolute temperature *T* defines in physics the thermal energy of a system. The value of the Boltzmann constant defines also the Avogadro constant N_A. The value of the latter accepted in modern physics, as was mentioned earlier, calls the questions. Therefore, on the basis of the WM, the notion of the Boltzmann constant, its meaning and value, was undergone the reconsideration. Let us show now, how this was done.

In a spherical field, amplitude of oscillations of the spherical shell of a particle [4, 5] is

$$\hat{A}_s = \frac{A_m \hat{e}_l(kr)}{kr}, \tag{27}$$

where

$$e_l(kr) = |\hat{e}_l(kr)| = \sqrt{\frac{\pi kr}{2}\left(J^2_{l+1/2}(kr) + N^2_{l+1/2}(kr)\right)}, \qquad kr = z_{m,n}, \tag{28}$$

and $z_{m,n}$ are roots of the Bessel functions, $J_{l+1/2}(kr)$ and $N_{l+1/2}(kr)$ [6].

Let us determine a quantum of the average energy of a nucleon at the level of the frequency ω_0, defined by the equation (17). We regard this frequency as one of the fundamental frequencies of the atomic level. Under the constant rate of mass exchange (exchange charge) of the value *e*,

$$e = \omega_e m_e = \omega_0 m_\pi, \tag{29}$$

where m_e is the electron mass, a particle with the mass $m_\pi \approx 273 m_e$ corresponds to the frequency ω_0. This is the π-meson level of masses. This frequency relates to the frequency range of the "electromagnetic" field and defines the characteristic energy of the nucleon level E_s.

The root of Bessel functions, corresponding to the first potential extremum of the first-order spherical function, $z'_{1,1} = a'_{1,1} = 2.08157598$ [6], defines the discrete (quantum) state with this energy; hence, the corresponding quantum of energy is

$$E_s = \frac{m_0 \omega_0^2}{2} \left(\frac{A_m}{a'_{1,1}} \right)^2 , \tag{30}$$

where m_0 is the proton mass. Amplitude A_m is determined from the formula

$$A_m = r_0 \sqrt{\frac{2hR_\infty}{m_0 c}} , \tag{31}$$

where h is the Planck constant, R_∞ is the Rydberg constant ($R_\infty = 10973731.568539\ m^{-1}$), and c is the speed of light [4,5].

Denoting the quantum of energy (30) as

$$E_s = \frac{k_B}{2} , \tag{32}$$

and setting numerical values for all physical quantities entered in (30), we arrive at the quantity

$$k_B = m_0 \omega_0^2 \left(\frac{A_m}{a'_{1,1}} \right)^2 = 1.3512886 \cdot 10^{-16}\ erg , \tag{33}$$

which is the *characteristic quantum of energy* of the H-level. The latter is close in value to the ideal level k_Δ,

$$k_B \approx k_\Delta = \pi \lg e \cdot 10^{-16}\ erg , \tag{34}$$

because it is multiple, to an accuracy of the second figure after comma, to a half of the fundamental period-quantum Δ of the Decimal Code of the Universe [3],

$$\Delta = 2\pi \lg e . \tag{35}$$

The quantum k_B (33) practically coincides, in value, with the Boltzmann constant (3) designated in the same manner (letters), but it has the dimensionality of energy, J (or *erg*), in comparison with the Boltzmann constant k_B (3) of the dimensionality $J \cdot K^{-1}$.

Let us denote the *number of quanta of energy* (32) by the symbol T_e, and then the nucleonic energy can be rewritten as

$$E_s = \frac{k_B}{2} T_e \,. \tag{36}$$

Thus, the Boltzmann constant k_B represents, in (36), the characteristic quantum of energy k_B (33), and the *absolute temperature T defines to the number of these quanta, T_e*.

The nucleon energy has the *potential-kinetic* character. The potential energy is negative and the kinetic energy is positive. Hence, the relative nucleon energy T_e is *negative* for the potential energy and *positive* for the kinetic energy. Therefore, in a general case, (30) can be presented as

$$\hat{E}_s = \frac{m_0 \omega_0^2 A_m^2}{2a_{1,1}'^2} e^{2i\omega t} = \frac{k_B}{2} \hat{T}_e \,, \tag{37}$$

where

$$\hat{T}_e = T_m e^{2i\omega t} \,. \tag{38}$$

is the *relative potential-kinetic energy*.

Motion-rest has the wave character; hence, we must speak about the *wave of relative energy*

$$\hat{T}_e = T_m e^{2i(\omega t - kr)} \,, \tag{39}$$

which satisfies the wave equation

$$\Delta \hat{T}_e - \frac{1}{2c^2} \frac{\partial^2 \hat{T}_e}{\partial t^2} = 0 \,. \tag{40}$$

A *positive component* of the relative energy is known under the name the *absolute temperature*. Modern physics operates mainly with the *averaged positive amplitude temperature* of macrofields of motion-rest with a high part of the state of chaos.

The notion of the *negative absolute temperature* is used in modern physics for the description of a thermodynamic system (for example, quantum generators [7, 8]), which satisfies certain conditions. According to the latter the thermodynamic system, *first*, must be in the thermodynamic equilibrium with environment in order for the system to be described by the temperature at all. *Second*, there must be an upper limit to the possible energy of the states allowed for the system. *Third*, the system must be thermally isolated from all systems which do not satisfy both of the first two requirements [9, 10].

At the *subatomic level* of motion-rest, under the high degree of ordering, the temperature microfield is, in essence, a different expression of the “electromagnetic” field.

According to the equation (37), the speed of pulsations of the wave shell of the hydrogen atomc at the temperature of $T_0 = 273\,K$, in a general case, is

$$\upsilon = \frac{\omega_0 A_m}{z'_{m,n}} \sqrt{T_0} \approx \frac{3103}{z'_{m,n}} \; m \cdot s^{-1}. \tag{41}$$

This field of motion-rest generates its own basis level of the wave motion. The maximal speed of pulsation of the nucleon shell, equal to $\upsilon_m = 1490 \; m \cdot s^{-1}$, corresponds to the root $z'_{1,1} = a'_{1,1} = 2.08157598$.

At depths of 100–200 *m*, in warm seas, the sound speed amounts to the minimum, which is about $1490 \, m \cdot s^{-1}$. In other liquids, sound speed is also close to this value. It allows concluding that carriers of sound waves are *hydrogen atoms*, which are constituents of all other atoms, and their field. Consequently, *sound waves* are *extended across the all levels*, overlying and underlying, of cosmic space. In solid, liquid, and gaseous spaces, the intensity of sound waves is comparatively simply registered by various modern devices. However, in Cosmos their intensity is negligibly small and it is natural that the modern technical devices cannot perceive them.

4. The Avogadro constant

Since $h = 2\pi m_e \upsilon_0 r_0$ and $R_\infty = \dfrac{\upsilon_0}{4\pi r_0 c}$, the amplitude (31) can be rewritten as

$$A_m = \frac{m_e \upsilon_0^2}{m_0 c^2} r_0^2, \qquad \text{or} \qquad A_m = \alpha^2 r_0^2 \frac{m_e}{m_0} \tag{42}$$

where $\alpha = \dfrac{\upsilon_0}{c}$ is the fine-structure constant; r_0 and υ_0 are the Bohr radius and speed, respectively.

The meaning of the oscillation amplitude of the spherical shell of the hydrogen atom A_m is clearly seen from the above presentation of the form (42). The amplitude A_m is proportional to the Bohr radius squared and to the ratio of two characteristic energies of the binary wave system (the hydrogen atom is such a system): an oscillatory energy of the orbiting electron, $m_e \upsilon_0^2$, and the dynamic (carrying) energy of the pulsating proton, $m_0 c^2$ [11].

Hence, setting (42) in (30), with allowance for (32) and because

$$\omega_0 = \frac{\omega_e}{10^2 \Delta}, \tag{43}$$

$$\lambda\!\!\!^{-}_e = \frac{1}{k} = \frac{c}{\omega_e}, \tag{44}$$

where *k* is the wave number, we arrive at

$$E_s = \frac{k_B}{2} = \frac{m_e \omega_0^2}{2a_{1,1}'^2}\left(\frac{\upsilon_0}{c}\right)^2 r_0^2 = \frac{m_e \upsilon_0^2}{2a_{1,1}'^2}\left(\frac{r_0^2}{\lambda\!\!\!^{-}_e{}^2}\right)\frac{1}{10^4 \Delta}\, erg\,. \tag{45}$$

Thus, the constant k_B of the dimensionality of energy,

$$k_B = 2E_s\,, \tag{46}$$

is the combination (product) of the fundamental parameters (constants), which characterize the wave motion at the atomic level: the *oscillatory energy* of an electron in the hydrogen atom $m_e \upsilon_0^2$, the *Bohr radius* r_0, the *fundamental wave radius* $\lambda\!\!\!^{-}_e$, and the *fundamental period-quantum* Δ.

The constant k_B (33) is "fundamental" in the meaning just like it is "fundamental" the fine-structure constant α. The latter is a dimensionless quantity, but formed from the four basic physical constants $e, \hbar, c$ and ε_0, being at the same time the ratio of two basic speeds, υ_0 and c, [12]:

$$\alpha = \frac{e^2}{4\pi\varepsilon_0 \hbar c} = \frac{\upsilon_0}{c}\,. \tag{47}$$

Setting (47) in (45), the characteristic quantum of energy E_s can be presented also by the three fundamental constants: m_e, r_0, ω_0 (we assume that ω_0 must belong to them), and α (which is the combination of other fundamental constants):

$$E_s = \frac{k_B}{2} = \frac{m_e \omega_0^2}{2a_{1,1}'^2}\alpha^2 r_0^2\,. \tag{48}$$

Thus, an explicit form of the fundamental constant k_B (see (33)) is

$$k_B = m_e \omega_0^2 r_0^2 \alpha^2 \left(\frac{1}{a_{1,1}'}\right)^2. \tag{49}$$

Accordingly, the Avogadro constant N_A can be presented by the following formula:

$$N_A = \frac{R}{k_B} = \frac{a_{1,1}'^2 R}{m_e \omega_0^2 r_0^2 \alpha^2}\,. \tag{50}$$

Calculations of N_A carried out with use of this expression, where $R = 8.3144621\ J \cdot mol^{-1} \cdot K^{-1}$, give

$$N_A = 6.152995046 \cdot 10^{23}\, mol^{-1}\,. \tag{51}$$

We see that the resulting value of N_A practically coincides with (4), $N_A \approx 6.16 \cdot 10^{23}\, mol^{-1}$, obtained theoretically by Planck from his radiation formula (6).

5. Conclusion

A new insight into the notions of the Boltzmann constant and the absolute temperature, originated from the Shell-Nodal atomic model and the Dynamic Model of elementary particles, earlier presented in [13] and also in an article posted (in 2008) on the author's website [14], has been considered in this Lecture.

It was shown that the Boltzmann constant k_B represents, in essence, a *quantum of average energy of a nucleon* at the level of so-called *meson frequency* ω_0. The number of such quanta defines the relative *nucleon potential-kinetic energy* of a system, which inherently is what we call the *absolute temperature*. The latter is the *alternating wave magnitude*, as the relative potential-kinetic energy, according to the found peculiarity. Therefore, the absolute temperature is *negative* for the relative potential energy and *positive* for the relative kinetic energy.

The coincidence of the two values for the fundamental constant N_A, (4) and (51), obtained theoretically by two different ways, respectively: by Planck with use of his radiation formula (6) and just as was done in the WM by Eq. (50) [13, 14], that has been demonstrated here, naturally called certain questions which were resolved. An analysis of the resulting data leads to the natural assertion that Planck's calculations of 1901 and the calculations presented here gave the more *correct* value of N_A than the value (4) accepted in modern physics. Why?

As can be seen, N_A (51) derived in the WM from (50) represents by itself (like k_B, see (33) and (49)) the truly *fundamental* constant of the atomic level. The word "*fundamental*" is applicable to the obtained physical constant (and, hence, to the derived Boltzmann constant k_B) by the reason that its value is the combination of the truly *fundamental physical constants* entering in the formula (50) of determining N_A; just like it takes place with the fine-structure constant α (47) which, being also the combination of other fundamental constants, is recognized as fundamental.

The accepted value of N_A (5), obtained in modern physics by the *indirect* way from calculations based on the data of measured parameters related to the structure of matter, does not respond to the above definition, *i.e.*, to the condition for to be fundamental, it differs from the theoretical values, (4) and (51). For this reason, being not a *fundamental constant* in the above meaning, we have grounds asserting that the Avogadro constant (like the accepted value of k_B) is not precisely defined by commonly used methods.

In light of the presented above findings, it seems to be obvious; the Avogadro and Boltzmann constants have to be subjected to the further comprehensive analysis and reconsideration, and the methods of their determinations should be reevaluated.

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Lecture 3

Subelectronic Particles

1. Introduction

Continuing our discussion on the flaws inherent in theories within the Standard Model dominating in modern physics, which began in Lecture 1 with quantum mechanics, we decided now to turn attention of the readers to our view, based on the Wave Model, to the particles of the subelectronic level of the Universe. Specifically, we intend to consider the nature of *photons* and a role of subelectronic particles well-known in physics as *neutrinos*. What they are both, and whether is a relation between them?

A photon is usually considered as a *quantum* of light and all other forms of electromagnetic radiation. However, the main features ascribed in physics to a photon, as to the quantum of electromagnetic radiation, are very strange, unreal in essence. Actually, according to modern notions, photons are *massless* and *formless* neutral (with zero charge) formations, *i.e.*, in fact, they represent *mathematical points*. For this reason, and basing on common sense, they are no more than mystic images. Nevertheless, a photon is considered in physics as an elementary particle, having, besides, a spin 1.

Thus, following Einstein, electromagnetic (EM) waves represent a flux of quanta of *pure energy* in the form of *massless* particles (called in 1923 by Compton *photons*), moving with the speed of light c. How could appear such a strange concept of *massless* mysterious particles?

Introducing for the first time, in 1905, the notion of small portions ("grains") of energy ("lightquanten") rushing in *empty space* with the speed c [1], Einstein was forced to accept their rest mass m_0 to be equal to zero; otherwise their relativistic mass m will turn out to be equal to infinity according to the equation $m = \frac{m_0}{\sqrt{1-\upsilon^2/c^2}}$. And he had understood that it is unconditionally inadmissible. His quanta of energy have no size in space being mathematical *formless* objects. Indeed, the relativistic relation (Lorentz-FitzGerald contraction) for lengths of objects, moving along the x-axis with a velocity υ, has the form $\Delta x = \Delta x_0 \sqrt{1-\frac{\upsilon^2}{c^2}}$.

Einstein interpreted the length Δx_0 as a length in a state of rest, and the length Δx - as a length in a state of motion. Because of this, the length of an object moving with the speed c in the direction of motion is assumed to be equal to zero. As a result of such an interpretation, a photon is transformed into a fig-leaf of a zero thickness, which, moreover, moves in an allegedly empty space and has wave properties, looking like (in some meaning) an energetic snake-sinusoid. It transgresses the bounds of science. Such a model of the wave motion of something representing nothing is deeply naïve and speculative. Obviously, the concept of mystic photons with unusual properties, nonsensical to real essences, is a result of disregarding common sense for the sake of fitting such a concept to the theory of relativity.

We will try to elucidate the physical meaning of the aforementioned fundamental notions, basing on the wave approach, to which we adhere, answering to the following fundamental questions. What represents a photon, substantially, as a material formation? What is mass of photons? Whether there is a bond between luminiferous photons and neutrinos?

Answering to the aforementioned questions, we take into account the dialectical binary character of the wave process and apply a new view on an effect of wave perturbation caused by an electron in transient processes of an exited atom. A mechanism of propagation of electromagnetic waves in space, considered here, differs also from the well-known established explanations.

According to the Wave Model, photons are *ponderable* particles; as all other particles they have *mass* and *size*. Their mass spectrum, belonging to the subelectronic level, coincides with the *mass spectrum of neutrinos*. These particles fill up the cosmic space. They are responsible for the electromagnetic energy transport over a wide band of wavelengths, which proceeds like propagation of any material waves, *e.g.*, sound waves in an ideal gas.

Let us proceed now to discussing the arguments in favor of the above assertions.

2. Basis and superstructure in wave processes

One should realize that wave motion is the *mass process* having the binary character [2]. It means that the wave process of any subspace of the Universe runs simultaneously at two levels: a level of *basis* and a level of *superstructure*. The *basis level* embraces an interaction of particles between themselves in a subspace. This interaction gives rise to its own *superstructure*, which is the dynamic collective interaction of particles with the subspace resulted in the wave motion of the longitudinal-transversal structure. Here, the *basis* is the *cause* and *superstructure* is the *effec*t. Thus, any wave process is a contradictory complex of *basis* and *superstructure*, of *cause* and *effect*.

For example, an interaction of atoms between themselves in a string (fixed from both ends) is a process occurring at the level of *basis* of the string. A disturbance of the equilibrium interaction (caused by an external influence) leads to the expansion of this

disturbance along a string, which has the wave character. At that the *oscillatory* motion with the speed υ of every atom of the mass *m* of the string (in the wave of the expansion) and the *wavelength* itself λ_υ represent the collective parameters of the wave motion related to the level of *superstructure*.

The energy of the wave quantum of *superstructure*

$$E = h\frac{\upsilon}{\lambda_\upsilon} \tag{1}$$

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

$$E = h\frac{c}{\lambda}, \tag{2}$$

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

$$\nu_1 = \frac{1}{T_1} = \frac{\upsilon}{\lambda_1} = \frac{c_a}{\lambda_a}. \tag{3}$$

The similar situation takes place under disturbance of the hydrogen atom, where υ is the orbital (oscillatory) speed of the electron – superstructure of H-atom. The basis speed, equal to the speed of light *c*, is the speed of interaction (strictly speaking, of exchange of matter-space-time) of the longitudinal (radial) wave field of the proton with the transversal (cylindrical) wave field of the electron at the fundamental frequency of exchange of the subatomic level ω_e [3]. At the same time, *c* is the basis speed of interaction of any particles of the subatomic level, including elementary particles vibrating (during the wave process) in an outer space with a variable speed of superstructure υ dependent on the intensity of their disturbance.

3. Associated nature of particle mass

As concerns the notion of mass, according to the Dynamic Model of Elementary Particles (DM), the rest mass of elementary particles does not exist. That we call the rest mass m_0 is actually the *associated mass*, so that for any material microobjects the inequalities $m_0 \neq 0$ and $m_0c^2 \neq 0$ are valid. The mass of all elementary particles has thus the associated character and is the measure of exchange of matter-space-time. The rate of mass exchange defines the

exchange charge, its dimensionality is $g \cdot s^{-1}$. All details about associated nature of mass were considered in Lectures of Vol. 2.

According to the Wave Model, during the motion in a transient process, the electron in the hydrogen atom causes the wave perturbation. The myriad of particles of the subelectronic level is involved in this process. These particles have nothing in common with mathematical points-photons of zero rest mass, $m_0 = 0$, and, correspondingly, *zero rest energy*, $m_0 c^2 = 0$. They represent a huge world of particles which belong to the level lying below the electron level. For them, Earth is in the highest degree the "rarefied" spherical space. These particles pierce the Earth just freely as asteroids pierce the space of the solar system and galaxies. Just their directed motion, fluxes, called "magnetic field" surrounds a conductor with a current, a bar magnet, our Earth and fills up interplanetary, interstellar, and intergalactic spaces. It is the cylindrical field-space of the subelectronic level.

Mysterious neutrinos belong to a rich spectrum of subelectronic particles. Their rest mass is believed to be zero, as the rest mass of photons, so according to the theory of relativity the particle must move with the speed of light with respect to any observer. A neutrino that transfers "relativistic" mass m also transfers energy mc^2 and momentum mc.

An analysis conducted in [2] shows that it is acceptable to identify neutrinos with subelectronic particles, which have the associated mass $m_0 \neq 0$ much less that the electron mass. These particles fill up cosmic space and are, apparently, that material medium owing to which the propagation of electromagnetic waves is realized in nature.

In this Lecture we intent to discuss the wave propagation of EM radiation in space filled up with neutrinos. With this, we rest on a supposition according to which the propagation of EM waves (including the light band) occurs in such a space like propagation of any material waves, for instance, sound waves in an ideal gas. We will show that masses of subelectronic particles responsible for the propagation of EM waves are equal in value to the masses of neutrinos, which were ascribed to them in last years. This material reproduces without substantive changing the paper published in 2004 [4].

Let us define and specify now the *notion of mass* for particles participating in a wave process, which is one of the main in principle notions necessary for the present consideration.

4. Field mass and a quantum of mass of radiation

Important parameters of wave processes are the mass m of vibrating particles participating in wave motion (in transfer of energy carried by the wave), the speed of their vibrating (the speed of superstructure of the wave), and the wavelength λ, representing the collective parameter (of superstructure) of the wave motion. The above parameters are

indissoluble; therefore, it is natural to introduce the dynamic parameters of superstructure such as the momentum

$$p = m\upsilon\,, \tag{4}$$

and the wave action

$$h = m\upsilon\lambda\,, \tag{5}$$

and the wave number of superstructure

$$k = \frac{2\pi}{\lambda} = \frac{2\pi p}{h}\,. \tag{6}$$

Vibrating particles represent the discrete component of the wave, whereas the wave motion of the particles is the continuous component of the wave. At the same time, the wavelength expresses the discrete side of the wave space, defining the natural quantum of its extensiveness λ. The quantum λ is indissolubly related with the time period-quantum by the speed of the wave process *c* at the level of basis

$$\lambda = cT\,. \tag{7}$$

The wave process is the exchange of motion and the exchange of mass. Accordingly, it is necessary to distinguish the power of exchange of motion

$$F = m\frac{d\upsilon}{dt} \tag{8}$$

and the power of exchange of mass

$$F = \frac{dm}{dt}\upsilon\,. \tag{9}$$

We must also distinguish the three kinds of energies of exchange [2, 5] in wave processes:

1) *oscillatory* (vibrating) energy E_υ, the energy at the level of superstructure,

$$E_\upsilon = \int \frac{dm}{dt}\upsilon dl = \int \frac{dm}{dt}\upsilon\upsilon dt = \int \upsilon^2 dm\,, \quad \Delta E_\upsilon = \Delta m\upsilon^2\,; \tag{10}$$

2) *wave* (transfer) energy E_c, the energy at the level of basis,

$$E_\upsilon = \int \frac{dm}{dt} c dl = \int \frac{dm}{dt} c c dt = \int c^2 dm\,, \quad \Delta E_c = \Delta m c^2\,; \tag{11}$$

3) *oscillatory-wave* energy $E_{\upsilon c}$ and $E_{c\upsilon}$, the energy at the level of basis-superstructure,

$$E_{\upsilon c} = \int \frac{dm}{dt}\upsilon dl = \int \frac{dm}{dt}\upsilon c dt = \int \upsilon c dm\,, \quad \Delta E_{\upsilon c} = \Delta m\upsilon c\,, \tag{12}$$

$$E_{c\upsilon} = \int \frac{dm}{dt} c dl = \int \frac{dm}{dt} c\upsilon dt = \int c\upsilon dm, \quad \Delta E_{c\upsilon} = \Delta m c\upsilon . \tag{13}$$

Last two energies are qualitatively different, however, quantitatively they are equal. The mass Δm is the mass of a group of particles (a cluster) participating in the wave motion.

The *oscillatory-wave energy density* is equal to

$$w_{ow} = \rho\upsilon c , \tag{14}$$

where ρ is the *density* of a medium, υ is the *oscillatory speed* of particles (superimposed onto the speed of their incessant random motion and a drift) involved in the wave process of energy transfer of a disturbance, c is the *wave phase speed* of propagation of the disturbance in the medium.

The relation between the speeds of basis and superstructure, *i. e.*, between oscillatory and wave speeds, υ and c, has the fundamental meaning. The maximal ratio of the speeds is expressed by the fine-structure constant alpha

$$\alpha = \frac{\upsilon_0}{c} = 7.297352568(24) \cdot 10^{-3} , \tag{15}$$

where $\upsilon_0 = 2.187691263 \cdot 10^8 \; cm \cdot s^{-1}$ is the speed of the electron on the Bohr first orbit. This interpretation of physical meaning of alpha is less known for the majority. The more known definition of alpha according to which it is a dimensionless quantity formed from the four basic physical constants e, $\hbar$, c, and ε_0:

$$\alpha = \frac{e^2}{4\pi\varepsilon_0 \hbar c} , \tag{16}$$

regarded as the “coupling constant” or measure of the strength of the electromagnetic force that governs how electrically charged elementary particles (*e.g.*, electron, muon) and light (photons) interact.

As was shown in [5], alpha reflects the *scale correlation* of basis and superstructure of wave fields-spaces of objects in the Universe, *i.e.*, conjugate oscillatory-wave processes at different levels of the Universe (this issue was considered in detail in Lecture 9 of Vol. 2). In particular, alpha constant shows the maximal possible oscillatory speed of coupled particles – a lighter particle of superstructure (electron) with respect to the basis speed of its interaction (binding) with the heavier conjugate basis particle (proton) at equilibrium,

$$\upsilon_{\max} = \alpha c . \tag{17}$$

By the way, in the works [2, 5] it was shown as well that the fundamental physical constants, such as the Planck constant h and the fine-structure constant α, characterize also some of the dynamic parameters of man at the acoustic level, in particular, perception of sound by man – threshold of audibility and threshold of pain.

Let us suppose that the same relation for both speeds, oscillatory and wave, is valid for a huge world of particles of the subelectronic level filling the interstellar and intergalactic spaces. As was mentioned in Introduction, these particles are, apparently, responsible for the transfer of EM (including light) energy. With allowance for (17), their maximal *oscillatory-wave energy density* $w_{ow} = \rho\upsilon_{\max}c$ (14) can be expressed as

$$w_{ow} = \rho\alpha c^2, \tag{18}$$

where ρ is the density of the space consistent of these particles. Note in this connection that the space of such particles is one of the infinite set of spaces of the Universe embedded in each other [2, 3].

The energy of quanta of EM radiation, transmitted through the space, depends on the frequency of radiation ν and is defined by the equation $E = h\nu$, where $h = 6.6260693(11)\cdot 10^{-27}\ erg\cdot s$ is the Planck constant. Obviously, for the transfer of the same amount of energy and with the same frequency by particles behaving like particles of an ideal gas, the Planck's action *h* has to be equal to the *oscillatory-wave action* of the particles, which is defined by

$$h_{ow} = \frac{m_\lambda w_{ow}}{\rho\nu}. \tag{19}$$

In this expression m_λ is the *field mass* bound up with the wave λ. This mass differs from the equivalent mass *m* estimated from the dynamic energy $E = mc^2$ [3]. The mass m_λ is ranged within the values

$$m_\lambda = \frac{h_{ow}\rho\nu}{w_{ow}} = \frac{h\nu}{\upsilon c} \tag{20}$$

defined by the frequency band of EM spectrum. Obviously, in the case when $\frac{\upsilon}{c} = \alpha$, the mass m_λ is approximately 137 times as much the mass *m* of particles, whose dynamic energy at the subatomic level is equal to mc^2. Thus, because the energy of transmitted quanta $h\nu$, equal to the oscillatory wave energy

$$h_{ow}\nu = m_\lambda \upsilon c, \tag{21}$$

is compared to the energy mc^2 (as it takes place at the estimation of the equivalent mass of photons), we have under the condition $\frac{\upsilon}{c} = \alpha$ the *field mass*

$$m_\lambda = \frac{m}{\alpha} \approx 137\, m. \tag{22}$$

Let us show how one can come to this relation in other way [2].

In wave processes, the change of an extension Δl of the wave element of space (along the wave-beam) takes place. Simultaneously, the change of the field mass, Δm_λ, bound up with an element of space l, occurs. The following relation approximately expresses this peculiarity:

$$\frac{\Delta l}{l} = \frac{\Delta m_\lambda}{m_\lambda}. \tag{23}$$

The Δl is the local extension stipulated by oscillations of a group of particles with the speed υ; therefore, $\Delta l = \upsilon \Delta t$. The element of space is defined as $l = c\Delta t$, hence, we have

$$\frac{\Delta l}{l} = \frac{\Delta m_\lambda}{m_\lambda} = \frac{\upsilon}{c} = \frac{\omega a}{c} = ka, \tag{24}$$

where a is the amplitude of axial displacement. Hence, the axial element of the mass Δm_λ, say "thickening" (let us denote it as m_r), along the wave-beam of basis is

$$m_r = \Delta m_\lambda = \frac{\upsilon}{c} m_\lambda = m_\lambda ka. \tag{25}$$

In the limiting case, when $\upsilon = c$, the field mass m_λ and the mass m_r are equal, $m_\lambda = m_r$. One should regard the wave "thickening" of the mass m_r as the *wave quasiparticle*. If its mass turns out to be equal to the electron mass, this particle can be regarded as a quasielectron, or a wave electron, participating only in the wave process of radiation and absorption. Thus, for the wave λ, the following relation is valid:

$$\frac{m_r}{m_\lambda} = \frac{\upsilon}{c} = \frac{2\pi a}{\lambda} \tag{26}$$

and

$$m_\lambda = \frac{c}{\upsilon} m_r. \tag{27}$$

If $\upsilon = \upsilon_0$ is the Bohr velocity, corresponding to the amplitude equal to the Bohr radius, $a = r_0$, and m_r is the quasielectron, then, the mass of radiation (field mass) m_λ of the unit wave quantum (quantum of mass of radiation) m_r is

$$m_\lambda \approx 137 m_r. \tag{28}$$

5. Mass spectra of neutrinos and luminiferous photons

According to contemporary physics, the EM spectrum is between the frequency limits

$$3 \cdot 10^0\ s^{-1} \qquad \text{and} \qquad 3 \cdot 10^{22}\ s^{-1}. \tag{29}$$

As was shown in the works [2, 3], the fundamental frequency of exchange (interaction) at the subatomic level is equal to

$$\omega_e = 1.869162505 \cdot 10^{18}\, s^{-1}. \tag{30}$$

In fact, it is the frequency of the field which is regarded in contemporary physics as *electrostatic*. This frequency, unrecordable on the human time scale, is the carrying frequency of EM waves and, accordingly, it is the ultimate frequency of the EM spectrum. Therefore, all observed (detected) electromagnetic waves are just the waves of the frequency modulation of this carrying exafrequency ω_e.

The fundamental wave radius $\lambda\!\!\!^{-}_e$, corresponding to the fundamental frequency ω_e, is

$$\lambda\!\!\!^{-}_e = \frac{c}{\omega_e} = 1.603886538 \cdot 10^{-8}\, cm. \tag{31}$$

It is equal to one-half of an average value of interatomic distances in crystals. This fact shows that the frequency of the field responsible for the interaction (binding) between atoms in substance is equal to the aforementioned fundamental carrying frequency of the subatomic level ω_e.

Accordingly, for the ultimate value of the EM band of frequencies, $\nu_u = \nu_e = \frac{\omega_e}{2\pi} = 2.97486452 \cdot 10^{17}\, s^{-1}$, we have the following ultimate value of the *field mass* (under the condition that $\upsilon = \alpha c$):

$$m_{\lambda,u} = \frac{h\nu_e}{\alpha c^2} = \frac{6.6260693 \cdot 10^{-27} \cdot 2.97486452 \cdot 10^{17}}{7.297352568 \cdot 10^{-3} \cdot (2.99792458 \cdot 10^{10})^2} = \\ = 3.00549679 \cdot 10^{-28}\, g \approx 0.33\, m_e, \tag{32}$$

where $m_e = 9.109382531 \cdot 10^{-28}\, g$ is the electron mass.

As follows from the experiment [6], the same mass is ascribed to a limiting mass of *muon neutrino*,

$$m_\mu < 170\, keV = 0.33\, m_e \tag{33}$$

(the electron mass in the units of energy is $m_e c^2 = 510.998902(21)\, keV$).

The corresponding ultimate quantum of mass of particles of the EM band, equivalent to the energy mc^2, is

$$m_r = m_{\lambda,u}\alpha = 2.193216972 \cdot 10^{-30}\, g \approx 2.4 \cdot 10^{-3}\, m_e. \tag{34}$$

The waves of near infrared, visible, and near ultraviolet relate to the frequency band of $\nu = 3 \cdot 10^{14} \div 3 \cdot 10^{15}\ s^{-1}$. For the value near $\nu = 6.15 \cdot 10^{14}\ s^{-1}$, we arrive at the following *field mass*

$$m_{ph} = \frac{h\nu}{\alpha c^2} = 62 \cdot 10^{-32}\ g \approx 68 \cdot 10^{-5}\ m_e . \tag{35}$$

This quantity is multiple to the characteristic value of the metrological spectrum [7].

Masses of all elementary particles take the definite discrete (quantum) values. The mass m_{ph} obtained is close to the mass of quanta of the visible region, near ultraviolet. It is multiple on the average (in units of the electron mass) to the fundamental measure [8] in a quarter of the fundamental period Δ,

$$\Delta = 2\pi \lg e = 2.7288 : \tag{36}$$

$$\tfrac{1}{4}\Delta = (\pi / 2) \lg e = 0.682196844 , \tag{37}$$

like well-known elementary particles. For instance, on the average, *g*-particle has the mass,

$$m_g \approx \tfrac{1}{4}\Delta \cdot 10^2 = 68.22\, m_e , \tag{38}$$

γ -quantum,

$$m_\gamma \approx \tfrac{2}{4}\Delta \cdot 10^2 = 136.44\, m_e , \tag{39}$$

$\mu^{\pm}$ -mesons,

$$m_\mu \approx \tfrac{3}{4}\Delta \cdot 10^2 = 204.656\, m_e , \tag{40}$$

$\pi^{\pm}$ -mesons,

$$m_\pi \approx \tfrac{4}{4}\Delta \cdot 10^2 = 272.88\, m_e , \tag{41}$$

etc. (some details on this matter one can find in the works [7, 8]).

The *g*-particle had no luck. It was ascribed to the spectrum of elementary particles under different names, such as muonic and electronic neutrino and antineutrino, *etc*.

An average mass of *tau neutrino* discovered later is about 34 m_e [6]; accordingly, *g*-quantum could be regarded as consistent of two particles of the mass

$$m_\tau \approx \tfrac{1}{8}\Delta \cdot 10^2 = 34.11 m_e . \tag{42}$$

A relation between masses of the components of the hypothetic coupled system, the m_{ph} *particle* (photon or neutrino, (35)) – the *electron* (m_e), almost coincides with the analogous relation existed between the masses, m_e and m_p, of a components in the *electron-proton* system (as it is realized in the hydrogen atom):

$$\frac{m_{ph}}{m_e} = \frac{62 \cdot 10^{-32}\ g}{9.109382531 \cdot 10^{-28}\ g} \approx 68 \cdot 10^{-5}, \tag{43}$$

$$\frac{m_e}{m_p} = \frac{9.109382531 \cdot 10^{-28}\ g}{1.67262171 \cdot 10^{-24}\ g} \approx 54.46 \cdot 10^{-5}\ , \tag{44}$$

Therefore, it is believable that particles just of the mass m_{ph} (35) are related to satellites of electrons, just like electrons relate to satellites of proton. The more so neutrinos are created with electrons when an atom disintegrates through beta decay. The quantum of mass of radiation of these particles (equivalent to the energy mc^2) is

$$m = m_{ph}\alpha = 4.52 \cdot 10^{-33}\, g \approx 49 \cdot 10^{-7}\, m_e\,. \tag{45}$$

This mass is close to the one of the estimated upper limits of the electron neutrino mass,

$$m_e < 2.5\, eV = 49 \cdot 10^{-7}\ m_e\,. \tag{46}$$

For the frequency, lying close to the mean value of the whole EM spectrum, $<\nu> = 1.23 \cdot 10^{11}\, s^{-1}$, we obtain the following unit field mass

$$m_{\lambda,\nu} = \frac{h<\nu>}{\alpha c^2} = 17.03201074 \cdot 10^{-33}\ g \approx 18.7 \cdot 10^{-6}\, m_e \tag{47}$$

In this case, the quantum of mass (equivalent to the energy mc^2) is

$$m_\nu = m_{\lambda,\nu}\alpha = 124.2885873 \cdot 10^{-36}\, g \approx 136.44 \cdot 10^{-9}\, m_e\,. \tag{48}$$

The chosen frequency $<\nu>$ relates to the extremely high frequency (EHF) band of millimeter waves. It is the region of the cosmic microwave background radiation [9, 10]. The mass obtained and taken for estimations is also multiple (in units of the electron mass) to a quarter of the fundamental measure Δ (36). It practically coincides with one of the highly plausible masses of neutrinos estimated roughly in [11] around

$$m_\nu = 0.07 \pm 0.04\, eV\,. \tag{49}$$

Taking into account the multiplicity of elementary particles to the aforementioned fundamental measure of $\frac{1}{4}\Delta$, the expectative value of neutrino mass in units of the electron mass is about

$$m_\nu = (136 \pm 68) \cdot 10^{-9}\, m_e\,. \tag{50}$$

6. Density and modulus of elasticity of cosmic space

A particle flux of the discrete spectrum of masses, responsible for the transfer of EM radiation, fills in and drifts in cosmic space. Their density depends on the carrying frequency of the EM spectrum, basis speed and temperature. We know from experience that at illumination of 50 lux and $\lambda = 0.55 \cdot 10^{-4} cm$, the number of photons incident on a surface of 1 cm^2 per one second is $N = 2 \cdot 10^{13} cm^{-2} \cdot s^{-1}$. Such an illumination is usual for reading without fatigue of eyes. In this case, the photon concentration is

$$n = \frac{N}{c} = \frac{2 \cdot 10^{13}}{3 \cdot 10^{10}} \approx 660 cm^{-3}. \tag{51}$$

Assuming roughly that in outer space of Cosmos an average concentration of particles of the subelectronic level, transmitted EM energy of radiation, is equal to the same order of magnitude as photons have in the above case, we obtain for the particles of the mass $m_{ph} = 68 \cdot 10^{-5} m_e$ (35) the following density

$$\rho_{ph} = n m_{ph} = 660 \cdot 62 \cdot 10^{-32} \approx 4.1 \cdot 10^{-28} g \cdot cm^{-3}. \tag{52}$$

For the particles of the mass $m_{\lambda,\nu} = 18.7 \cdot 10^{-6} m_e$ (47), we have

$$\rho_{\lambda,\nu} = n m_{\lambda,\nu} = 660 \cdot 17.03 \cdot 10^{-33} \approx 11.2 \cdot 10^{-30} g \cdot cm^{-3}. \tag{53}$$

The modulus of elasticity of such hypothetical field-spaces, filled with the above particles, is turned out to be equal, respectively, to

$$E_{ph} = \rho_{ph} c^2 \approx 4.1 \cdot 10^{-28} \cdot (3 \cdot 10^{10})^2 = 3.69 \cdot 10^{-7} dyne \cdot cm^{-2} \tag{54}$$

and

$$E_{\lambda,\nu} = \rho_{\lambda,\nu} c^2 \approx 11.2 \cdot 10^{-30} \cdot (3 \cdot 10^{10})^2 = 10.08 \cdot 10^{-9} dyne \cdot cm^{-2}. \tag{55}$$

The possible shortest wavelength of transfer of wave disturbance is determined by the possible shortest average distance between vibrating particles, which are regarded as particles of an ideal gas being in ceaseless random motion. We assume that the minimal average distance between subelectronic particles in Space cannot exceed the double value of the fundamental wave radius $\lambda\!\!\!^{-}_e$ of the subatomic level. This condition is realized, for instance, in crystals. In such a case, for the volume occupied by one particle

$$V = (2\lambda\!\!\!^{-}_e)^3 = 33.0073978 \cdot 10^{-24} cm^3, \tag{56}$$

the density of the field-space of particles, *e.g.*, of the mass $m_\nu = 136.44 \cdot 10^{-9} m_e$ (3.20) in outer space of Cosmos (see Table 1) is

$$\rho_\nu = \frac{m_\nu}{V} = \frac{124.28858678 \cdot 10^{-36}}{33.0073978 \cdot 10^{-24}} \approx 3.76 \cdot 10^{-12}\, g \cdot cm^{-3}, \tag{57}$$

and the modulus of elasticity of such a field-space is turned out to be equal to

$$E_\nu = \rho_\nu c^2 \approx 3.76 \cdot 10^{-12} \cdot (3 \cdot 10^{10})^2 = 3.38 \cdot 10^9\, dyne \cdot cm^{-2}. \tag{58}$$

Table 1. The density, base speed and modulus of elasticity of different media

Parameters	*air*	$m_{ph} - gas$ ($for\ n = 660\ cm^{-3}$)	$m_\nu - gas$	$m_\nu - gas$ ($n = 3 \cdot 10^{22}\, cm^{-3}$)	*sea water*
$\rho\ (g/cm^3)$:	$1.21 \cdot 10^{-3}$	$4.1 \cdot 10^{-28}$	$11.2 \cdot 10^{-30}$	$3.76 \cdot 10^{-12}$	1.02338
$c\ (cm/s)$:	$3.44 \cdot 10^4$	$3 \cdot 10^{10}$	$3 \cdot 10^{10}$	$3 \cdot 10^{10}$	$1.5 \cdot 10^5$
$\rho c^2\ (dyne/cm^2)$:	$1.42 \cdot 10^6$	$3.69 \cdot 10^{-7}$	$10.08 \cdot 10^{-9}$	$3.38 \cdot 10^9$	$2.3 \cdot 10^{10}$

For comparison with the above obtained parameters, there are presented analogous parameters estimated for air (T = 293 K, P = 1 atm) and sea water (T = 288 K) used for the description of propagation of sound in them [12]. The modulus obtained exceeds the modulus of elasticity of air, but less than that one of water. The temperature of the medium, consistent of particles of the mass $m_\nu = 136.44 \cdot 10^{-9} m_e$, obviously, could be assumed to be equal to the temperature of cosmic background radiation, which is equal to 2.7288 K [9, 10, 13].

7. Oscillatory speed of neutrinos participating in wave propagation

Let us estimate the oscillatory speed of m_ν-particles assuming that they transmit the quanta of energy of the wide band of EM spectrum of waves. With that, one should not forget that the oscillatory and wave speeds are the speeds of motions superimposed onto the ceaseless random motion and a drift of particles as it takes place in a gas. The oscillatory-wave action h_{ow}, equal to Planck's action h, is

$$h = h_{ow} = \frac{m_{\lambda,\nu} w_{ow}}{\rho\nu} = \frac{m_{\lambda,\nu} \upsilon c}{\nu} = m_{\lambda,\nu} \upsilon \lambda\,. \tag{59}$$

Hence, for $\lambda = 0.555 \cdot 10^{-4}\, cm$ of the visible band (green light), corresponding to the maximal sensitivity of human eye, the *oscillatory* speed of m_ν-particles must be equal to

$$\upsilon = \frac{h}{m_{\lambda,\nu}\lambda} = \frac{6.62606876 \cdot 10^{-27}}{17.03201074 \cdot 10^{-33} \cdot 0.555 \cdot 10^{-4}} = 7 \cdot 10^{9}\, cm/s, \qquad (60)$$

i.e., it exceeds $\upsilon \approx \frac{c}{137}$ and is close to the basis speed of subatomic level *c*. For $\lambda = 3 \cdot 10^{2}\, cm$, related to the frequency $\nu = 10^{8}\, s^{-1}$ of the television band of EM waves, the oscillatory speed is $\upsilon = 1.3 \cdot 10^{3}\, cm \cdot s^{-1}$. For $\lambda = 3 \cdot 10^{4}\, cm$, $\nu = 10^{6}\, s^{-1}$ of the radio waves band, the oscillatory speed of m_ν-particles is $\upsilon = 13\, cm \cdot s^{-1}$, *etc.*

8. Conclusion

It is highly plausible that ghostly electron neutrinos are nothing else than ponderable particles of the mass spectrum of the subelectronic level responsible for the energy transport of a huge EM band of wavelengths. Most of the above described particles, including those of the mass $m_\nu = 136.44 \cdot 10^{-9}\, m_e$, rather represent a part of a whole spectrum of the particles. Judging by their masses, these particles, identical in mass with electron neutrinos, can be referred to satellites of electrons. The more so the ultimate estimated mass of electron neutrinos, known from the literature, does not exceed $m_\nu = 20\, eV \approx 4 \cdot 10^{-5}\, m_e$. In a sense, like fish in an ocean of water, we live in an ocean of neutrinos do not feeling it. As concerns mystic massless and formless mathematical points-photons, it is obvious, such objects do not exist in nature; they relate to the realm of fancy.

A hypothesis about the same nature of mass both photons and neutrinos, put forward in [4], along with other hypotheses touched here too, can untie many misconceptions of modern physics and astrophysics. In particular, it can help revealing the characteristic feature of the ether-drift of about $20\, km \cdot s^{-1}$ in approximately the south-north direction along the horizontal component of Earth's magnetic field, observed in experiments by Dayton Miller (1866-1941) [14]. The latter subject will be considered in detail in the next Lecture.

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Lecture 4

On the Nature
of
the Ether-Drift, Magnetic Strength, and Dark Matter

1. Introduction

A fundamentally new idea on a generality of the nature of ether-drift and magnetic strength was first set forth in 2007 in [1]. This idea is based on a hypothesis, expressed earlier by the author in 2004 [2], according to which a huge world of ponderable particles of the subelectronic level fills space of the Universe. Vortical fluxes of the particles form the transversal (cylindrical) field-space, which is perceived and detected as magnetic field. Near the Earth's surface, these (magnetic) fluxes are detected within optical and millimeter wave bands as ether-drift. It is shown that thece subelectronic particles, constituents of the interstellar and intergalactic magnetic fields, can be regarded as real constituents of the so-called nonbaryonic dark matter in the Universe.

The previous Lecture (reproduced actually the work [2]) was devoted to a problem of masses of photons and neutrinos. It was shown that the mass of a photon is not equal to zero and its value correlates with the masses of neutrinos estimated in recent years. The consideration in [2] was based on the results of a detailed analysis carried out in [3] concerning the atomic structure and the nature of wave processes. The presumed parameters of the wave space composed of the subelectronic particles of the resulting masses, characteristic for photons and neutrinos (considered in Lecture 3), were calculated in [2].

In the reference works it was asserted that myriad particles of the subelectronic level are involved in the wave process caused by perturbation of equilibrium electron states in exited atoms. It is a huge world of tiny particles that belong to the level lying below the electron one. For them, Earth is in to the highest degree a rarefied spherical space. These particles pierce Earth just as freely as asteroids pierce the space of the solar system and galaxies. Calculations made in [2] showed that their masses coincide with the masses ascribed in the last decade to neutrinos.

There also was made a supposition that just a directed motion of the subelectronic particles, *i.e.*, their fluxes, form observable fields in spaces, which are regarded in contemporary physics as magnetic fields. This means that the fluxes of subelectronic particles, considered as magnetic fields, surround a conductor with a current, a bar magnet, and our Earth, and fill up interplanetary, interstellar, and intergalactic spaces.

The vortical fluxes of the particles belong to the cylindrical (transversal) field-space of the subelectronic level. As appears from [2], the mass spectrum of the particles coincides with the mass spectrum of the neutrinos. The ultimate estimated value of the mass of electron neutrinos, known from the literature, does not exceed $m_\nu = 20\,eV \approx 4\times10^{-5} m_e$. The dominant values of masses of subelectronic particles, which were derived in [2], range from $m = 68.22\times10^{-7}\, m_e$ to $m_\nu = 136.44\times10^{-9} m_e$.

We believe that the aforementioned supposition (hypothesis) put forward first in [2] and [3] can contribute to an understanding of the nature of dark matter and untangle as a result some problems of physics and astrophysics. It can help to reveal the nature of the ether-drift, which was measured credibly enough in comprehensive experiments carried out by Miller on his sensitive optical instruments from 1906 through the mid-1930s [4, 5]. His results were repeated in 1929 by Michelson, Pease and Pearson [6]. Experiments by other researches, including those performed quite recently in 2001 and 2002 [7, 8], confirmed and specified Miller's results on the ether-drift speed and its direction.

It should be noted that the Michelson-Morley first experiments of 1887 [9] on the detection of supposed ether-drift have involved only six hours of the data collection over 4 days. Therefore a slight positive result obtained in these experiments (imperfect as it turned out later on) had relatively high uncertainty. Naturally, modern physics ignored this originally obtained result as unconvincing. Unfortunately, the negative conclusion on the existence of the ether, hasty made in 1887 just on the basis of this preliminary result, was accepted and used by leading physicists as the firm argument in the well-known struggle of physical ideas on the structure of space that took place at that time, the time of appearance of the relativity theory.

Analyzing the results of all aforementioned experiments [4-9], we found that ether-drift proved to move approximately along the same direction as the horizontal component of Earth's magnetic field in the middle altitudes. No one of scientists turned his attention to this important circumstance till now. The axis of the drift appears to be roughly perpendicular to the plane of the ecliptic.

Resting on the above finding and the data obtained for the ether-drift speed, we put forward an idea that the observed ether-drift is nothing else but the directed motion (flux) of subelectronic particles, identical to the magnetic flux. This idea allows us, knowing the speed of the flux ("ether-drift") and the characteristic parameters of the magnetic field, to estimate the concentration of subelectronic particles in the flux. We can estimate thus the

concentration of subelectronic particles both near the Earth's surface and in interstellar space, in particular, in the Milky Way galaxy, whose magnetic field strength is known on average, and then in intergalactic space. In the latter case indeterminacy of such estimation will be, obviously, much higher because of the high uncertainty in the order of magnitudes for intergalactic magnetic strengths, which are only roughly estimated at present.

In this way, the above idea can shed light on the nature of dark matter. This problem was one of the main subjects considered in the paper [1], which is based on the ideas and results presented in [2], being its natural continuation.

From measurement of the rotation parameters of spiral galaxies like the Milky Way, calculations show that at least 90% of the mass of any galaxy – and possibly as much as 99% of the mass of the Universe – is in the form of matter that cannot be seen and called therefore dark matter. There are a few candidates for dark matter in galaxies. Among them are the so-called massive astrophysical compact halo objects (MACHOs) (such as planets, dead or unborn stars, black holes, etc.), which do not emit electromagnetic radiation. A significant amount of dark matter, as astrophysicists assume, can be "hidden" in neutrinos if their mass is in the range $(0.2-1.0)\times 10^{-4} m_e$ ($(10-50)eV\times c^{-2}$) or at least more than $2\times 10^{-6} m_e$ ($1eV\times c^{-2}$). Convincing evidence that neutrinos have mass of the latter magnitude was obtained in the Super-Kamiokande experiment in Japan [10]. Another hypothetical candidate for dark matter is the family of heavier neutral particles predicted by the so-called supersymmetric (SUSY) extension to the Standard Model. They are known as weakly interacting massive particles (WIMPs) (the most known among them is the neutralino).

We assume that subelectronic particles, including those having mass equal to the mass ascribed in [2] to photons and neutrinos, are reliable candidates for the dark matter. We will show this here.

The supposition set forth here that the observed phenomenon called ether-drift is due to the flow of subelectronic particles is based on, and originates from, a new view on the nature of both magnetic fields and wave physical field-spaces in general. What is specific in this view for the understanding of Nature, it is considered in detail in [3]. We begin here from the concise elucidation of the main aspects and definitions of just this question.

Obviously, the nature of wave field-spaces is the question of principle for the whole of physics. The elucidation below, at the beginning, which we have considered already in our Lectures, is necessary to remind again because it is the basis for our consideration of the subject noticed above.

2. The main parameters of the wave physical space

We regard the *mass* of physical space *m* as the *amount of physical space* of an *embeddedness* ε, defined by the equality

$$m = \varepsilon V = \varepsilon_r \varepsilon_0 V\,, \tag{1}$$

where V is the volume of the space [3]. The embeddedness $\varepsilon = \varepsilon_r \varepsilon_0$, in other words, is the density of the space, where ε_r is the relative density and $\varepsilon_0 = 1\, g \times cm^{-3}$ is the absolute unit density of the space. The notion of "embeddedness" originates from the dynamic model of elementary particles. According to the latter, the physical field-space of the Universe represents by itself an infinite series of spaces embedded in each other. All details concerning this notion can be found in [11], which is accessible online in PDF format.

For a more accurate description of the wave physical space, we operate with the *kinematic vector-speed E*, at the level of the basis space. To stress its directed character, one can use the symbol **E**. The reference dimensionality of the vector-speed E is $cm \times s^{-1}$.

The dynamic vector, conjugate to the kinematic E vector, is defined as

$$D = \varepsilon E = \varepsilon_r \varepsilon_0 E\,. \tag{2}$$

We can see that the D vector is a vector of the *density of momentum of physical space* with the embeddedness ε; its dimensionality is $(g \times cm \times s^{-1}) \times cm^{-3}$.

Vectors D and E are used for the description of the longitudinal wave field. The analogous pair of vectors H and B presents the transversal wave field

$$H = \varepsilon B = \varepsilon_r \varepsilon_0 B\,. \tag{3}$$

Vectors D and E describe the *spherical* ("electric") wave field of the basis space; while H and B describe the *cylindrical* ("magnetic") wave field of the same basis space.

Along with the "right" embeddedness $\varepsilon = \varepsilon_r \varepsilon_0$, we operate also with the "inverse" embeddedness $\mu = \mu_r \mu_0$, where

$$\mu_0 = \frac{1}{\varepsilon_0} \qquad \text{and} \qquad \mu_r = \frac{1}{\varepsilon_r}\,. \tag{4}$$

Then (2) and (3) take the form

$$E = \mu_r \mu_0 D\,, \qquad B = \mu_r \mu_0 H\,. \tag{5}$$

We postulate the validity of the equality $\varepsilon_r = 1$ for the basis space. This is quite natural because, at this level, the embeddedness, in essence, relates to the space itself, *i.e.*, the *self-embeddedness* of the space takes place.

Thus, in wave field-spaces, the *central field-space* of exchange is inseparable from its *negation*, which is represented by the *transversal field-space* of exchange. The central field of exchange is described by the two vectors E and D; the analogous vectors, B and H,

describe the transversal field. The *B* vector is the *speed-strength vector* and the H vector is a *vector of the density of momentum* of the transversal exchange.

Both fields-spaces (central and transversal) form the unit contradictory *longitudinal-transversal field-space* with the following vectors:

$$\hat{A} = E + iB \qquad \text{and} \qquad \hat{C} = D + iH\,. \tag{6}$$

In the general case each vector of exchange (*E*, *D*, *B*, and *H*) has contradictory potential-kinetic character (that is, designated by the symbol ^) [3, 12]. Therefore, more correctly, (6) must be presented in the following form:

$$\hat{A} = \hat{E} + i\hat{B} \qquad \text{and} \qquad \hat{C} = \hat{D} + i\hat{H}\,, \tag{7}$$

where *i* is the unit of negation of the central field by the transversal field. Thus the letter *i* indicates the transversal character of the field of $\hat{B}$ and $\hat{H}$ vectors as against the central field of *E* and *D* vectors. Simultaneously, the letter *i* indicates the potential character of the corresponding vectors as the negation of the kinetic ones because

$$\hat{E} = E_k + iE_p\,, \qquad \hat{B} = B_k + iB_p\,,$$

and

$$\hat{D} = \varepsilon_0\varepsilon_r\hat{E}\,, \qquad \hat{H} = \varepsilon_0\varepsilon_r\hat{B}\,. \tag{8}$$

Obviously,

$$A_k = E_k + iB_k\,, \qquad C_k = D_k + iH_k \tag{9}$$

and

$$A_p = E_p + iB_p\,, \qquad C_p = D_p + iH_p\,. \tag{10}$$

Each vector of exchange belongs to the generalized vector of exchange

$$\hat{\Psi} = U + iV\,, \tag{11}$$

where $\hat{\Psi} \in (\hat{E}, \hat{B}, \hat{D}, \hat{H}, \hat{A}, \hat{C})$. This vector satisfies the wave equation

$$\Delta\hat{\Psi} - \frac{\partial^2\hat{\Psi}}{\partial\tau^2} = 0\,, \tag{12}$$

The longitudinal-transversal field of exchange $\hat{A} = \hat{E} + i\hat{B}$ is an image of the longitudinal-transversal structure of the world. At the subatomic level it is called the electromagnetic field, in which the field of the transversal exchange (or more exactly the transversal subfield of the longitudinal-transversal field) is termed the magnetic field and the longitudinal subfield is called the electric field. The binary field-spaces are the basis of the space of the Universe.

Strictly speaking [3], the electromagnetic field must be called by only one name: the electric (or magnetic) longitudinal-transversal field with longitudinal-transversal charges. This is a very important question of the logical semantics of the field, which inclines to definite concepts. From the point of view of semantics, the name "electromagnetic" field makes no sense. It literally means the "amber-magical" field. This is, roughly speaking, the "alias" or the pseudonym. We should refrain from the pseudonym because it initially generates the erroneous concepts and directions of research. Moreover, on the basis of the pseudonym, cognition of the nature of electromagnetic phenomena becomes impossible.

The intensity of the electromagnetic field should be described by the vector of velocity of exchange $\hat{\mathbf{E}}$ (the strength vector) of the logical structure:

$$\hat{\mathbf{E}} = \hat{\mathbf{E}}_l + \hat{\mathbf{E}}_\tau , \tag{13}$$

where $\hat{\mathbf{E}}_l$ is the vector of the longitudinal electric subfield and $\hat{\mathbf{E}}_\tau$ is the vector of the transversal electric subfield.

To an equal degree, the electromagnetic field can be called the longitudinal-transversal magnetic field with the corresponding vectors of the longitudinal $\hat{\mathbf{B}}_l$ and transversal $\hat{\mathbf{B}}_\tau$ magnetic subfields:

$$\hat{\mathbf{B}} = \hat{\mathbf{B}}_l + \hat{\mathbf{B}}_\tau \tag{14}$$

Binary fields-spaces are elementary links in a chain of mutually negating longitudinal-transversal field-spaces that form the multidimensional spatial structure of the matter-space-time of the Universe.

The fields of transversal exchange are, mainly, the fields of cylindrical structure. The presence of a field of the cylindrical structure points to the motion in the field of matter-space-time.

Physicists study the longitudinal-transversal field of exchange of the *subatomic microlevel* "from above" (because they tower over this field in laboratory conditions); therefore they clearly see its longitudinal and transversal sides. But at the same time they are inside the cosmic longitudinal-transversal field. Being on Earth, they feel only the longitudinal side of the field and not its transversal component, which is represented by the shells of the gravitational field of the Sun and its planets.

In such a situation, when "complexes of sensations" do not help, it is necessary to turn to reason and dialectics. Only they will lead the researcher to the understanding of the fact that the gravitational field is also the longitudinal-transversal field, analogous to the longitudinal-transversal field of the subatomic level.

3. Dimensionality of H and B vectors

The following three systems of units were introduced in physics before the appearance of the SI units:

1. CGS, for the description nonelectromagnetic phenomena;

2. CGSE, for the description of the electric (longitudinal) subfield;

3. CGSM, for the description of the magnetic (transversal) subfield.

The CGS system was first applied to mechanical phenomena and then extended to enable thermal measurements (by the addition of the inconsistently defined calorie). Now this system, called the Gausian (or symmetric) system, can be called the circulational system, because it unites in a single whole the CGSE and CGSM systems through the circulational equation of exchange [3]:

$$\Gamma = \frac{1}{c}\frac{dq}{dt} = \frac{1}{c} I \,, \tag{15}$$

where $\Gamma = 2\pi r H = 2\pi r \varepsilon_0 \varepsilon_r B$ is the circulation of the momentum density vector H (3) or the circulation of the linear density of tangential (transversal) flow of speed-strength B (5) – the parameters of the transversal ("magnetic") subfield. Historically, the circulation Γ was referred to as the current in the magnetic system of units I_m. Electric current I is the parameter of the longitudinal subfield.

The circulation expresses the law of total current in so-called Gaussian units:

$$\oint (Hdl) = \frac{1}{c} I \,. \tag{16}$$

On the basis of (15) it is possible to introduce the circulation charge:

$$q_\gamma = \frac{1}{c} q = \int \Gamma dt \,. \tag{17}$$

The following relation was found between theoretical A (in the framework of the present approach) and phenomenological A_E parameters [3, 13]:

$$A_E = (\sqrt{4\pi\varepsilon_0})^k A \,, \tag{18}$$

where k is an integer. In particular, the exchange charge q and the Coulomb charge q_E are related as

$$q = \sqrt{4\pi\varepsilon_0} \times q_E \,. \tag{19}$$

The speed-strength vectors E and B and the electric induction and magnetic induction vectors E_E and B_E are connected as

$$E = \frac{E_E}{\sqrt{4\pi\varepsilon_0}} \qquad \text{and} \qquad B = \frac{B_E}{\sqrt{4\pi\varepsilon_0}}, \tag{20}$$

We are interested in the dimensionality of the *velocity-strength B* (known as the magnetic field induction): the *gauss* and the *tesla*.

According to the definition in Section 2, the *B* vector is the vector of the *rate of exchange* in the transversal ("magnetic") field, and its objective dimensionality is $cm \times s^{-1}$. According to (20), the dimensionality of the phenomenological magnetic induction vector B_E, expressed in gauss G_E, is

$$\dim(G_E) = \dim(B_E) = \dim\left(\sqrt{4\pi\varepsilon_0} \times B\right) = g^{1/2} \times cm^{-1/2} \times s^{-1}. \tag{21}$$

An objective measure of the magnetic gauss is equal to

$$1G = \frac{1G_E}{\sqrt{4\pi\varepsilon_0}} = 2.820947918 \times 10^{-1}\, cm \times s^{-1}, \tag{22}$$

The phenomenological magnetic tesla is equal to 10^4 gauss:

$$1T_E = 1 \times 10^4 G_E. \tag{23}$$

Hence the following objective tesla *T* corresponds to the phenomenological tesla T_E:

$$1T = 1 \cdot 10^4 G = \frac{10^4}{\sqrt{4\pi\varepsilon_0}} = 2.820947918 \cdot 10^3\, cm \times s^{-1}, \tag{24}$$

Let us turn now to the transversal (magnetic) field of the Earth, namely to its horizontal component B_h (analogous to the magnetic intensity, former magnetic field strength). The experimental data show that the daily solar variations of B_h (in years of low magnetic activity and tranquil days, for middle latitudes) have a broad range ([14, p. 997]):

$$B_h = (0.7 - 4) \times 10^{-4}\, Oe. \tag{25}$$

We take for the estimation $B_h = 2.5 \times 10^{-4}\, Oe$. Its objective measure, making allowance for (22), is

$$B_h = 2.5 \times 10^{-4}\, Oe = 2.5 \times 10^{-4} \times 2.820947918 \times 10^{-1} \approx 7 \times 10^{-5}\, cm \cdot s^{-1}. \tag{26}$$

In the CGS system vectors *H* and *B* are equal in value of their units, 1 G to 1 Oe. The same equality in value is maintained in the description of the fields presented here. Actually, according to the above definition, the relation between vectors H and B is expressed by (19), $H = \varepsilon_r \varepsilon_0 B$, where the absolute unit density $\varepsilon_0 = 1\, g \cdot cm^{-3}$ and the relative density $\varepsilon_r = 1$. Hence the *density of momentum of the geomagnetic field* is

$$H = \varepsilon_r \varepsilon_0 B = 7 \times 10^{-5} (g \cdot cm^{-3})(cm \cdot s^{-1}) . \tag{27}$$

This value gives the magnetic moment μ caused by moving charges in the unit volume V of the field:

$$\mu = HV = 7 \times 10^{-5}\, g \cdot cm \cdot s^{-1} \approx 1.97 \times 10^{-8}\, J \cdot T^{-1}, \tag{28}$$

where $1T = \frac{10^4}{\sqrt{4\pi}}\ cm \cdot s^{-1}$ [3].

4. Ether drift and magnetic field-spaces

The precise *ether-drift* experiments carried out up to 1929 [6] found a maximal ethereal wind speed of about $6 \times 10^5\, cm \cdot s^{-1}$ at an altitude 1830 *m* (the Mount Wilson observatory, Pasadena). The direction of the ether-drift, as we have found by analyzing the experimental results, almost coincides with the direction of the magnetic field, H_h. Experiments repeated later also confirmed this conclusion. Galaev's studies [7, 8] showed that the horizontal component of the ethereal wind speed reaches a value $1.414 \times 10^5\, cm \cdot s^{-1}$ in Kharkov, at a height above sea level of 42 *m*. At a height of 4.75 *m*, the average speed is about $4.35 \times 10^4\, cm \cdot s^{-1}$. It is equal to $2.05 \times 10^4\, cm \cdot s^{-1}$ at a height of 1.6 *m*.

We assume that the speeds of fluxes (registered as magnetic fields) of such an obtained order can also exist near the surfaces of other similar objects in the Universe. Let us take at first for calculations, as the minimal speed, the speed at a height of 4.75 *m* [8]:

$$\upsilon = 4.35 \times 10^4\, cm \cdot s^{-1} . \tag{29}$$

According to the definition considered above in Section 3, the *H* vector represents by itself the *density of momentum* of the transversal (magnetic) field-space; therefore the following equality is valid:

$$H = \rho \upsilon , \tag{30}$$

where ρ is the density equal to the mass of all subelectronic particles in the unit volume *V* of the space, and υ is the speed of their ordered motion in the direction defined by the vector *H*. This equality is valid if we accept the hypothesis, set forth first in [2] and [3], that the magnetic field is the flux of subelectronic particles.

Thus, knowing the speed of the flux of these particles, Eq. (30) enables estimation of the density of the subelectronic particles that fill the space and detected at their motion as the magnetic field.

The corresponding, to the speed (29), the maximal density of geomagnetic space of the particles at the height of 4.75 *m* is

$$\rho = \frac{H}{\upsilon} \approx 1.6 \cdot 10^{-9}\, g \cdot cm^{-3}. \tag{31}$$

The masses of subelectronic particles, which one can regard as the most probable main components of magnetic fluxes, were estimated in [2] (Lecture 2). It was shown that the most probable particles could be, among others, the two with masses:

$$m = 68 \times 10^{-7} m_e \approx 6.19 \times 10^{-33}\, g, \tag{32}$$

$$m_\nu = 136.44 \times 10^{-9} m_e \approx 1.243 \times 10^{-34}\, g, \tag{33}$$

where $m_e = 9.109382531 \times 10^{-28}\, g$ is the electron mass.

If we take the first particles of mass m (32), then their corresponding maximal concentration, moving with the speed (29), is

$$n = \frac{\rho}{m} = 2.58 \times 10^{23}\, cm^{-3}. \tag{34}$$

For m_ν particles (33) we have

$$n_\nu = \frac{\rho}{m_\nu} = 1.29 \times 10^{25}\, cm^{-3}. \tag{35}$$

The velocity-strength of the *interstellar* magnetic field B_{is} (of the Milky Way) is about 10^{-6} times the strength of Earth's field [15] (which is 0.65 *Oe* on the magnetic pole and 0.35 *Oe* on the magnetic equator [14]) and has approximately the magnitude

$$B_{is} = 0.5 \times 10^{-6}\, Oe. \tag{36}$$

Its objective measure, in accordance with (22), is

$$B_{is} = 0.5 \times \cdot 10^{-6} \times 2.820947918 \times 10^{-1} \approx 1.41 \times 10^{-7}\, cm \cdot s^{-1}. \tag{37}$$

The *density of momentum* H_{is} and the magnetic moment of the unit volume of interstellar magnetic field μ_{is} are equal, correspondingly, to

$$H_{is} = \rho_{is} \upsilon = 1.41 \times 10^{-7}\, (g \cdot cm^{-3})(cm \cdot s^{-1}), \tag{38}$$

and

$$\mu_{is} = H_{is} V = \rho_{is} \upsilon V = 1.41 \times 10^{-7}\, g \cdot cm \cdot s^{-1} = 3.98 \times 10^{-11}\, J \cdot T^{-1}. \tag{39}$$

Assuming at the first approximation that in interstellar space the *minimal speed* of magnetic fluxes is equal to the speed measured for ether-drift at a height of 4.75 *m* above sea level [8],

i.e., under the condition $\upsilon = 4.35\times10^{4}\, cm\cdot s^{-1}$, we arrive at the corresponding *maximal density* of the interstellar magnetic field:

$$\rho_{is} = \frac{H_{is}}{\upsilon} \approx 3.24\times10^{-12}\, g\cdot cm^{-3}. \qquad (40)$$

We assume that quanta of mass $m_{\nu} = 136.44\times10^{-9} m_e$ dominate in cosmic magnetic fields. As was shown in Lecture 2, their frequency $<\nu> = 1.23\times10^{11}\, s^{-1}$ of the millimeter band is close to the mean value of the whole electromagnetic spectrum. This is all the more so because this frequency is the region of the cosmic microwave background radiation [16]. If these particles are the main components of magnetic fields, then their maximal concentration in the field (at the above conditions) is

$$n_{\nu} = \frac{\rho_{is}}{m_{\nu}} = \frac{3.24\times10^{-12}}{136.44\cdot10^{-9}\times9.11\times10^{-28}} = 2.6\times10^{22}\, cm^{-3}. \qquad (41)$$

The maximal possible modulus of elasticity of such field-spaces is

$$E_{\nu} = \rho_{is} c^2 \approx 2.9\times10^{9}\, dyne\cdot cm^{-2}. \qquad (42)$$

Thus, we have arrived at the parameters of space, which have the same order of magnitude as obtained in [2] (Lecture 2) based on another approach. The two middle columns in Table 1 demonstrate this fact. The practical coincidence of the results obtained in different (in principle) ways justifies the validity of both concepts (ways), presented here and in [2].

Table 1. The density, base wave speed and modulus of elasticity of a wave space consisting of m_{ν} particles at a height of 4.35 *m* above sea level[(a)]

Parameters	*Air*	m_{ν} – *space*		*Sea Water*
		$(n = 2.6\cdot10^{22};$	$3\cdot10^{22}\, cm^{-3}$ [2])	
$\rho\ (g\cdot cm^{-3})$:	1.21×10^{-3}	3.24×10^{-12}	3.76×10^{-12}	1.02338
$c\ (cm\cdot s^{-1})$:	3.44×10^{4}	3×10^{10}	3×10^{10}	1.5×10^{5}
$\rho c^2\ (dyne\cdot cm^{-2})$:	1.42×10^{6}	2.9×10^{9}	3.38×10^{9}	2.3×10^{10}

(a) The data are derived in two ways, in comparison with the corresponding parameters of air and sea water. The second column contains the present data calculated here for the ether-drift speed $\upsilon = 4.35\times10^{4}\, cm\cdot s^{-1}$ and $B_h = 2.5\times10^{-4}\, Oe$. The third column shows the data obtained earlier in [2] and presented in Lecture 2.

Parameters of the medium (magnetic field-space) composed of m_ν particles, calculated under the condition that the speed of the magnetic flux is higher than (29) and is about $6\times10^5\, cm\cdot s^{-1}$ (detected as the *ether-drift*, or ethereal wind, at a height of 1830 *m* above sea level [8]), are

$$\rho = 2.35\times10^{-13}\, g\cdot cm^{-3},$$

$$n_\nu = 1.9\times10^{21}\, cm^{-3}, \tag{43}$$

$$E_\nu = \rho c^2 = 2.1\times10^8\, dyne\cdot cm^{-2}.$$

The main role in the approach described here is played by the speed of magnetic fluxes accepted for the calculations. The estimations presented above were carried out under the condition of *minimal speeds* typical for the fluxes registered just at the Earth's surface in middle latitudes as *ethereal wind.* Experiments carried out in [4] to [8] show that the *ether* has viscosity and the speed of the *ethereal wind* increases with increasing height above Earth's surface.

Apparently, the average speeds of magnetic fluxes in the cosmos exceed the speeds typical for Earth's surface taken above for estimates. Let us suppose therefore that in interstellar space the speed of magnetic fluxes approaches, or is equal to the speed of light, *i.e.*, $\upsilon = c$; this is quite possible. In this case the corresponding *minimal density* of the interstellar magnetic field-space composed of m_ν particles, of the same strength $B_{is} = 0.5\times10^{-6}\, Oe$ (36), will be equal to the value

$$\rho_{is} = \frac{H_{is}}{c} = 4.7\times10^{-18}\, g\cdot cm^{-3}. \tag{44}$$

The concentration and modulus of elasticity of the space of such a density composed of m_ν particles (33) are, respectively, equal to

$$n_\nu = 3.78\times10^{16}\, cm^{-3}, \tag{45}$$

$$E_\nu = \rho_{is} c^2 = 4.23\times10^3\, dyne\cdot cm^{-2}. \tag{46}$$

The last magnitude is about 10^{-3} times the modulus of elasticity of air, which is $1.42\times10^6\, dyne\cdot cm^{-2}$ (see Table 1).

5. Dark matter

An important question today in cosmology, how much mass is contained in the Universe. There is a lot of uncertainty about the average density of the Universe. Part of the problem lies in the fact that we can only see a mere 5-10% of the matter that's thought to make up the

cosmos. The rest is mysterious "dark matter", whose presence is inferred from the gravitational motions of galaxies. We just don't know how much dark matter is out there.

The “critical density” of the Universe is actually not “calculated” in the normal sense of the word. It actually comes out as a parameter in the Friedman equation for the expansion of the Universe. It is really a function of how fast the Universe is expanding. Hubble's law shows that the velocity of a galaxy is proportional to distance

$$\upsilon = H_0 r \,. \tag{47}$$

On this basis, the critical density is found to be

$$\rho = \frac{sH^2}{8\pi G} = 5\times 10^{-30}\, g\cdot cm^{-3} \tag{48}$$

where $H_0 = (1.587 - 1.62)\times 10^{-18}\, s^{-1}$ and $G = 6.6742(10)\times 10^{-8}\, cm^3 \cdot g^{-1}\cdot s^{-2}$.

Currently, the best-known values for Hubble’s constant H_0 and gravitational constant G give a value for the critical density about $\rho = 1\times 10^{-29}\, g\cdot cm^{-3}$. Recent measurements indicate that the actual density of our Universe is very close to the critical density.

The Wilkinson Microwave Anisotropy Probe (WMAP, NASA Explorer Mission measuring the temperature of the cosmic background radiation) determined that the Universe is flat, from which it follows that the mean energy density in the Universe is equal to the critical density (within a 2% margin of error). This is equivalent to a mass density of $9.9\times 10^{-30}\, g\cdot cm^{-3}$, which is equivalent to only 5.9 protons per cubic meter.

We should realize that there is some doubt in this value because it is the result of a long chain of estimations. What is more, the nature of the red shift has been questioned hitherto, just like the nature of the microwave background radiation [3, 16, 17].

It is highly plausible that dark matter of the Universe, the still unknown nature of which is currently a big problem of astrophysicists, is partially hidden in invisible subelectronic particles of interstellar space of galaxies with the above parameters and mostly in intergalactic space.

Let us now estimate the values of the parameters ρ and n for the intergalactic magnetic field-space. Unfortunately, the strength of the intergalactic magnetic fields (IGMFs) has not been determined so far [18]. Most of the methods estimate the value of the fields in the range 10^{-10} to $10^{-20}\, G$ [19-22]. To interpret the microgauss magnetic fields, the seed fields required in so-called dynamo theories could be as low as $10^{-20}\, G$ [23, 24]. At present, theoretical calculations of primordial magnetic fields show that these fields could be of order $10^{-20}\, G$ or

even as low as $10^{-29}G$, generated during the cosmological QCD or electroweak transition, respectively [25].

Obviously, indeterminacy in the values of the strength of IGMFs will result in indeterminacy in the calculated density of the space of IGMF. Among the values indicated in [18] to [25], we take the velocity-strength of IGMF of the order $1\times10^{-20}G$. This magnitude is more appropriate because it is almost in the middle between the upper and lower limits of the strengths indicated in the above references. An objective measure of the magnitude, according to (22), is

$$B_{ig} = \frac{10^{-20}}{4\pi\varepsilon_0} \approx 2.82\times10^{-21}\, cm\cdot s^{-1}. \tag{49}$$

The density of the momentum of the field is

$$H_{ig} = \varepsilon_r\varepsilon_0 B_{ig} = 2.82\times10^{-21}\,(g\cdot cm^{-3})(cm\cdot s^{-1}). \tag{50}$$

Hence the density of IGMF, at $\upsilon = c$ and $\varepsilon_r = 1$, is

$$\rho_{ig} = \frac{H_{ig}}{c} = 0.94\times10^{-31}\, g\cdot cm^{-3}. \tag{51}$$

We assume that among a whole spectrum of subelectronic particles the particles of masses $m = 68\times10^{-7}m_e$ and $m_\nu = 136.44\times10^{-9}m_e$ play a dominating role in the IGMFs. Note that the mass of these particles is a multiple of the fundamental measure (in units of the electron mass) in a quarter and a half of the fundamental period $\Delta = 2\pi\lg e = 2.7288$ [26, 27], respectively.

Concentrations of the particles of the mass $m = 68\times10^{-7}m_e$ in IGMF of density (51) would be:

$$n = \frac{\rho_{ig}}{m} = 1.51\times10^{1}\, cm^{-3}. \tag{52}$$

If the IGMF consists mainly of particles of mass $m_\nu = 136.44\times10^{-9}m_e$, their concentration in the field is

$$n_\nu = \frac{\rho_{ig}}{m_\nu} = 7.6\times10^{2}\, cm^{-3}. \tag{53}$$

Subelectronic particles represent a huge world of particles of the level of the Universe, which is below the electron level. They take part in transient processes together with electrons. These particles form the transversal (magnetic) field of moving electrons and, hence, can be regarded as their satellites. Accordingly, their speed is of the same order as the

speed of electrons. The maximal speed of an electron in the hydrogen atom is the Bohr speed υ_0. The relation between υ_0 and the speed of light c is equal in magnitude to the fine-structure constant [28]. On the basis of this fact, we can take for estimation, as the speed of fluxes of subelectronic particles (magnetic fluxes) υ in (30), the value υ_0:

$$\upsilon_0 = \alpha c = 2.187691263 \times 10^8\, cm \cdot s^{-1} \approx 2.19 \times 10^8\, cm \cdot s^{-1}, \qquad (54)$$

where $\alpha = 7.297352568 \times 10^{-3}$. In this case all the above parameters, obtained for the speed c, will have to take into account the extra factor α.

The above-calculated parameters for the horizontal component of Earth's magnetic field at a height of 4.35 m above sea level, for interstellar and intergalactic magnetic field-spaces (at two speeds of magnetic fluxes, $\upsilon = c$ and $\upsilon = \alpha c$) composed of m_ν particles are presented in Table 2.

Table 2. The calculated density and concentration of m_ν particles near Earth's surface magnetic field[(b)], in interstellar and intergalactic magnetic fields[(c)];

	B_h (26)		B_{is} (36)	B_{ig} (49)	
	$2.5 \times 10^{-4}\, Oe$		$0.5 \times 10^{-6}\, Oe$	$1 \times 10^{-20}\, Oe$	
υ $(cm \cdot s^{-1})$	4.35×10^4	2.19×10^8	3×10^{10}	2.19×10^8	3×10^{10}
ρ $(g \cdot cm^{-3})$	3.24×10^{-12}	6.4×10^{-16}	4.7×10^{-18}	1.29×10^{-29}	0.94×10^{-31}
n_ν (cm^{-3})	2.6×10^{22}	5.15×10^{18}	3.78×10^{16}	1.04×10^5	7.6×10^2

(b) The first column.

(c) B_h, B_{is} and B_{ig} are the strengths of corresponding magnetic fields.

We see thus that the estimated densities of the IGMFs range from 1.29×10^{-29} to $0.94 \times 10^{-31}\, g \cdot cm^{-3}$, *i.e.*, just near the critical density of the Universe $5 \times 10^{-30}\, g \cdot cm^{-3}$ (48) obtained from the Friedman equation on the basis of the Hubble's constant H_0 and gravitational constant G.

6. Conclusion

The nonbaryonic matter problem has found a new resolution [1] discussed in this Lecture. This became possible on the basis of understanding the nature of magnetic fields as a part of longitudinal-transversal field-spaces of the Universe. This understanding is also due to

revealing the objective dimensionalities for magnetic field parameters (vectors *H* and *B*) expressed, as follows from the Wave Model, by the integer powers of the units of matter, space, and time (*g*, *cm*, and *s*) [3].

The key idea set forth here, that *ether drift* is the flux of subelectronic particles identical with magnetic flux, originates from the aforementioned understanding what is the magnetic field.

The mass that astronomers infer for galaxies including our own is more than 10 times as large as the mass that can be associated with stars, gas, and dust. This mass was called baryonic matter and was made up of protons, neutrons, and electrons. Until about 30 years ago, astronomers thought that the Universe was composed almost entirely of this baryonic matter. However, in the past two decades, there has been ever more evidence accumulating that suggests there is something in the Universe that we cannot see, perhaps some new types of particles (nonbaryonic matter) or even a new form of matter or new forces.

As appears from this Lecture, the plausible candidates (particles) for the nonbaryonic *dark matter* can be subelectronic particles of the masses ascribed to them in [2], especially ranging from $m = 68 \times 10^{-7} m_e$ to $m_\nu = 136.44 \times 10^{-9} m_e$. These particles fill the space of the Universe, along with other objects and particles, and just their directed motion in space defines the field that we call the *magnetic field* and detect near Earth's surface as *ether drift*.

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Lecture 5

Cosmological Redshift

1. Introduction

The following three main causes of *astronomical* redshirt are distinguished at present:

1) The *Doppler Effect* – classical and relativistic Doppler redshirt.

2) *Energy loses* in gravitational fields – gravitational redshift,

3) *Expansion of the Universe* – cosmological redshift.

From the enumerated above constituents, the dominant (much more) part to the astronomical redshirt, as believe, contributes the *cosmological* redshift (CRS). The stretching of space (and time) due to its expansion, as postulated by general relativity, is considered as its main cause. Emitted waves, moving in such an expanding space, as assumed, are stretched, their wavelengths increase. In the case of visible light, it becomes redder.

As it is commonly believed, the cosmological *space expansion* has began at once after explosion (called the Big Bang) of a "singularity" initiated, allegedly, coming into being our Universe.

The Big Bang model of the born of the Universe is the main element of the modern cosmological model accepted in astrophysics. According to the Big Bang hypothesis, the Universe is continuously expanding in a near homogeneous way from a denser hotter state and achieved currently the thermalized state with the 2.728 *K* cosmic background radiation. Therefore, the observed *cosmic microwave background* (CMB) radiation with the indicated above temperature is regarded as the evidence in support of the Big Bang hypothesis [1, 2].

The CMB, on which is only based the unfounded, in our opinion, acceptation and recognition of the Big Bang as an ostensibly real phenomenon of the far past, should not be taken into account, because the CMB has an objective source of its origin, hydrogen. This follows from the Wave Model (WM) and confirmed by the related phenomena having the same source.

Really, a discovery within the WM of *microwave background radiation of hydrogen atoms* (that we have considered in Lecture 3, Vol. 3), having a thermal black body spectrum at a temperature of 2.728 *K* [3], compels us to cast doubt in the Big Bang and, accordingly, in the validity of an ascription to the imaginary Big Bang the cause of origin of the CMB, and, hence, calls into question the standard cosmological model and the accepted explanation of the nature of cosmological redshift.

As it would not have been strange, but the mythical Big Bang hypothesis having, actually, no experimental proofs has become, nevertheless, the basis for the standard cosmological model. Physicists-theorists still adhere their initial assumption, accepted finally in physics, regarding the CMB as an effect of the Big Bang despite the fact (which persistently being hushed up) that there are the firm proofs of an existence of the objective cause (real to all appearances) mentioned above on the origin of the CMB.

We intend to discuss in this Lecture the noted above questions and, basing on the wave approach, will present for consideration our view on the nature of the CRS.

2. The Big Bang concept on the nature of CMB and CRS

Thus, following the Big Bang hypothesis, cosmological redshift is explained as a result of running away galaxies, mainly, due to the supposed expansion of the Universe. Accordingly, sufficiently distant light sources must show redshift corresponding to the rate of increase of their distance *D* from Earth. This is expressed by the Hubble's law,

$$\upsilon = H_0 D\,, \tag{1}$$

where H_0 is the constant of proportionality (the Hubble constant), and v is the recessional velocity ("Hubble velocity") of a galaxy at a particular distance *D*.

It is assumed that the largest redshift, corresponding to the greatest distance and furthest back in time, is that of the observed CMB radiation. In this case the redshirt z of the source for the observer is defined as the ratio of the difference of a hypothetical "old" temperature (T) of the CMB at some reference time (the "look-back time") and the CMB temperature at present (T_0) to the latter,

$$z = \frac{T - T_0}{T_0}\,. \tag{2}$$

The magnitude

$$1 + z = \frac{T}{T_0} \tag{3}$$

is called the cosmological redshirt factor.

All redshifts are usually seen in the spectroscopic observations of astronomical objects. The wavelength λ of a typical background radiation with a blackbody spectrum is inversely proportional to *T*; therefore, cosmological redshirt is equally expressed in wavelengths of the observed (at present) and emitted ("old") CMB radiations, λ_0 and λ_e, respectively.

The CMB was discovered in 1964-65 by Arno A. Penzias and Robert W. Wilson. It is postulated now as radiation supposedly left over from an early stage in the creation of the Universe; and, that is amazing, this supposition is used, in turn, as a landmark confirmation of a validity of the hypothetical Big Bang model of the development of the Universe.

A precise measurement of the CMB was realized by the COBE satellites [1]. The most accurate measurement was achieved by the WMAP experiment [2]. The final estimated CMB temperature is about $T_0 = 2.728\,K$.

We will not consider here all details related to the relevant calculations, but only present the estimated value of cosmological redshirt (the CMB's redshirt) taken from [2], it is about

$$z = 1089. \tag{4}$$

It implies, as stated in the above reference, the state of the Universe about 13.7 billion years ago, and 379,000 years after the initial moments of the Big Bang. By that time the Universe expanded and cooled down to a temperature of approximately *T*=3000 *K* (strictly in accord with (3)). At such temperature, protons and electrons can combine to form neutral hydrogen, and ordinary matter can coalesce into the dark matter clumps. The waves emitted right after the recombination can now travel undisturbed and are those that we see in the CMB radiation. The Universe becomes transparent. The CMB travels freely from this time until now.

Adherents of the above described model believe that the CMB anisotropy gives a picture of the Universe at that time. It is evident, their reasoning is based on an assumption that the mystic Big Bang has really happened, although they understand that the latter never seen by the observer and, moreover, never can be proved experimentally. If we will follow this model then cosmological redshift must be dominated for objects far outside our Local Group of galaxies; therewith, the farther away, the bigger the apparent velocity.

At the hypothesized redshirt of z = 1089, the CMB's velocity *v* (the radial velocity of the source) estimated with use of the Doppler effect formula (taking into account relativistic effects) [2], $1+z = \sqrt{\frac{(1+\beta)}{(1-\beta)}}$, where $\beta = \frac{\upsilon}{c}$, is practically equal to the phase wave speed of the emitted waves, *i.e.*, the speed of light *c*:

$$\upsilon = \frac{(z+1)^2 - 1}{(z+1)^2 + 1} c = 0.9999983c \tag{5}$$

However, our analysis conducted in [3, 4] convincingly shows that the Big Bang conception, which is in the foundation of modern standard cosmological model, is controversial. Actually, as follows from the calculations presented in the above references (to the point, unquestioned till now) and from a series of resulting effects, the CMB is nothing more than the microwave background radiation of hydrogen atoms abundant in the Universe. This compels us to cast doubt on the above results (see (4) and (5)) and, accordingly, on the modern cosmological model on the whole. We will show this below. In the light of the aforementioned data, the Big Bang concept has now no firm justification and for further use it must be thoroughly debated and reconsidered with taking into account of the new data presented in [3, 4].

3. The hydrogen nature of CMB

Let us turn to the foundations of physics. As follows from the Wave Model [5], in a general case, elementary optical spectra are defined by the universal formula of energetic transitions:

$$\frac{1}{\lambda} = R_\infty \left(\frac{e_p^2(kr_m) z_{p,1}^2}{z_{p,m}^2} - \frac{e_q^2(kr_n) z_{q,1}^2}{z_{q,n}^2} \right) \tag{6}$$

where there are not customary quantum numbers (integer numbers *n* and *m*), but instead of them there are roots of Bessel functions $z_{\nu,s}$, *i.e.* right radial solutions of the general wave equation. In this formula,

$$e_\nu(z_{\nu,s}) = \sqrt{\frac{\pi z_{\nu,s}}{2}\left(J_\nu^2(z_{\nu,s}) + Y_\nu^2(z_{\nu,s})\right)}, \tag{7}$$

$$R_\infty = \frac{\upsilon_0}{4\pi r_0 c} = \frac{\alpha}{4\pi r_0}. \tag{8}$$

R_∞ is the Rydberg constant: υ_0 is the oscillatory speed of the first stationary wave shell of the radius r_0 (Bohr radius), $\alpha = \frac{\upsilon_0}{c}$ is the fundamental constant reflecting the scale correlation of conjugated threshold parameters, oscillatory and wave, inherent in wave motion [6] (called in modern physics the fine-structure constant); $z_{\nu,s} = kr_s$ are roots of Bessel (radial) functions $J_\nu(z_{\nu,s})$ and $Y_\nu(z_{\nu,s})$ ($Y_\nu(z_{\nu,s})$ is also called the Neumann function), $k = \frac{\omega_e}{c}$ is the wave number, ω_e is the fundamental frequency of atomic and subatomic levels ($\omega_e = 1.869162505 \times 10^{18}\ s^{-1}$) [5, 7], $\nu = l + \frac{1}{2}$ is the order of Bessel functions, *s* is the number of their zero or maximal values.

Eq. (6) is in essence the *generalized spectral formula* deduced for the first time in a correct mathematical form unknown earlier in contemporary physics. All particular cases, including spectral series of the hydrogen atom, follow from this formula.

Note that (6) does not require an electron (please, have a look at it attentively; it does not contain electron mass and charge). The presence of an electron is not obligatory. Why? According to the dynamic model of elementary particles [7], rest masses do not exist. A mass of an elementary particle has associated wave character and is the measure of wave exchange (interaction) of the particle with ambient. Therewith, an electron, characterized as an elementary period-quantum of the associated mass, is the minimal quantum of the rate of mass exchange, or an elementary exchange charge. It defines the quantum-period of an elementary action (moment of momentum) of the spherical field at the atomic and subatomic levels, and hence, the period-quantum of emitted energy. From this point of view, the H-atoms radiative spectrum is regarded as a result of the rebuilding of associated masses of the atoms: *associated masses* distinctive in exited states *are transformed* into associated masses characteristic for equilibrium states that is accompanied with emission of excessive energy.

As a particular case, from (6) it follows an existence of microwave background radiation of the hydrogen atom occurred in a stationary unexcited state, in dynamic equilibrium with ambient. An accurate form of the equation, described the background radiation of the hydrogen atom, taken from [4], is:

$$\frac{1}{\lambda} = R_\infty\left(\frac{1}{n^2} - \frac{1}{(n+\delta n)^2}\right) = R_\infty\left(\frac{1}{n^2} - \frac{1}{\left(n + \sqrt{\frac{2Rh}{m_0 c}}\cdot\frac{e_p(z_{p,s})}{z_{p,s}} - \beta_n \frac{r_e^2}{r_0^2}\sqrt{\frac{2Rh_e}{m_0 c}}\cdot\frac{e_q(z_{q,d})}{z_{q,d}}\right)^2}\right), \quad (9)$$

where

$$h_e = 2\pi m_e \upsilon_0 r_e = 5.222105849\times 10^{-28}\ erg\times s \quad (10)$$

is the orbital action of an electron in the equilibrium state (analogous to the Planck action quantum, h) caused by an electron proper rotation around its own centre of mass with the Bohr speed v_0, therewith, $r_e = 4.17052597\times 10^{-10}\ cm$ is the radius of the electron wave shell originated from the formula for associated masses [7]; $\beta_n \approx 1$ is the numerical factor, equal to 1 or slightly different from 1. All details concerning the derivation of (9) one can find in [4].

The results of calculations by (9) show that a spectral line of the background radiation of the hydrogen atom in the stationary state ($n = 1$ and $p = q = 0$) has the wavelength

$$\lambda = 0.106315\ cm. \quad (11)$$

This value is within a maximum of an equilibrium spectral density of the cosmic microwave background radiation and corresponds to an absolute temperature of the blackbody of

$$T = 2.72774\ K\,. \tag{12}$$

It was found as well that differences of the background terms (spectral lines) with high accuracy coincide with the experimental values for the Lamb shifts in the hydrogen atom [4, 8]:

$$L_{1,s} = 8172.837\ MHz\,, \qquad L_{2s-2p} = 1057.8446\ MHz \tag{13}$$

The latter revelation (obtained without use of hypothetical virtual particles of QED) is an additional firm proof justified a validity of both Eq. (9) and all effects originated from its solutions. The validity of (9) is also confirmed by the fact that on the basis of the approach, lying in the base of its derivation, for the first time in physics the formula of an anomalous magnetic moment of an electron has been deduced, just like the aforementioned Lamb shift, without use of the notion of virtual particles [4, 9]. A calculated value of the anomalous magnetic moment of an electron has turned out with high precision coincident with the experimental data.

In the light of the aforementioned results, an accepted explanation of the nature of cosmological redshirt in modern physics based on observations of the CMB gives rise to doubt. In particular, we assume that the observed fluctuations in a cosmic microwave background temperature in the space of the Milky Way [2] reflect fluctuations in a distribution of hydrogen there. By all appearances, the density of hydrogen must be higher in the plane of galaxy, than outside in the ambient space. Actually, microwave background radiation of hydrogen from our galaxy dominates along its plane, where stars and, generally, matter are mainly concentrated. This is clearly seen on the WMAP maps [2] of the sky on the equator; and the radiation is quite small away from the equator.

4. The CRS as an effect of waves fading

Thus, on the basis of the data presented in [3, 4], one can state that cosmological redshift does not relate to the mythic Big Bang. In view of this, let us consider an origination of the redshift resting upon the basic concepts of dialectical physics, namely taking into account the wave nature of elementary particles (according to the dynamic model of elementary particles [7]) and internal elementary processes accompanied a generation of quanta-waves by atoms.

A source of light is a wave excitation of a spherical shell (field) of hydrogen atoms, constituents of all atoms of the periodic table, *i.e.*, free hydrogen atoms (z = 1) and hydrogen atoms located (and bound) in nucleon nodes of the shells of composite atoms ($z \geq 2$).

Within the bounds, inside polar-azimuth nucleon nodes differently disposed in an internal spherical space of various atoms (of different atomic numbers *z*), constituent H-atoms have the different relative freedom of motion (oscillations) that conditions the specific clear-cut distinction of their optical atomic spectra one from another. For this reason, the structure of these spectra is qualitatively similar, in some extent, to the optical spectrum of an individual (unbound, free) hydrogen atom. Distinctions of atomic spectra of different atoms depend on the difference in the number and geometrical disposition of completed nucleon nodes in them resulted in a different field structure (configuration) of their internodal bonds and, hence, a multitude of possible forms of intra-nodal oscillations of hydrogen atoms located in the nodes.

The visible spectrum of light from the free hydrogen atom (the Balmer series) displays four wavelengths: 410.2 *nm* (H-δ, violet), 434.1 *nm* (H-γ, violet), 486.1 *nm* (H-β, blue-green), and 656.3 *nm* (H-α, red) that correspond to emissions of electromagnetic energy during transitioning from the upper excited energy levels $n \geq 3$ to the level $n = 2$ (*n* is the principal quantum number).

According to dialectical physics [5], during motion in a transient process, an electron in the hydrogen atom causes the wave perturbation. The myriad of particles of the subelectronic level is involved in this process. They have nothing in common with mathematical points-photons of zero size, zero rest mass, and, correspondingly, zero rest energy. These are a huge world of particles which belong to the level lying below the electron level. For them, Earth is in the highest degree the “rarefied” spherical space. These particles pierce the Earth just freely as asteroids pierce the space of the solar system and galaxies. Just their directed motion, fluxes, called “magnetic field” surrounds a conductor with a current, a bar magnet, our Earth and fills up interplanetary, interstellar, and intergalactic spaces. It is the cylindrical field-space of the subelectronic level [10].

An analysis conducted in [10, 11] shows that it is acceptable to identify neutrinos with subelectronic particles, every of which has the associated mass substantially smaller than the electron mass. These particles fill up cosmic space and are, apparently, those material medium owing to which the propagation of electromagnetic waves is realized in nature. Namely we assume that the propagation of electromagnetic waves (including the light band) in space occurs like propagation of common material waves, for instance, sound waves in an ideal gas. Masses of subelectronic particles, responsible for the propagation of the waves, are turned out to be equal in order-of-magnitude to the masses which were ascribed to neutrinos in last years.

Subelectronic particles of cosmic space (like particles of a gas), oscillating with the speed *v*, represent discrete components of the wave, whereas the propagation of their disturbance (wave motion) with the phase speed *c* (analogous to the phase speed *u* of sound

in a gas) is the continuous component of the wave. The wavelength expresses the discrete side of the wave space, defining a natural quantum of its extensiveness, $\lambda = \frac{2\pi c}{\omega}$.

As was mentioned above, H-atoms are elementary emitters, determining the structure of optical spectra of all atoms. Energy of a wave quantum of a microgalactic field of the Universe is proportional to the frequency ω; it can be presented as

$$\varepsilon_x = \hbar_x \omega . \tag{14}$$

In this equality, $\hbar_x = m\upsilon r$ is the moment of momentum (action) of a particle with mass m that participates in a wave excitation of a spherical field of hydrogen atoms, both free and bound in nucleon nodes of composite atoms. If $m = m_e$, $\upsilon = \upsilon_0$, and $r = r_0$ are, respectively, electron mass, Bohr speed, and Bohr radius, *i.e.*, parameters of the hydrogen atom in an equilibrium stationary state, then the action

$$\hbar_x = \hbar = m_e \upsilon_0 r_0 \tag{15}$$

coincides in magnitude with the fundamental constant of physics, the reduced Planck constant, $\hbar = \frac{h}{2\pi}$.

Energy density of the microgalactic field of the Universe is proportional to the frequency ω as well; it is equal to

$$w_\varepsilon = \rho_\hbar \omega , \tag{16}$$

where $\rho_\hbar$ is the average density of wave action, the constant magnitude, because the action itself is constant.

A wave process, appearing at a level of the multi-dimensional field-space of the Universe, generates waves going into an infinite series of embedded field-spaces of lower and higher lying levels. Accordingly, because of the infinite embeddedness of fields, while moving, wave quanta going deeply inward the field-spaces of the Universe will lose their amplitude and, hence, a total energy with distance. It is a negligibly small effect in a scale of the solar system, and accumulating must manifest itself at huge distances of the cosmic level (at least comparable with and rather exceeding intergalactic distances). The longer these distances, the longer energy looses.

As follows from (16), the wave motion at significant distances in cosmic scale must be accompanied with the decrease not only amplitude and, accordingly, the total energy, but also with the decrease of the average energy density w_ε and, hence, because of the constancy of $\rho_\hbar$, with the decrease of the frequency ω of propagated wave quanta with passed distance.

Insignificantly small energy looses, occurred at relatively small cosmic distances, accumulated during a continuous recession of waves with distance must be noticeable at significantly bigger distances that is observed in reality. By virtue of this, the length of waves, coming from objects far remote from the solar system, turns out to be increased in the red region of the visible spectrum that is detected at present as cosmological redshirt.

The same mechanism naturally reveals the reason, why the night sky is dark for man. The wavelengths increase by a redshirt factor of (1+ z). Since emitted energy varies as 1/λ, redshifted radiation has reduced energy by the factor of (1+ z). So distant stellar objects are not only faint due to their distance, but their observed light loses energy by the (1+ z) factor as well. The largest cosmological redshift ever observed is z = 8.2 [12].

Thus, cosmological redshift takes place due to a decrease in energy density of emitted wave quanta with distance resulted in the decrease of their frequency. What is a possible internal mechanism of this phenomenon? An innate feature of any wave process in any real media, and infinite cosmic space is not exclusion, if we do not regard it as an absolute vacuum (emptiness), is a damping (and finally, a fading) of waves. The extent of this phenomenon differs for various media and depends on distance. A wave damping in natural media leads to a decrease in amplitude with time (distance). Frequency of damping waves is also reduced as compared with the eigenfrequency of radiation of a wave source.

Thus, as we have assumed, subelectronic particles, oscillating around their equilibrium states in space, are elementary transmitters of disturbances, as discrete parts of a wave process and having masses unequal to zero; *i.e.*, they are responsible for the propagation of waves of an electromagnetic spectrum. In such a case, generalities of a theory of oscillations can be applied for consideration to them.

All subelectronic particles, participating in the propagation of disturbance (waves), located along an imaginary line connecting a source with an observer in space (in an approximation of pointlike objects), can be considered as a unit oscillatory system. Then, at a small damping, amplitude of oscillations of the system will decrease with time following the equality

$$x = a_0 e^{-\beta t} \cos(\omega t + \alpha), \tag{17}$$

where β is the damping coefficient, a_0 is the initial displacement of an oscillator (amplitude at an initial moment of time), α is an initial phase of oscillations; ω is the frequency of damping oscillations. The latter depends on the extent of damping and is defined by the formula

$$\omega = \sqrt{\omega_0^2 - \beta^2}, \tag{18}$$

where ω_0 is the eigenfrequency of the oscillating system equal to the frequency of a source of radiation.

A total energy of the system is proportional to amplitude squared; therefore, the energy of the system decreases with time as

$$E = E_0 e^{-2\beta t}, \tag{19}$$

where E_0 is the initial energy of the system at $t = 0$.

Observed frequency of emitted quanta, ω, and frequency of the source for the observer, ω_0, are related with the redshift z as

$$\omega = \frac{\omega_0}{1+z}. \tag{20}$$

Let us to estimate now, on the basis of the formulas presented above, the damping coefficient β of the given system for the quanta emitted from the IOK-1 galaxy (Lyman-α radiation, λ_0 = 121.6 *nm*) that has been observed with a redshift z = 6.96. This galaxy is considered as one of the oldest and most distant galaxies found in 2006; and it is assumed that its age, about 12.88 billion years, has been more reliable established [13].

At the redshift $z = 6.96$, we have

$$\frac{\omega}{\omega_0} = \frac{1}{7{,}96}. \tag{21}$$

Hence, according to (18), the damping coefficient β for the Lyman-α radiation with the frequency $\omega_0 = \frac{2\pi c}{\lambda_0} = 1.55 \times 10^{16}\ s^{-1}$, has the value

$$\beta = \sqrt{\omega_0^2 - \omega^2} = 0.992\omega_0 = 1.538 \times 10^{16}\ s^{-1}. \tag{22}$$

During a time interval equal to $t = 12.88 \times 10^9\ years = 4{,}062 \times 10^{17}\ s$, an exponent in (19) achieves a magnitude of

$$2\beta t = 6.25 \times 10^{33}. \tag{23}$$

Respectively, during this time, energy of the system at damping oscillations decreases exponentially in $e^{2\beta t}$ times and, in respect to the initial energy E_0, takes the value equal to

$$\frac{E}{E_0} = e^{-2\beta t} = \frac{1}{\exp(6.25 \times 10^{33})} \tag{24}$$

Above obtained magnitudes are within the orders typical for parameters of cosmic scale phenomena.

5. Conclusion

Basing on the presented above arguments, we can conclude that the Universe is not expanding.

The proposed explanation of the origin of cosmological redshifts, performed on the basis of the well-known notions of *wave physics*, is verisimilar. Effectiveness of the *wave approach* is confirmed by a series of the discoveries that were made on this basis. Remind, for example, the discovery of *generalized spectral formula of energetic transitions* and the discovery of *microwave background radiation of hydrogen atoms*. Frequency spectra of both phenomena are directly defined by the strict radial solutions (the roots of Bessel functions) of the *general ("classical") wave equation* [3]. From the spectral formula of the microwave background radiation of hydrogen atoms, originated from the generalized spectral formula, it directly follows the true nature of origin of the Lamb shifts in the atoms [4, 8]. This means that the Lamb shift, a small difference in energy between the two definite energy levels in the hydrogen atom, has nothing in common with mythical virtual particles invented and used in quantum electrodynamics for explaining this phenomenon. Further, for the first time in physics, the anomalous magnetic moment of an electron in the hydrogen atom was also derived without use of the virtual particles. It was carried out on the basis of the *wave approach* and, moreover, was performed with very high precision [4, 9]. Etc.

A theoretical discovery of the hydrogen nature of the origin of CMB can be independently verified by direct experiments which, there is a hope, sooner or later, will be designed and carried out in the future. As concerns the Big Bang hypothesis, alas, the latter cannot be verified ever experimentally in principle. Moreover, as fictitious, this hypothesis should not be used as a trusted basis for explaining any phenomena. But what we have seen in reality.

At the beginning, being unaware its true nature, the detected CMB was attributed arbitrarily to (identified with) the so-called "relict" radiation left over the mystic Big Bang. That is, an explanation of the CMB origin was adapted (slanted) in favour of the created Big Bang myth. In turn, the Big Bang became regarded as proven phenomenon by the fact itself of an existence of the CMB. With time, the Big Bang myth was transformed in modern physics into (postulated as) the real fact once occurred.

Thus, the Big Bang and an assumed resulting stretching of space are myths just like other created myths as, for example, a myth of quantum electrodynamics about virtual particles. On the basis of the myths physicists create, actually, a virtual reality which then is tacitly accepted and, finally, dogmatically considered as an objective reality. If such approaches can prosper then it is obvious that something is wrong with the research methodology in modern physics.

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Lecture 6

Superluminal Speeds

1. Introduction

Superluminal speed is a topical issue of modern science, including physics and philosophy. Therefore, it makes sense to present here the specific relation to this problem of dialectical physics in the framework of the Wave Model (WM). The dialectical approach to this problem differs essentially from those ones which are used currently within the concepts of the Standard Model (SM) in modern physics.

Material presented in this Lecture is based completely on the author paper published in 2008 in the *Magazine of New Energy Science and Technology* [1]. Therefore, the content of the paper is reproduced here practically without changes.

Superluminal (faster-than-light) speed shows itself in anomalous dispersion of electromagnetic waves. It is observed experimentally on artificially exited media in laboratories (see for example [2-4]), but not in normal conditions existing in nature. The origin of superluminal speed observed is not understood properly because the explanation of this phenomenon, conducted in the framework of accepted in modern physics theories, is not convincing.

In this connection it is to the point to say that an existence of a superluminal speed is a natural phenomenon in the Universe viewed in the framework of the Dialectical Model of the Universe (DM) developed in last few years [5]. Most do not yet know about this model and, hence, do not use it in planning experimental research and for explanation of the data obtained. Therefore, the basic concepts of the DM and the cause of origination of anomalous dispersion are an important issue to be presented here.

We will start by comparing two models of the Universe, which are different in principle: (1) modern, accepted in physics (resting on formal logic), and (2) new, dialectical (DM) (resting on dialectical logic). The general structure of physical field-space in view of the DM is discussed. Concepts on divisibility and dimensionality of physical spaces, as necessary details for deeper understanding of the general features of the DM related to the general structure of the Universe, are presented as well.

The third section is dedicated to an analysis, in view of the structure considered above, of some literature on observation of anomalous dispersion of light. The latter, realized in specific laboratory conditions, is stipulated, as supposed in [1], by the resonant amplification of the disturbance transition caused by the light pulse at the subelectronic level, where the characteristic wave basis speed exceeds the speed of light *c*. From the point of view of the DM, this means that we are approaching (in aforementioned experiments) another world – a world of deeper levels of the Universe, the nearest world of subelectronic particles where the wave basis speed exceeds the speed of light *c*.

Thus, the principal concepts of Dialectical Physics, concerning the structure of the Universe and basis speeds of its different levels, including light and superluminal, and the supposition based on these concepts about the nature of anomalous dispersion are briefly discussed in this Lecture.

2. The Dialectical Universe

At the base of classical and contemporary physics lies the model of the Universe, which can be called the model of one space, presented throughout the nineteenth century by the concept of "*world ether*". The world ether was regarded as an initial level of the Universe. Today it is referred to as Dirac quantum vacuum, *etc*. Thus, in essence, the classical "ether" was transformed into the *quantum "vacuum"*. The latter is interpreted as some primordial quantum-mechanical chaos, in which chance and not necessity, in connection with the indeterminacy principle, is presented.

From our point of view, this model does not respond to the needs of the present time. In this connection, we propose to turn to philosophy, as universal science, in particular, to *dialectical philosophy* with its *dialectical approach* to the structure of the Universe [5].

The word *dialectics* (as "*dialectical philosophy and dialectical logic"*) means, on the one hand, the search for truth by conversations, which were carried out through the formulation of questions and the methodical searching of answers to them. On the other hand, *dialectics* means the capability for vision and reflection by means of notions of the opposite facets of nature.

In the wide sense of this word, *dialectics* is a skill of many-sided description of an object of thought and a logic formation of the prediction of necessary and possible events. Thus, *dialectics is regarded as logic of philosophy and all sciences, i.e., as the logic of cognition on the whole.*

Dialectics represents a synthesis of the best achievements of both materialism and idealism and it is the ground for understanding the material-ideal essence of the World. Physics based on axioms of dialectics is called *Dialectical Physics*.

The essence of the *dialectical model* of an arbitrary state or process is the fact that any property of the Universe, denoted by the limiting brief judgment **Yes**, always responds (without any exceptions) to the property **No**. This rule is the fundamental principle of the "dialectical model" that thus claims that any **Yes** has its own negation **No**. Moreover, there is not a clear boundary between **Yes** and **No**: many properties of **Yes** continuously and discontinuously turn into the opposite properties **No**. For example, it is the continuous transfer of potential energy in kinetic one and vice-versa at oscillation of a pendulum, *etc*.

Thus, the symmetry of a pair **Yes-No** is the foundation of the Dialectical Model of the Universe, resting upon the fundamental law of dialectical logic – the law of *affirmation-negation*.

Contemporary physics recognizes formal logic, the logic of either only **Yes** or only **No**. Therefore, it is unable to overcome its one-sided plane view of the World. Nevertheless, at the same time, contemporary physics operates with the dialectical law of affirmation-negation, but in the implicit, and the extremely cut off form. In particular, it mentions discontinuity (**Yes**) and continuity (**No**), particles (**Yes**) and antiparticles (**No**), symmetry (**Yes**) and asymmetry (**No**), rectilinear (**Yes**) and curvilinear (**No**), *etc*.

However, following Einstein, contemporary physics states that only relative motion exists. But at the same time it operates with the absolute speed of electro-magnetic waves, the speed of light, which is the same "*for all observers in uniform relative motion, independently of the relative motions of sources and detectors*". If we use the accurate language of logic, this assertion means that physics simultaneously implicitly operates with the absolute motion of electro-magnetic waves and with their absolute speed, since their absoluteness means their independence of a system of coordinates.

In the Dialectical Model, the aforementioned logical manipulations are not required, because the property of motion **Yes** = "**relative**" responds to its symmetrical property **No** = "**absolute**". It means that any motion in the World is a complicated symmetrical complex of absolute-relative motion, *i.e.*, of motion **Yes-No**, in which the law of conservation and transformation of absolute-relative motion is valid.

Conceptual unfoundedness of an introduction in quantum mechanics of the notion of *hybridization of atomic orbitals* [6], which have led in particular to the development of quantum chemistry, is also a result of such formal logical one-sided view.

Conjugate potential-kinetic parameters give the complete description of potential-kinetic fields [7]. The dialectical image of a judgment $\hat{\Psi}$, $\hat{\Psi} = \Psi_p + i\Psi_k$, of the general binary structure of **Yes-No,** reproduces mathematically the real image and binary character of the original. The letter *i* (imaginary unit) in the equation designates the unit of negation [8], *i.e.*, points out the qualitatively opposite property Ψ_k (kinetic) with respect to Ψ_p (potential).

A misunderstanding of the latter gave rise to a nothing-grounded interpretation of the wave Ψ-function, in quantum and wave mechanics, according to which the real physical sense has only its modulus squared. Actually, since Max Born introduced the probabilistic interpretation of the wave function [9], untill now the "imaginary" parts, regarded as unreal quantities, did not have a firm physical interpretation. Let us cite Born's explanation: "*The reason for taking the square of the modulus is that the wave function itself* (*because of the imaginary coefficient of the time derivative in the differential equation*) *is a complex quantity, while quantities susceptible of physical interpretation must of course be real*" [9, p.142].

In reality, as proved by all experience of physics, "real" and "imaginary" parts of complex wave functions are both real. They represent two *qualitatively different* entities, in particular, the *potential* and *kinetic* features of the wave process described by the functions.

One can present many other examples that justify limiting possibilities and unsuccessfulness of formal logic. Thus, the DM is based on the binary field of conjugate real numbers (parameters), related to opposite properties [7, 8].

Further, the DM is also based on the principal axioms on the structure of the Universe on the whole [5], which are the following.

1. The Universe is the Material-Ideal System with infinite series of levels of **embedded** potential-kinetic longitudinal-transversal **fields** of absolute-relative motion of matter-space-time, in which all processes occur simultaneously both at the same level ("horizontal" processes) and between levels ("vertical" processes).

2. Mutual transformations of fields with opposite properties (for example, the **potential field** $\Leftrightarrow$ the **kinetic field**) cause the wave nature of the World. The wave process, appearing at some level, generates waves going deep into an infinite series of embedded fields-spaces, and vice versa, wave processes of the exchange of deeper levels, rising up, induce wave processes at the higher lying levels.

3. Any object of the Universe at a k-level simultaneously belongs to a lower situated infinite series of embedded fields-spaces; therefore, the structure of megaobjects of the Universe is defined by the structure of their microobjects (and the microfields related to them of an infinite series).

4. Between objects, objects and the ambient field of matter-space-time, there exists an **interchange** of matter-space-time occurring both in horizontal (within the same level) and vertical (between different levels) directions.

5. The longitudinal-transversal structure of the wave field of exchange of the Universe of an arbitrary level is presented by the spherical-cylindrical wave field of matter-space-time.

According to the above axioms, the physical field-space represents by itself an infinite series of spaces embedded in each other:

$$\Omega = \Pi_M + \Pi_A + \Pi_H + \Pi_\mu + \Pi_C + \ldots + \Pi_{C_\mu} + \ldots + \Pi_X + \ldots \ , \qquad (1)$$

where Π_X is an arbitrary level of the physical field-space. This series is analogous, to some extent, to the infinite functional series of a function:

$$f(x) = \sum_{k=1}^{\infty} u_k(x) \ . \qquad (2)$$

Both, the structure of the infinite series (which represents the function) and the infinite series of embedded physical fields-spaces, express the fundamental idea of dialectical philosophy – the infinite divisibility of matter-space-time according to approaching to the zero field-space, as the ideal formation.

We express the structure of the real physical field-space Ω, defined by the series (1), by a graph of spaces, which can be regarded as a simplified structural model of the physical space (Fig. 1). Every level of space is the basis level for the nearest above situated level and, simultaneously, it is the level of superstructure for the nearest below situated level of space. It means that above situated field-spaces are formed on the basis of below lying fields-spaces. Accordingly, in dialectics, there is no sense in speaking about the very last elementary particles in the common classical sense of this word.

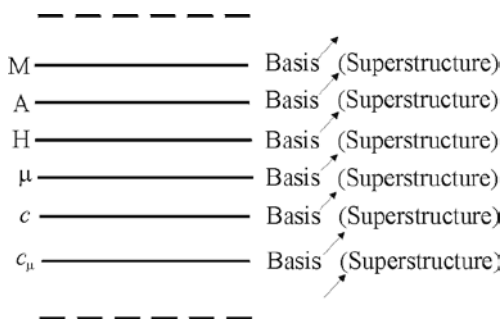

Fig. 1. A graph of spaces of the molecular (M), atomic (A), H-atomic (H), and microparticles (μ) levels; c and c_μ are the levels of spaces, correspondingly, with the basis speed c and c_μ; *etc*.

For the description of the upper spaces M, A, H, and μ (see Fig. 1), we take, in the capacity of the basis space, the space with the basis wave speed c.

Two metaphysical viewpoints exist in philosophy and science about the general structure of the Universe: matter has a lower limit of its divisibility or, alternatively, there is no lower limit and matter is infinitely divisible. These viewpoints have appeared under influence of rules of formal logic: only **Yes** or only **No**.

According to the law **Yes-No**, dialectics asserts that the *Universe is infinitely-noninfinitely divisible*. This assertion has the universal character and relates not only to matter.

The concept of existence of the last indivisible state of matter excludes any exchange without which this state cannot be a basis for the formation of overlying non-elementary levels of matter. But if each state of matter is elementary for overlying more complicated levels and complicated for underlying levels, then this means that we deal with the material realization of the principle of divisibility-indivisibility.

Every level of matter is the manifestation of the definite finite divisibility **Yes** with its own structure. And at the same time, every level has the internal structure, which supposes the further division, thus expressing **No** of the finite divisibility of the level **Yes**, *etc*. The essence of dialectics of divisibility-indivisibility **Yes-No** is in this.

At such an approach, there is no sense in speaking about motion of matter in vacuum, as a pure mathematical non-being, because any state of matter moves in the space of underlying states.

Under the notion *motion-rest*, it understands the complicated wave process of space-time, because in the wave fields, lying in the basis of all levels (states) of matter, a simple mechanical displacement cannot exist. Quantum mechanics encountered this dilemma in its time, attempting to solve the problem on the basis of chaos of the probabilistic indeterminacy.

3. The finite-infinite-dimensional Universe

Since, from the viewpoint of dialectics, matter is unlimitedly divisible deep down, the real spaces-fields turn out to be embedded in each other. One of the sides of *n*-dimensionality of physical field-spaces lies in this.

The Universe consists of a great number of objects with their own limited spaces that just stipulates the physical *n*-dimensionality of space. These spaces are related to the subspaces of the Universe. Subspaces of the Universe consist of the structural elements of subspaces, being the subspaces of subspaces. Such elements are restricted and, consequently, their spaces are restricted as well. We can erect a perpendicular to the spaces of elements, which then will be the fourth dimension for them, *etc*.

Subspaces of any elements are scalar structures, but they have the definite anisotropy and in this sense they are the physical vectors. Thus, real spaces are scalar-vector spaces, *i.e*., they are spaces **Yes-No** in relation to dialectics of the contradiction, directedness and undirectedness.

The ideal point is zero-dimensional, while the material point is three-dimensional. Ideal points can form an ideal one-dimensional line, whereas material points form the material four-dimensional line.

The ideal line, moving in space, forms a two-dimensional surface. The material line (Fig. 2b), recurring many times, forms a five-dimensional material surface $\Delta\Omega$ (Fig. 2c). Its

volume is equal to the scalar product of the volume of material line ΔV by the line ΔL along which the displacement takes place:

$$\Delta\Omega = \Delta V\, \Delta L \sin\alpha\,. \tag{3}$$

Replicating in space, the ideal surface forms a three-dimensional ideal volume; the material surface makes up a six-dimensional volume ΔU equal to the scalar product of a five-dimensional surface $\Delta\Omega$ by the length ΔH of the line of the displacement (Fig. 2d):

$$\Delta U = \Delta\Omega\, \Delta H \sin\beta\,, \tag{4}$$

where β is the angle formed by the plane of the five-dimensional surface and the direction of the line ΔH.

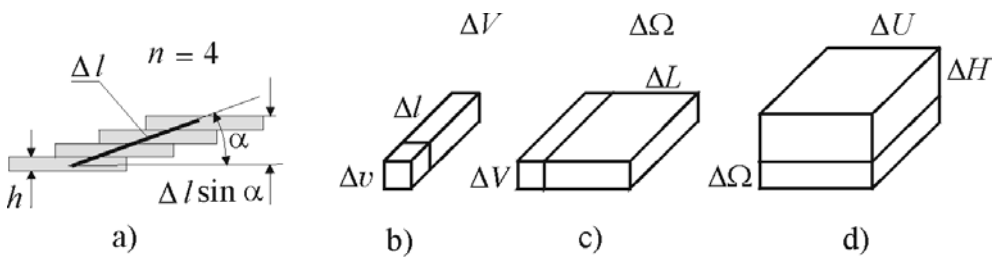

Fig. 2. To the definition of the four-dimensional line (a); elementary physical volumes: the four-dimensional material line (b), five-dimensional material surface (c), six-dimensional volume (d).

In successive recurrence, the six-dimensional formation, as a material point, will form, like its primogenitor, a seven-dimensional line in space. A set of the seven-dimensional lines forms an eight-dimensional surface, which can generate a nine-dimensional volume. Everything will be repeated again in the sequence: *point – line – surface – volume* with measures of the types of V, Vx Vxy, $Vxyz$, where the volume is the material point of a new structure. Thus, *dimensionality of the real space is a periodical magnitude with the fundamental period equal to three.*

We will give concrete examples of multidimensional objects in light of dialectical understanding of multidimensionality. Let, for example, the form of an object be represented by the equation:

$$x^2 + y^2 + z^2 \oplus u^2 = \hat{R}\,, \tag{5}$$

where *x*, *y*, *z* are coordinates of the rectangular frame of reference; *u* is the first coordinate of the following three-dimensional space; $\oplus$ is the symbol of the impractable operation of addition realizing a kinematic joint of a three-dimensional spherical volume of a radius *a* with

a point *C*; $\hat{R} = r^2 \oplus c^2$, $u = c$, $c = a + b$ and *r* is a variable radius whose values pertain to some interval of quantitative values: $r \in (0, a)$ (Fig. 3a).

In this case, the realizable sum of squares of three variables describes a *sphere* (of the radius *a*). The *point C* above the latter is the fourth dimension of the object because it lies outside the space of the sphere.

Let *c* change in the interval $c \in (a, b)$, then we have a three-dimensional sphere with the *perpendicular* of the length *b* erected to it, which also represents the fourth dimension for the three-dimensional sphere (Fig. 3b).

Now, we construct the five-dimensional formation:

$$x^2 + y^2 + z^2 \oplus u^2 + v^2 = \hat{R}, \tag{6}$$

where *u* and *v* are rectangular coordinates of the plane space perpendicular to the spherical space; $\hat{R} = r^2 \oplus \rho^2$, at that $r \in (o, a)$, $\rho = a + b$ and $u^2 + v^2 = \rho^2$.

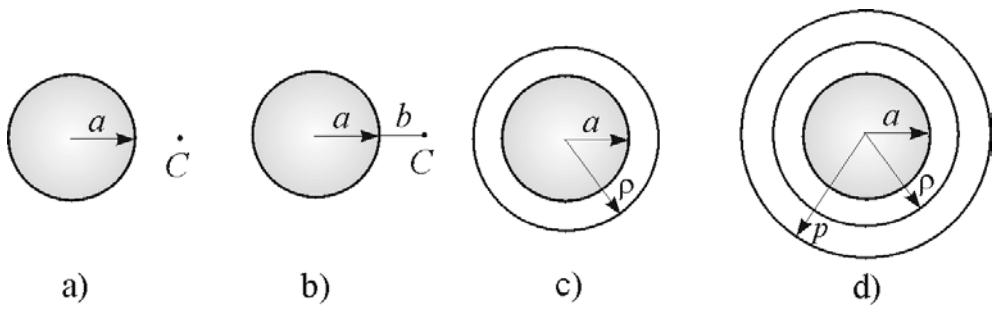

Fig. 3. A sphere and the point *C* above (a), the sphere and the perpendicular *b* to it (b), the sphere and a circumference (c), the sphere with two circumferences (d).

This object is a *sphere* with a *circumference* at the same center (Fig. 3c). The similar five-dimensional formations fill the Universe: a star and an orbit of its planet, a planet and an orbit of its satellite. The space (*u*, *v*) is a restricted space; it is represented only by the circular orbit and is in essence the linear space.

A seven-dimensional object of the type:

$$x^2 + y^2 + z^2 \oplus u^2 + v^2 \oplus w^2 + s^2 = \hat{R}, \tag{7}$$

where (*w*, *s*) is the plane linear space, analogous to the space (*u*, *v*); $\hat{R} = r^2 \oplus \rho^2 \oplus p^2$ defines a sphere with two circumferences at the same center (the center of the sphere). In the Solar system, Mars and two orbits of its satellites represent such a formation.

The above examples illustrate rather clearly the *dialectical understanding of multidimensionality*. The structure of equations describing multidimensional objects consists

of separate components interlinked by the signs of unrealizable addition. Every one of the components in the equation describes a subspace of the dimensionality $n \leq 3$ of the multidimensional space of a complex object.

The extension of the Universe satisfies to the universal law of dialectics **Yes-No**: the Universe has boundaries and it is boundless.

An infinite part of the Universe is represented by the infinite space, while its objects represent its finite part. For instance, the internal space of an electron does not belong to the Universe, this is the external side of the Universe and the electron surface is a boundary of the Universe [10, 11]. In this sense, any electron is one of the terminations of the Universe. Dialectical judgments of this kind are not a pun. Let us imagine that a drop of a liquid is in a spacecraft in an imponderable state. The drop may contain air bubbles inside it. This drop has the external spherical boundary and the internal boundary represented by spherical surfaces of the air bubbles, the internal space of which does not belong to the drop space. We speak about the Universe in this natural sense as well.

Thus, an infinite series of levels of matter of the Universe, represented by their proper elementary objects, is simultaneously an infinite series of the levels of its terminations; while the Universe has not the external boundary and it is infinite. However, there is also a contradiction here: the infinity is closed on to zero and, consequently, any ideal point in the space expresses the infinite boundary of the Universe.

Any microlevel of the Universe consists of a series of sublevels, which make up a structural spectrum of the microlevel.

Every sublevel is characterized by some mean speed of motion inherent only to this level. Amongst all sublevels of any level, there is a basic sublevel that makes the main contribution to transfer of motion and rest. We term this sublevel a basic or carrier_sublevel of the given microlevel, its basis or characteristic speed bears its name.

Motion and rest are mutually unstable states and the transfer of motion-rest bears a wave character. The characteristic speed of the basic sublevel is the carrier wave speed for the rest sublevels belonging to the given microlevel.

4. Basis speeds inherent in the deeper levels of the Universe

As follows from the Dialectical Model, any object of the Universe at a level simultaneously belongs to a lower situated infinite series of embedded fields-spaces (see axiom 3, Section 2). Thereby the structure of megaobjects of the Universe is defined by the structure of their microobjects. And between objects, objects and the ambient field of matter-space-time, there exists an *interchange* of matter-space-time occurring both in horizontal (within the same level) and vertical (between different levels) directions (axiom 4). With this, in comparison with sublevels of the characteristic basis speed equal to the speed of light c,

distinguished now by man, deeper situated levels (Fig. 1) can have wave basis (carrier) speeds higher than *c*. Thus, in accordance with the transition to deeper levels of space, the *wave basis speeds at these levels increase*.

Therefore, any cause and effect, in a set of embedded spaces, are reflected in all these spaces. This is expressed through an infinite series of events – causes and effects – at all levels of matter-space-time, generated by the initial event at a level. Corresponding perturbations are propagated there with different characteristic basis speeds.

Accordingly, before a cause A_{k+1} would appear at a level k+1 (regarded as an upper level), in a domain *M* of matter-space-time, it happens at the deeper levels in the form of a series of causes of the lower situated levels (Fig. 4). The cause A_k of the lower level *k* is a harbinger of the cause A_{k+1} at the level k+1.

The cause A_k generates in a domain *N* an effect B_k later at the time τ_k, which is defined by the speed c_k of the wave signal at the *k* level (Fig. 4).

At the same time, the cause A_{k+1} at the level k+1, in the same domain *N*, generates its own effect B_{k+1}, appeared there later at the time τ_{k+1}, during which the wave signal of this level passes with the speed c_{k+1} (where $c_{k+1} < c_k$). Since $\tau_k < \tau_{k+1}$, the effect (of a cause in the domain *M*) in the domain *N* appears later on at the level k+1 than at the level *k*.

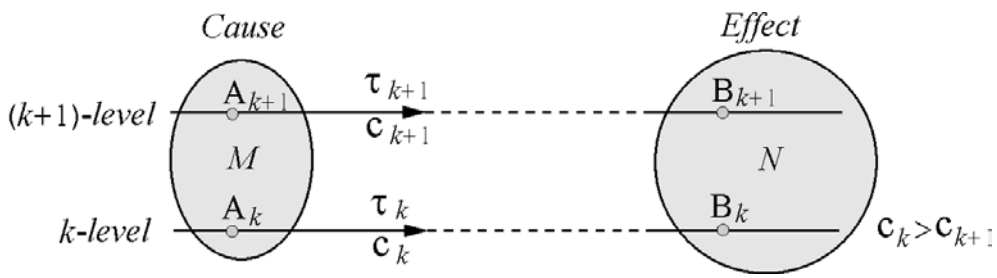

Fig. 4. The dialectics of cause and effect.

Thus, if an event-cause *P* in a domain *M*, at the level of electromagnetic waves (k+1 level) generates an effect *S* in a domain *N*, then, at the deeper (*k*) level, this effect can arise in the domain *N* (at the *k* level) earlier than at the electromagnetic (k+1) level. Moreover, if the time Δt_P of the process of coming into being (the cause *P*) turns out to be significantly less than the time τ_k, then the signal at the *k*-level can appear in the domain *M* before the cause *P* would happen there at the electromagnetic (k+1) level.

If we suppose that one of the deeper levels is characterized by the speed multiple to the fundamental measure $\Delta = 2\pi \lg e$ [12], for example $c_k = 100\Delta \cdot c_{k+1}$, then the signals of this level outstrip the electromagnetic signals 100Δ times.

We discuss the propagation of wave perturbations that occur naturally in real space at different levels of the Universe. Thus the above consideration is applied to a naturally occurring medium. And what media are used in experiments on superluminal propagation of light currently carried out in laboratory conditions?

In Wang's experiments on superluminal speed of propagation of light pulses [2], we deal with such a preparation of a transparent medium, properties of which differ extremely from the properties of media usually occurring in nature, as far as we know. Due to active external influences ("pumping"), there were created special conditions under which appears *anomalous dispersion of light*. In an anomalous disperse medium the refractive index decreases as the frequency of light increases. Because of this, as is assumed, the group velocity of optical pulses in this medium exceeds the speed of light *c* in vacuum many times.

The superluminal speed of the pulse in Wang [2], where the group refractive index achieved the value $n_g = -310$, is explained as a result of '*rephasing of the wave components*' which underwent the anomalous dispersion inside of an artificially created active medium. '*Rephasing*' occurred at an earlier time (62 *ns*) than the vacuum propagation time (0.2 *ns*) through the medium (see also Wanare [13]). Thus, '*rephasing*' takes place 310 times faster than the speed of light *c* in vacuum.

However, there is no convincing explanation why rephasing is so fast. The similar explanation that some media "*can modify the phase of the pulse's frequency components*" is in Wei Guo's theoretical work on propagation of a light pulse through a dielectric slab [14]. Modern physics does not find other explanations of the superluminal speed propagation [2] and similar experiments [3], apart from use of the '*rephasing*' concept.

The physical mechanism of origination of anomalous dispersion is also unknown. Only the fact itself of an appearance of anomalous dispersion is stated without explanation of an internal cause (process) of its arising.

There is another principal question debated in connection with the data obtained. It is the relation of superluminal speed of propagation and superluminal speed of information [15 - 17]. Different experiments on superluminal speed of propagation, including experiments with microwaves [4], leave this question open.

The DM, on the basis of dialectics of cause and effect described above (Fig. 4), explains Wang's experiments [2] (and similar ones) and the cause of origination of anomalous dispersion in the following way. There is no known naturally occurring anomalous dispersive medium, which is transparent in the visible region of the spectrum. In Wang's experiment, the specific medium, a 6-cm-long rubidium-metal vapor at a temperature near zero degree Kelvin, was affected to uniform magnetic field and laser-polarized light of relatively high intensity. An extremely high background of excitation of subatomic levels of the medium (taking place at such conditions) does hamper (makes it impossible) realization on this background of the subsequent additional wave excitation of the levels by the investigated

light pulse, transferred through the active ('pumped') medium. It leads to the resonant amplification of the disturbance transition of the light pulse mainly at the *subelectronic level* [18], lying below atomic and subatomic, with the basis wave speed of the level exceeding the speed of light *c* in vacuum. Recall, the speed *c* is characteristic for upper lying levels (molecular, atomic, and subatomic).

Waves of higher frequencies, constituents of the pulse, are closer to resonant frequencies of particles of the *subelectronic level* of physical space [18]. There exists an analogy with forced oscillations of a pendulum, whose amplitude depends on frequencies of external excitation and achieves maximum under resonance conditions. Therefore, approaching the subelectronic level, not only the base (carrier) speed of wave's propagation increases, but also the amplitude relation between wave components of the traveling light pulse changes thereby. As a result, while the pulse moves through the active medium, the location of the pulse pick in the time scale is shifted, that is observed in experiment.

Apparently, not understanding the fact, optics actually achieves under *anomalous dispersion of light* conditions such a level of excitation of media at which the spaces of deeper (subelectronic) levels, lying below atomic and subatomic, mainly work as carriers of excitation. These spaces with the wave basis speed of much higher value than the speed of light *c* in vacuum make major contribution in carrying of wave packages of pulses under such conditions.

5. Conclusion

1. Dialectical Model of the Universe is based on principal axioms of dialectics set forth first in Kreidik and Shpenkov [5]. The five of them, concerning the structure of the Universe, have been presented here. The DM takes into account the natural harmony, or natural harmonic bond, existing between any objects and phenomena in nature at all its levels, including mega and micro. This bond is conditioned, as we assume, by the fact, reflected in the corresponding axiom, that physical field-space represents by itself an *infinite series of spaces embedded in each other*. The principal deference of the DM as opposed to the accepted model of the Universe of modern physics is clearly seen from the latter.

2. The DM regards the Universe as *infinite dimensional* that is naturally related to the aforementioned embeddedness of spaces. With this the dimensionality of real space is a *periodical magnitude* with the fundamental period equal to three.

3. *Basis wave speeds are different* in different basis spaces of the Universe. The speed of light *c* is inherent in macro and micro levels – molecular, atomic, and subatomic. At the deeper levels, below atomic and subatomic, there are spaces with the basis speeds exceeding the speed of light *c*. Thus, the *superluminal speed is a natural speed in the Universe* viewed in the framework of the Dialectical Model.

4. *Anomalous dispersion*, observed in specific laboratory conditions (in aforementioned experiments with the light pulses) is, apparently, *stipulated by the resonant amplification of the disturbance transitions at the subelectronic level* of the Universe where the characteristic wave basis speed exceeds the speed of light *c*.

5. Thus, an appearance of anomalous dispersion points out the fact that *we affect another world* – the world of deeper levels of the Universe. It is the world of subelectronic particles, where basis speeds of signals propagation are much higher than that we know now.

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Lecture 7

Advantages of the Wave Model

1. Introduction

Theories of Dialectical Physics, generalized in the *Wave Model* (WM): the *Dynamic Model* (DM) of elementary particles (DM) and the *Shell-Nodal* atomic model (SNAM), became known from 1996 after publishing a book "*Alternative Picture of the World*" by L. G. Kreidik and G. P. Shpenkov. These theories, judging by the results presented in the Lectures and numerous publications (indicated in References), beginning from the aforementioned book, proved to be crucial that led, in fact, to breakthrough in physics.

The WM follows *dialectical logic* unlike formal logic accepted in modern physics. And only *one postulate*, namely, the postulate on the wave nature of all objects and phenomena in the Universe is in the basis of the WM. This conceptual basis cardinally distinguishes the WM compared to the SM. Remind, for example, that only one theory, quantum mechanics, from a number of the theories in framework of the SM, is based on six abstract-mathematical postulates.

After reading all the Lectures, everyone apparently could make sure that the WM really gave answers to many of the principle questions, which are insolvable fundamentally in the framework of the *Standard Model* (SM) of modern physics, exceeding all optimistic expectations.

In accordance with the WM elementary particles are *dynamic microobjects*, *i.e.*, wave spherical microformations *pulsating* simultaneously at two *basic frequencies*: extremely high, ω_e, and extremely low, ω_g. Wave exchange at these *fundamental frequencies* determines basic types of the *fundamental* interactions, which have obtained at last, thanks to the WM, the *unified description*.

A series of fundamentally important discoveries, along with the noted above *frequencies*, was made in the WM. Deserve special attention also discoveries of the *origin of mass* and the *nature of electric charge* of elementary particles. The DM is the only theory existing today

which reveals the nature of the notions. Moreover, these discoveries follow from the DM so just naturally, as that what granted.

Further, thanks to the WM it was found that such physical phenomena observed experimentally as: *cosmic microwave background radiation* (called sometimes as "*relict*"), the *Lamb* "*shift*", and the so-called "*anomaly*" of electron's magnetic moment, as it turned out, have the same source of their origin – the incessant intra-atomic oscillatory-wave motion in both the excited state and equilibrium. These phenomena have obtained in the WM the logically noncontradictory *unified* description and explanation.

We should recognize that contemporary physics is currently on a relatively low level. For the presently existing civilization, physics, as science about fundamental regularities in Nature, makes yet first steps on the Earth. For this reason, modern technologies are still based mostly on a very primitive principle, namely on burning of mineral raw material such as mineral oil, gas, and coal and on use of radioactive materials.

Official mass media little pay attention to the flaws, on the contrary, speak mainly on the progress, as they believe, takes place all time in physics. Here is a bright example: quantum mechanics has been recognized by media at the turning point of centuries as the most outstanding physical theory of the past 20th century. However, as can be seen from comprehensive analysis published in [1-3] and considered in Lecture 1, it is the hopeless most primitive abstract-mathematical theory based on the erroneous concepts.

It is no wonder. Let us turn to history. Fundamentals of classical mechanics were generalized and formulated by Sir Isaac Newton in 1687. This year can be seen conditionally as the year of the beginning of contemporary physics. The 328 years have passed only from that time. A hundred year later (1785-1789), essential principles of electricity as the science were established by Coulomb. What are the 328 years in the cosmic time scale? Another words, what are 328 revolutions around the Sun in comparison with 4.54 billion revolutions of the Earth during, as believe, 4.54 billion years of its existence? It is less than the twinkling of an eye in the cosmic scale.

Really, nothing has changed from Newton and Coulomb's times till now in contemporary physics for understanding the nature of such primordial notions as *mass* and *electric charge*.

Why do we speak about these two aforementioned fundamental notions? First of all because understanding just their origin and nature, in our opinion, is the main clue for revealing other most important mysteries of Nature, which are directly related with *mass* and *charge*. Ignorance of the nature of the above physical notions holds the further development of physics and, consequently, technological progress. In particular, ecologically clean technologies unknown till now can be discovered and get their development rather on the basis of knowledge, first of all, these aforesaid primordial notions.

Physicists-theorists understand the flaws of the SM. Therefore they undertake different attempts, putting forth different ideas, in order to pull out physics from deadlock in which it is now. However, up to the present time, most of the proposed theoretical solutions are directed for change or improvement some fragments of existing theories, for patching holes in old clothes, leaving the existing basis of the SM untouched.

Thus, official physics prefers a renewal of the SM keeping its conceptual basis unchanged. In particular, it rests hopes upon String Models of elementary particles. Principal difference of the latter with respect to SM is only in the fact that elementary particles in String Models are considered already not as point like objects, but as microobjects having dimensions – as very small strings (less in size than atomic nuclei).

The total set of oscillatory modes of the strings should describe a whole variety of elementary particles and their interactions, including gravitational. A complicated mathematical tool is used with this because the strings are 10- and 11-dimensional structures. Actually, String Models, being yet more complicated abstract-mathematical theories than the SM theories, do not reflect the real image of elementary particles, tending to describe only their behavior. Unfortunately, physicists-theorists got used to the abstractiveness and complete mathematization of physics theories, and, as before, they adhere to this deadlock approach.

A generalized string theory is very far from its final form, if only such a theory will be built ever completely. And what is very important: String *Models do not resolve the fundamental problem of physics*, the problem on *the nature of mass and electric charge*. Therefore, the choice of String Models is unsuccessful, rather erroneous; such models have no perspective. It is a pity of lost efforts and time on their development.

For more than two decades *conceptually* a new basic physics theory, the WM, is continuously developing. This fundamentally a new basic theory, which is a subject of these Lectures, turned out incomparably much more effective that the SM**.** New physics paradigm underlying the WM includes dialectical philosophy and dialectical logic (instead of formal) and only one but real postulate reflecting the unquestioned fact that all objects and phenomena in the Universe have the wave nature. Judging by the results, the chosen conceptual basis turned out to be successful, and the WM can be rightfully regarded, as a viable alternative to the SM, to its abstract-mathematical theories dominating still in physics. An analysis of advantages of the WM shows that we are on a right way in our understanding the regularities in Nature and the structure of matter-space.

Recall now the principal discoveries of the WM.

2. The key discoveries of the Wave Model

The correct statement of a problem is half of the success to get right solutions. Apparently, this is that case. The Wave Model gave rise the domino effect in physics. A

chain reaction occurred when a fundamental change of our view on the nature of all objects and phenomena in the Universe, in particular, elementary particles structure caused the discovery of new fundamental parameters, which then caused a change of basic notions, which then caused another change of accepted theories, and so on in linear sequence.

It makes sense at summarizing to enumerate some of the fundamental discoveries obtained in the WM. Here they are.

1. The origin of *mass*.
2. The nature of *electric charges*.
3. The *fundamental frequency* of the atomic and subatomic levels.
4. The nature of "*electrostatic*" field.
5. The nature of *gravitation*.
6. The *fundamental frequency* of gravitational field.
7. The *Shell-Nodal structure* of the atoms.
8. The nature of *Mendeleev's Periodic Law*.
9. The structure and relative mass of all possible *isotopes*.
10. Physical meaning of the *fine-structure constant*.
11. The *unified description* of electromagnetic, gravitational, and strong interactions.
12. Objective *dimensionalities* of physical quantities.
13. Fundamental period-quantum of the *Decimal Code* of the Universe.
14. Derivation of the *magnetic moment of the proton*.
15. Derivation of the *magnetic moment of the neutron*.
16. The *magnetic moment of the electron* in the hydrogen atom.
17. Microwave *background radiation* of hydrogen atoms.
18. *Physical meaning of the speed of light* squared in the rest mass-energy formula.
19. The nature of the *Lamb shift*.
20. What the electron is.

The list of the discoveries presented above is very impressive. It is impossible, apparently, not to agree with this opinion.

It make sense in the given conclusive Lecture to present also in a *compact table form*, for the final *comparative analysis*, the main features of two physical models, respectively, the Wave Model (considered in the Lectures) and the Standard Model (dominated currently in modern physics). Such a table, which includes the discovered new fundamental parameters, the revealed notions and phenomena, relevant formulas, and necessary brief comments, was designed and framed [4]. It is presented below.

3. The Wave Model versus the Standard Model

The list of advantages of the WM (What does it follow from the WM?) is presented in the left column of Comparative Table. The corresponding comments on capability of the SM (based on Schrödinger's quantum mechanics, QM, Dirac's quantum electrodynamics, QED, and quantum chromodynamics, QCD), with respect to the enumerated points at issue, are presented in the right column. Principal details concerning the notions and discovered parameters, shown in Comparative Table, were discussed in our Lectures. Additional information one can find in References.

After browsing the data presented in Comparative Table for the visual demonstration, everyone, who is able to distinguish 'black from white', apparently, will note the unconditional advantage of the dialectical approach inherent in the WM, with respect to the concepts underlying the SM. Undoubtedly, the SM looks extremely poor in comparison with the WM. We have more than enough grounds to assert that the SM is, actually, the fail of huge efforts of physicists-theorists that last already about a century. It is obvious, the further existence of the SM does not give any chance for developing physics, for forming the true basis of natural sciences; accordingly, the SM must be replaced as soon as possible.

4. Conclusion

We assume that most will come to the same conclusion after reading Lectures and looking through the Comparative Table. Two Models, Wave and Standard, fundamentally differ, both in conceptual basis and in results. The readers meet here with absolutely a new physical theory, the WM, advantages of which, with respect to SM, are so clearly seen that they must not give rise to doubts.

The Dynamic Model of elementary particles and the Shell-Nodal atomic model are not casual inventions or fruits of imagination. They naturally originate from a new physics based on dialectics and on recognizing the wave nature and behavior of everything in the Universe. Dialectical philosophical system with its logic supersedes Aristotelian (dominated currently in physics) with its formal logic of limited possibilities.

According to the WM, *atoms* are regarded as the wave formations. They have *the shell-nodal* structure, and are, actually, *molecules of the strongly bound hydrogen atoms* to which we refer nucleons (proton and neutron) and protium.

The *main role* in the formation of molecules and crystals belongs to the hydrogen atoms located in the nodes of the shells. Chemical bonds are realized in interatomic space along characteristic directions defined by the topology of internodal bonds, *i.e.*, along strong bonds realized between the nearby intra-atomic nodes belonging to two external shells each of linked atoms.

	Advantages of the Wave Model (WM): *Dynamic Model (DM) of Elementary Particles and Shell-Nodal Atomic Model.* ***What does it follow from the WM and solutions of the wave equation?*** $\Delta\hat{\Psi} - \frac{1}{c^2}\frac{\partial^2\hat{\Psi}}{\partial t^2} = 0$	***Comments on capability of the Standard Model (SM),*** *including* *Schrodinger's QM, Dirac's QED, and QCD* ***(With respect to enumerated points at issue)***
1	***The origin of mass.*** *Mass has the field* ***associated*** *nature.* $m = \frac{4\pi\varepsilon_0 r^3}{1 + k_e^2 r^2}$; where $\varepsilon_0 = 1 g \cdot cm^{-3}$, $k_e = \omega_e / c$ (see 5). ***The rest mass does not exist.***	***Unknown***
2	***The nature of electric charges.*** ***The charge represents the rate of mass exchange*** $Q = dm/dt$	***Unknown***
3	***The relation between associated mass and exchange charge***: $Q = m\omega_e$	***Unknown***
4	***The objective central ("electric") charge of electron:*** $e = 1.70269155 \cdot 10^{-9}\ g \cdot s^{-1}$ ***Electron is the elementary quantum of the rate of mass exchange***	***Erroneous dimensionality and value*** $e = 1.602176462 \cdot 10^{-19}\ C$ (in SI), where $1C = \frac{c_r}{10}\frac{1}{\sqrt{10^9}} kg^{1/2} m^{3/2} s^{-1}$ and $c_r = 2.99792458 \cdot 10^{10}$. In CGSE system $e = 4.803204197 \cdot 10^{-10}\ CGSE_q\ \ (g^{1/2} \cdot cm^{3/2} \cdot s^{-1})$

5	***The fundamental frequency*** of the subatomic and atomic levels: $\omega_e = e/m_e = 1.869162559 \cdot 10^{18}\, s^{-1}$	***Unknown***
6	***Static fields do not exist in Nature*** "Electrostatic" fields are, actually, exofrequency fields of the fundamental frequency ω_e (see # 5)	***Unknown***
7	The objective ***transversal*** ("magnetic") ***charge*** of an electron on the Bohr orbit: $e_H = \frac{\upsilon_0}{c} e$	***Unknown***
8	***The fundamental wave radius***: $\lambdabar_e = c/\omega_e = 1.603886492 \cdot 10^{-8}\, cm$	***Unknown***
9	***The ratio of electron's orbital magnetic moment***, $\mu_{e,orb} = e\upsilon_0 r_0 / c$, ***to its orbital moment of momentum***, $\hbar = m_e \upsilon_0 r_0$: $\frac{\mu_{e,orb}}{\hbar} = \frac{e}{m_e c} = \frac{1}{\lambdabar_e} = k_e$	***Incorrect value*** $\frac{\mu_{e,orb}}{\hbar} = \frac{e}{2m_e c}$
10	***The magnetic moment of an electron***: $\mu_e = \frac{\upsilon_0}{c} e(r_0 + \delta r_0) = -1855.877359 \cdot 10^{-26}\, J \cdot T^{-1}$; $\upsilon_0 = 2.187691263 \cdot 10^8\, cm \cdot s^{-1}$ is the Bohr speed	***Incorrect value*** $\mu_e = (1+\alpha_e)\frac{e\hbar}{2m_e c} =$ $= -928.476410(80) \cdot 10^{-26}\, J \cdot T^{-1}$

11	***The proper magnetic moment of an electron (electron "spin" magnetic moment):*** $\mu_s = \frac{r_e}{z_{p,q}}\sqrt{\frac{2Rh_e}{m_0 c}} = -5.50792\cdot 10^{-29}\, J\cdot T^{-1}$	***Incorrect value*** $\mu_s = \mu_B = \frac{e\hbar}{2m_e c} =$ $= -927.400947(80)\cdot 10^{-26}\, J\cdot T^{-1}$
12	The radius of an electron shell (***electron's radius***): $r_e = \sqrt{\frac{m_e}{4\pi\varepsilon_0}} = 4.17052597\cdot 10^{-10}\, cm$; $\varepsilon_0 = 1g\cdot cm^{-3}$, $m_e = 9.10938253\cdot 10^{-28}\, g$	***Unknown*** Considered as a ***point like*** particle. ***Classical electron radius*** is $r_e = \left(\frac{\upsilon_0}{c}\right)^2 r_0 =$ $2.817940325\cdot 10^{-13}\, cm$
13	The radius of a proton shell (***proton's radius***): $r_p = 0.528421703\cdot 10^{-8}\, cm$ (calculated from the ***formula of mass***, see # 1)	***Unknown*** Proton ***rms charge radius*** is $r_p = 0.8750(68)\cdot 10^{-13}\, cm$
14	***The fundamental frequency of the gravity field***: $\omega_g = \sqrt{4\pi\varepsilon_0 G} = 9.158082264\cdot 10^{-4}\, s^{-1}$; $G = 6.6742\cdot 10^{-8}\, g^{-1}\cdot cm^3\cdot s^{-2}$, $\varepsilon_0 = 1g\cdot cm^{-3}$	***Unknown***

15	***The fundamental wave radius of the gravity field:*** $\lambda\!\!\!^{-}_g = c/\omega_g = 327.4 Mkm$	***Unknown***
16	**The gravitational spectrum of nucleon wave shells:** $r = \lambda\!\!\!^{-}_g z_{m,n}$; $z_{m,n}$ are roots of Bessel functions	***Unknown***
17	***The background spectrum of the hydrogen atom***: $\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{(n+\delta n)^2}\right)$; $\delta n = \delta r / r_0$	***Unknown***
18	***The nature of the Lamb shift***: the shift is precisely equal to the frequency gaps between the nearest spectral terms of the background spectrum (see # 17)	***An erroneous concept*** based on an influence of the invented (non-existed) virtual particles
19	***The precise derivation of binding energy*** in atoms ***without use*** of the relation $\Delta E = \Delta m \cdot c^2$	***Unable***
20	***The physical meaning of the speed*** of light c in the relation $E_0 = m_0 c^2$; m_0 is the ***associated mass*** of a particle (see # 1). Speed of light c is ***the basis wave speed of exchange of matter-space-time at the subatomic level.***	***Unknown*** m_0 is the "*rest*" mass.

21	***Internal spatial structure of atoms***, *i. e.*, the disposition of nucleons in atoms (The latter defines the structural variety at the molecular level in Nature: "***genetic code***")	The fixed (strictly geometrical) disposition of nucleons is ***Unknown***
22	***The g-lepton structure of nucleons***: ***Proton*** and ***Neutron*** are similar in g-lepton structure to isotopes ${}^{28}_{14}Si$ and ${}^{29}_{14}Si$, respectively, according to Shell-Nodal Atomic Model ($m_g = 68.22\, m_e$)	***Quark structure*** (does not similar to crystal)
23	***Crystal structure of solids***, including forbidden by mathematical laws of crystallography	***Unable***
24	***The structure of all isotopes and their relative masses*** (including limiting masses: minimal and maximal for every isotope)	***Unable***
25	***The nature of Mendeleyev's Periodic Law***: the similarity of nodal structure of external atomic nucleon shells.	***Different explanation:*** electron structure of atoms
26	***The fine structure constant physical meaning***: the scale correlation between basis and superstructure of wave (between oscillatory and wave processes in waves)	***Unknown***
27	***The unified description*** of ***electromagnetic***, ***gravitational***, and ***strong*** (***nuclear***) ***interactions***	***Unable***

28	***The nature of the spherical harmonics of wave and Schrodinger equations*** The spherical harmonics define polar-azimuthal coordinates of nodes and antinodes of standing spherical waves	***Unknown*** As a result, an introduction in quantum mechanics of the conceptually unfounded notion of hybridization of atomic orbitals
29	***The nature of integer and fractional quantization in quantum Hall effect*** The nature of quantization in the Hall conductance (the resistance quantum) is naturally uncovered as an internal feature of atomic structures considered as wave formations, without accounting an influence of external magnetic fields. ***The deduced spectrum of fundamental resistances*** $R_e = \frac{h}{e^2}\frac{m}{n}$	***Fitting theory in the spirit of the virtual particles of quantum electrodynamics*** Modern explanation is based on an imaginary quantum-mechanical fluid of a hypothetical new form and on a many body wave function. It predicts that the elementary excitations involve pseudo-particle charge carriers with charges that are fractions of the electronic charge.
30	***Precise derivation of the neutron magnetic moment*** $\mu_n(th) = \frac{e\upsilon_0}{c}\left[\left(\lambda\!\!\!^{-}_e + \frac{r_0}{y_{0,12}}\right)\sqrt{\frac{2Rh}{m_0 c}} + \frac{r_e}{j_{0,12}}\sqrt{\frac{2Rh_e}{m_0 c}}\right]$ $\mu_n(th) = -0.96623513 \cdot 10^{-26}\, J \cdot T^{-1}$	***Unable***
31	***Precise derivation of the proton magnetic moment*** $\mu_p(th) = \frac{(e+\Delta e_p)\upsilon_0}{c}\left(\lambda\!\!\!^{-}_e + r_0 \frac{1}{\beta}\frac{(a'_{0,11}+y_{0,12})}{2(a'_{0,11}y_{0,12})}\right)\sqrt{\frac{2Rh}{m_0 c}}$ $\mu_p(th) = 1.410606662 \cdot 10^{-26}\, J \cdot T^{-1}$	***Unable***

32	***Objective (true) dimensionalities of physical quantities in integer powers of units of matter (g), space (cm), and time (s):*** *Electric charge,* $[q]=[m]/[t]=g\cdot s^{-1}$ *Electric current,* $[I]=[q]/[t]=g\cdot s^{-2}$ *Circulation,* $[\Gamma]=[I]/[c]=g\cdot cm^{-1}\cdot s^{-1}$ *Electric field strength,* $[E]=[F]/[q]=cm\cdot s^{-1}$ *Magnetic field strength,* $[B]=[F]/[q]=cm\cdot s^{-1}$ *Electric field momentum density,* $[D]=[\varepsilon_0][E]=g\cdot cm^{-2}\cdot s^{-1}$ *Magnetic field momentum density,* $[H]=[\varepsilon_0][B]=g\cdot cm^{-2}\cdot s^{-1}$ *Potential,* $[U]=[F][l]/[q]=cm^2\cdot s^{-1}$ *Resistance,* $[R]=[U]/[I]=g^{-1}\cdot cm^2\cdot s$ *Conductance,* $[G]=[R]^{-1}=g\cdot cm^{-2}\cdot s^{-1}$ *Resistivity,* $[\rho]=[R][l]=g^{-1}\cdot cm^3\cdot s$ *Conductivity,* $[\sigma]=[\rho]^{-1}=g\cdot cm^{-3}\cdot s^{-1}$ *Inductance,* $[L]=[U][t]/[I]=g^{-1}\cdot cm^2\cdot s^2$ *Other physical quantities of electromagnetism contained electric charge, current, and their derivatives with corrected dimensionalities.*	***Incorrect dimensionalities*** *(subjective, phenomenological)* *Accepted in contemporary physics, the* ***dimensionalities of physical quantities of electromagnetism, based on the erroneous dimensionalities of electric charge, current, and their derivatives,*** *are* ***erroneous***
33	***The Fundamental Period of the Decimal Code of the Universe*** $\Delta=2\pi\lg e=2.7287527...$	***Unknown***

Electrons play the *secondary role*; they define only the strength of chemical bonds. An *electron* is an elementary quantum of the rate of mass exchange; its dimensionality is $g \times s^{-1}$.

The direct verification of the *shell-nodal structure* of the atoms was realized on *graphene*. Graphene, a one-atom-thick carbon layer with extraordinary conductivity and strength, has two-dimensional hexagonal lattice and, as commonly believe, *six-fold* rotational symmetry. Therefore, in full agreement with the basic symmetry theory, all properties in all directions in plane of graphene must be the same, for example, electronic conductivity.

However, as follows from the WM, this is not true. As it turned out, if one takes into account an *invisible part* (found thanks to the WM) in the structure of carbon atoms (graphene constituents), graphene has only *two-fold* rotational symmetry (but not six-fold according to the modern data of crystallography) and is an anisotropic crystal. Invisible empty polar potential-kinetic nodes form a channel favourable for *ballistic motion* of electrons. And the structure and, hence, properties along the channel differ from all in-plane other crystallographic directions. Thus, contrary to the well-known crystallographic data, from the WM it follows that graphene is the in-plane *anisotropic* crystal. This feature of graphene was verified on the samples of *unstrained pristine* graphene. Conducted tests completely confirmed this feature of graphene predicted theoretically in the WM.

Thus, because of specific spatial structure of carbon atoms (which, as was revealed, remind molecules) and their specifically ordered bindings in hexagonal lattice, graphene behaves as *anisotropic crystal*, has exotic electronic properties and, as a result, the great potential for practical applications. Moreover, it provides the unique possibility for the test on the validity of different theoretical models, theories, hypotheses. And the author of this Lectures took advantage of this possibility for verification of the shell-nodal structure of the atoms.

This discovery explains many interesting features of graphene and, in particular, the facts that …"*Graphene ... is an interesting mix of a semiconductor … and a metal ...*"; and that "*The electrons in graphene … have very long mean free paths*" [5], *etc*.

In-plane anisotropy of unstrained pristine graphene, originated from the WM, is confirmed also in independent experiments carried out with use of non-destructive *optical methods*. In particular, there is information (will soon published) about observation and studying the strong in-plane anisotropy in pristine graphene with a periodicity of 180 degree in a visible spectral region using the Microscopic Reflection Difference Spectroscopy.

Moreover, an analysis of the paper [6] published in Physical Review in 2009 has shown that its authors (not understanding this) have defined actually the orientation of characteristic crystallographic axes on a tested graphene monolayer, confirming thus (but not knowing about this) that graphene is anisotropic. This paper was analyzed in [7, see Picture 44 there].

Graphene is still on top of studying. Therefore, predicted and experimentally confirmed its in-plane anisotropy has practical significance both for current laboratory studies and for the future use of graphene in electronic industry along with silicon, germanium, and other semiconductors. It is clear; if a crystal is anisotropic then first of all it must be oriented in a certain way on substrates before studying or manufacture of electronic devices [8]. In opposite case, the uncontrolled parameters and properties spread will occur.

Obviously, for natural sciences, the discovery of anisotropy in hexagonal lattice of graphene has the great scientific significance: for foundations of physics, for our understanding the structure of atoms and molecules, and, hence, for revealing the true nature of intra-atomic and interatomic bonds.

From the WM it also directly and naturally follows the structure and relative mass of all possible *isotopes*. As it turned out, they are defined by the *extent of filling* all potential and potential-kinetic nodes (visible and invisible) in the spherical shells of the atoms, which have the shell-nodal structure.

It should be noted also that thanks to the Wave Model, the very *great mystery* for physicists has been unravelled. Namely, why does the speed c (equal to the speed of light) play the fundamental role in the formula of internal energy of quiescent particles, $E_0 = m_0 c^2$? According to the WM, the speed c is the *basis speed of wave exchange* (interaction) of elementary particles between themselves and with environment at the subatomic, atomic and gravitational levels, both in *rest* and *motion*. It is the *innate property* of the particles. Therewith, m_0 is the *associated mass* of a particle pulsating at the fundamental frequency ω_e.

Due to discovery in the framework of the WM of the *Law of Universal Exchange*, it became possible a *unified description* of the fundamental interactions at the subatomic, atomic, and gravitational levels. The energies inherent in the corresponding levels are defined by the *exchange charges* squared. If the energy (strength) of *electromagnetic interaction* is taken as 1, then in this scale, the energy of *strong interaction* has the order of 3.4×10^{6}, and *gravitation interaction* 0.8×10^{-36}. Hence, the strengths of three fundamental interactions: *strong*, *electromagnetic*, and *gravitational*, relate approximately as $10^{6}:1:10^{-36}$, overlapping the range of 42 decimal orders in magnitude.

All other findings, which were discussed in the Lectures and noted in Comparative Table, but which will not be mentioned once more here, in Conclusion, are also very important. Nevertheless, at the end it would be not superfluous to turn attention of the readers again to the following of them having the fundamental meaning too. From the WM it follows that the Earth's motion is in a *harmonic resonance bond* with the fundamental gravitational frequency ω_g. Just like the electron moving along the Bohr orbit is in a harmonic resonance bond with the fundamental frequency of the subatomic and atomic levels ω_e. That is, the Earth is fundamentally distinguished from other planets (just like the hydrogen atom is

distinguished from all other atoms of the Periodic Table) taking a special place in the field-space of the Solar system and maybe in Cosmos on the whole.

Thus, resting on a new philosophical and theoretical basis, the Wave Model of dialectical physics resolved many unsolvable puzzles *accumulated* in physics for the almost century of an existance of the modern Standard Model. The Wave Model opened, actually, floodgates of new discoveries, washing away generations of incorrect assumptions.

There is a hope that the comprehensive analysis and studying of the WM will lead ultimately to the acceptation of the WM by majority and, hence, to its further development. That is inevitable with time.

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Supplementary Data

I. The Wave Nature of Minerals

1. Introduction

The wave theory of probabilistic processes developed by the authors in the framework of the Wave Model (WM) was presented for the first time in three books [1-3] (of the 1996, 1998, and 2001 years). Discrete elements of the wave probabilistic field are regarded in the WM as "atoms" of such an abstract discrete-wave field. The correspondence of the mass numbers of the *abstract atoms* of the probabilistic wave spherical field with the *atoms of real physical space*, found thanks to the WM, was proven herewith. And all aspects concerning this discovery and its consequences were described in detail in the WM theory, which is the subject of our Lectures. In particular, with respect to the atomic structure, the general basis of the wave theory of the atoms has been especially considered in all 9 Lectures of Volume 5. We elucidated there the physical meaning of one of the principle notions of the WM, which is the notion of the *density of phase probability* $\hat{\Psi}$, and showed the way of its determination.

The wave nature of all objects and phenomena in the Universe (postulated in the WM) is confirmed in all cases that we have already considered. One more evidence in a series of the convincing proofs, which I would like to present in addition in favor of the aforementioned wave concept, is very opportunely at the end of the given Lectures. Namely, I intend to pay attention of the readers to the solid macro-formations, such as minerals. It is the supplementary data relating this time to the *molecular level* neighboring to atomic.

A mineral is a naturally occurring inorganic solid, with a definite chemical composition, and an ordered atomic arrangement of a definite crystal structure. The crystal structure of minerals is based on regular internal atomic or ionic arrangement that is often expressed in the geometric form that the crystal takes.

According to the Wave Model of dialectical physics, natural minerals with their crystal structure have the same wave nature like everything in the Universe; including atoms which consist of these minerals (the wave nature of the atoms was considered in Lectures of Vol. 5). Therefore, as atomic parameters, parameters of minerals should be also defined by solutions

of the universal ("classical") wave equation. Our analysis has shown that it is really so. What particular parameters of the minerals do we mean?

As it is known, the visible external shape of crystals is determined by the crystal structure (which restricts the possible facet orientations), the specific crystal chemistry and bonding (which may favor some facet types over others), and the conditions under which the crystal formed. With this, the roentgenographic method has greatly enhanced the understanding the crystal forms.

However, the derivation of the *characteristic angles of crystals*, determining their shape, was and still is an *unsolvable* problem of *modern physics*. This means that the *nature of* the formation of the definite geometrical configuration of facets in the crystals is not understood properly. Actually, till now the characteristic angles of crystals are determined only experimentally because within the Standard Model (SM) no one of the modern physical theories is unable to derive these angles directly of its principles. Therefore, the above problem still remains an important field of research in those branches of theoretical physics which are based on application of the fundamental concepts of quantum mechanics to crystallography and chemistry. These research areas are a realm of theoretical quantum chemistry and crystal chemistry.

In contrast to the SM, the *WM have solved this problem*. As it is known from the Lectures, in the framework of the wave approach, there were already revealed the wave *shell-nodal structure* of the atoms, the role of hydrogen atoms and electrons in chemical bonds formation, the nature of symmetry and periodicity in properties and the structure of the atoms, and many other things (listed in Lecture 7 of Vol. 6). Therefore, it is no wonder that the WM led us, directly and naturally, also to the right theoretical solution from which the aforementioned specific parameters, related to the shape of minerals, are determining simply and with high precision. What is the solution?

Since we recognize the *wave nature* of the atoms, hence, as an effect of this discovery, the wave origin of natural crystal formations consisting of such atoms could not be questioned. Therefore, we began seeking the characteristic angles of the shape of crystals also in solutions of the *wave equation*. Our expectations were met entirely. Indeed, like this follows from the WM, we found that the crystalline shape of minerals is really subjected to the particular solutions of the wave equation, moreover, to the same solutions that define the shell-nodal structure of the atoms. The experimentally data have confirmed convincingly enough the correctness of these solutions that we will demonstrate further below.

Thus, along with the already considered cases, the verification of the wave nature of all objects and phenomena in the Universe was confirmed also on the parameters inherent in crystals. In particular, it was found a coincidence of the experimental crystallographic data characteristic for the shape of natural minerals with the theoretical data obtained from the particular solutions of the wave equation. We mean the coincidence of the characteristic

angles of facets in the crystalline minerals with the corresponding *characteristic angles* obtained from the particular solutions of the wave equation for the wave phase probability $\hat{\Psi}$. More specifically, these angles correspond to *zero* and *extremal values* of the solutions for the polar constituent $\Theta_{l,m}(\theta)$ of the $\hat{\Psi}$-function.

We will show further these solutions completely. They are related to the discrete values of the polar function $\Theta_{l,m}(\theta)$, where the quantum number *l* takes the integer values from *l* = 2 to *l* = 6 ($m = 0, \pm 1, \pm 2, ..., \pm l$). However, before to show these data, it makes sense to recall some basic details that are necessary for understanding the origin of the presented there parameters.

2. Solutions for the polar variable, θ

The general *wave equation* has the form,

$$\Delta\hat{\Psi} - \frac{1}{c^2}\frac{\partial^2\hat{\Psi}}{\partial t^2} = 0. \qquad (1)$$

The potential of probability in (1) is determined by the *product of spatial* and *time potentials of probability*: $\hat{\Psi} = \hat{R}_l(kr)\Theta_{l,m}(\theta)\hat{\Phi}_m(\varphi)\hat{T}(\omega t) = \hat{\psi}\hat{T}(\omega t)$. The amplitude of the spatial factor $\hat{\psi}(r,\vartheta,\varphi) = \hat{R}(r)\Theta(\vartheta)\hat{\Phi}(\varphi)$ is described, in accordance with (1), by the equation,

$$\Delta\hat{\psi} + k^2\hat{\psi} = 0, \qquad (2)$$

which is called the Helmholtz equation. An equation for its polar constituent $\Theta_{l,m}(\theta)$ has the form,

$$\frac{d^2\Theta_{l,m}}{d\theta^2} + ctg\vartheta\frac{d\Theta_{l,m}}{d\theta} + \left(l(l+1) - \frac{m^2}{\sin^2\theta}\right)\Theta_{l,m} = 0. \qquad (3)$$

The normalizing condition for the polar component is

$$\int_0^\pi |\Theta(\theta)|^2 \sin\theta d\theta = 1, \qquad . \qquad (4)$$

The polar and azimuth equations are common (universal) for all models of objects of study if they are described by the wave equation (1). It concerns the description of crystals also.

Elementary solutions of equation (3), as known, have the form

$$\Theta_{l,m}(\theta) = C_{l,m} \cdot P_{l,m}(\cos\theta)\,, \tag{5}$$

where $C_{l,m}$ is the coefficient dependent on normalizing conditions, and $P_{l,m}(\cos\theta)$ are Legendre adjoined functions.

For calculation of characteristic polar angles of functions $\Theta_{l,m}(\theta)$, it is convenient to use the reduced polar functions $\tilde{\Theta}_{l,m}(\theta)$, which are normalized in the way shown in Lectures 1 and 2 of Vol. 5. For the reduced functions for $l \le 6$, they are presented in Table 1.

TABLE 1

The reduced polar functions $\tilde{\Theta}_{l,m}(\theta)$.

l	m	$\tilde{\Theta}_{l,m}(\theta)$	l	m	$\tilde{\Theta}_{l,m}(\theta)$
0	0	1			
1	0	$\cos\theta$	5	0	$\cos\theta\,(\cos^4\theta - 10/9\cos^2\theta + 5/21)$
	±1	$\sin\theta$		±1	$\sin\theta\,(\cos^4\theta - 2/3\cos^2\theta + 1/21)$
2	0	$\cos^2\theta - 1/3$		±2	$\sin^2\theta\cos\theta\,(\cos^2\theta - 1/3)$
	±1	$\sin\theta\cos\theta$		±3	$\sin^3\theta\,(\cos^2\theta - 1/9)$
	±2	$\sin^2\theta$		±4	$\sin^4\theta\cos\theta$
3	0	$\cos\theta\,(\cos^2\theta - 3/5)$		±5	$\sin^5\theta$
	±1	$\sin\theta\,(\cos^2\theta - 1/5)$			
	±2	$\sin^2\theta\cos\theta$	6	0	$\cos^6\theta - 15/11\cos^4\theta + 5/11\cos^2\theta - 5/231$
	±3	$\sin^3\theta$		±1	$\sin\theta\cos\theta\,(\cos^4\theta - 10/11\cos^2\theta + 5/33)$
4	0	$\cos^4\theta - 6/7\cos^2\theta + 3/35$		±2	$\sin^2\theta\,(\cos^4\theta - 6/11\cos^2\theta + 1/33)$
	±1	$\sin\theta\cos\theta\,(\cos^2\theta - 3/7)$		±3	$\sin^3\theta\cos\theta\,(\cos^2\theta - 3/11)$
	±2	$\sin^2\theta\,(\cos^2\theta - 1/7)$		±4	$\sin^4\theta\,(\cos^2\theta - 1/11)$
	±3	$\sin^3\theta\cos\theta$		±5	$\sin^5\theta\cos\theta$
	±4	$\sin^4\theta$		±6	$\sin^6\theta$

The polar components $\Theta_{l,m}(\theta)$ of space density of probability Ψ define characteristic parallels of extremes (principal and collateral) and zeroes on radial spherical shells.

Characteristic angles of these functions are their zero and extremal values.

We have denoted zeros of functions $\Theta_{l,m}(\theta)$ by the symbol $O_s(l,m)$, where s is the number of the root. Analogously, angles of extreme values $\Theta_{l,m}(\theta)$ were denoted as $\theta_s(l,m)$. The angles of zeros, extremes, their sums and differences, are characteristic angles of the obtained solutions. Obviously, every angle is characterized simultaneously by two measures: θ and $\pi - \theta$.

The discrete-wave probabilistic geometry of the density of probability ψ defines the probabilistic crystal structure of physical space. The data on the discrete geometry of principal and collateral extremes of the potential phase probability Ψ_p are shown schematically in the form of the spatial disposition of the nodes (see Fig. 6, L. 3 of Vol. 5). The presented points-nodes give us descriptive images of the phase wave probability. Black spheres conditionally draw vicinities of principal extremes; white spheres of a smaller diameter draw collateral extremes. At m = 0, radial shells are characterized by two polar extremes – “north” and “south” (white circles designated in the aforementioned drawings) by the symbols l_N and l_S, where l = 1, 2, 3...) and by extremes-meridians.

The geometry of the potential polar-azimuth probability $Y_{l,m}(\theta,\varphi)_p$ will be equal to the kinetic probability if the potential polar-azimuth probability were to turn around the Z-axis at a right angle. In this sense, both spaces (of rest and motion) are mutually perpendicular.

Other details can be found in Lectures of Vol. 5.

3. Characteristic angles of minerals: theoretical and experimental

The theory of phase wave probability has the general discrete-wave feature; therefore, it can be applicable to an analysis of any discrete-wave material spaces. This concerns also material spaces in the solid phase. Such physical spaces exist naturally in numerous minerals.

Since elementary characteristic directions of the probabilistic formation of space are determined by the polar-azimuth functions $Y_{l,m}(\theta,\varphi)_p = C_{l,m}C_m\Theta_{l,m}(\theta)\cos m\varphi$, it is natural to expect that the characteristic angles of this function will materialize in characteristic angles of the crystal forms of minerals.

The verification of this supposition was made in [2-4] by comparing our theoretical calculations with the experimental data compiled mainly by R. Haüy [5] and N. Kokscharov [5, 11]. We compare the characteristic angles of minerals, uninteresting in their composition, with the corresponding angles of the polar function of probability. Within this comparison, the sign "?" indicates a supposed correspondence.

The results of this comparison are presented in Table 2.

TABLE 2

Characteristic angles of the solutions $\tilde{\Theta}_{l,m}(\theta)$ and crystals of the natural minerals.

Characteristic angles of $\tilde{\Theta}_{l,m}(\theta)$ (*theoretical* values first calculated and published by L. Kreidik and G. Shpenkov [2-4])	The angles of crystal minerals (*measured* by R. Haüy [5], N. Kokscharov [6, 7], and others [8-23])

$\boxed{\tilde{\Theta}_{2,0}(\theta) = \cos^2\theta - 1/3}$

a) Zeros:

$O_1(2,0) = \arccos\sqrt{\frac{1}{3}} = 54^\circ\,44'\,8.''20$ — $54^\circ\,44'\,8.''20$

$O_2(2,0) = \arccos\left(-\sqrt{\frac{1}{3}}\right) = 125^\circ\,15'\,51.''80$ — $125^\circ 15' 52''$ [5: Part I, Vol. III, p.364, 1853]

b) Sectors:

$2O_1(2,0) = 109^\circ\,28'\,16.''40$ — Haüy: $109^\circ 28' 16''$ [5: p.29; 1*]

$O_2(2,0) - O_1(2,0) = 70^\circ\,31'\,43.''60$ — Haüy: $70^\circ 31' 44''$ [5: p.29; 1*]

$2(O_2(2,0) - O_1(2,0)) = 141^\circ\,03'\,27.''20$ — $141^\circ\,03'$ [6: Part. III, Vol. VII, p.26, 1844]

c) Extremes: $\theta_1(2,0) = 0^\circ$, $\theta_2(2,0) = 90^\circ$, and $\theta_3(2,0) = 180^\circ$ — characteristic angles of crystals

$\boxed{\tilde{\Theta}_{2,1} = \cos\theta\sin\theta}$

Zeros and **extremes** of 45° and 90° — characteristic angles of crystals

$\boxed{\tilde{\Theta}_{3,0} = \cos\theta(\cos^2\theta - 3/5)}$

a) Zeros:

$O_1(3,0) = \arccos\left(\sqrt{\frac{3}{5}}\right) = 39^\circ\,13'\,53.''47$ — Haüy: $39^\circ 13' 53''$ [5: p.85; 2*]

$O_2(3,0) = 90^\circ$,

$O_3(3,0) = \arccos\left(-\sqrt{\frac{3}{5}}\right) = 140^\circ\,46'\,06.''53$ — Haüy: $140^\circ 46' 7''$ [5: p.86; 2*]

b) Sectors:

$2O_1(3,0) = 78^\circ\,27'\,46.''94$ — Haüy: $78^\circ\,27'\,47''$ [5: p.85; 2*]

$O_2(3,0) - O_1(3,0) = 50^\circ\,46'\,06.''53$ — Haüy: $50^\circ 46' 06.''50$ [5: p.46; 3*]

$O_3(3,0) - O_1(3,0) = 101^\circ\,32'\,13.''06$ — Haüy: $101^\circ\,32'\,13''$ [5: p.46; 3*]

c) Extremes:

$\theta_1(3,0) = 0^\circ$

$\theta_2(3,0) = \arccos\left(\sqrt{\frac{1}{5}}\right) = 63^\circ\, 26'\, 05.''82$ — Haüy: $63^\circ\, 26'\, 06''$ [5: p.61; 4*]

$\theta_3(3,0) = \arccos\left(-\sqrt{\frac{1}{5}}\right) = 116^\circ\, 33'\, 54.''18$ — Haüy: $116^\circ\, 33'\, 54''$ [5: p.61; 4*]

$\theta_4(3,0) = 180^\circ$

d) Sectors:

$2\theta_2(3,0) = 126^\circ\, 52'\, 11.''64$ — $126^\circ\, 52'12''$ [6: Part I, Vol. III, p.322, 1853]

$\theta_3(3,0) - \theta_1(3,0) = 58^\circ 54'32.''65$ — $58^\circ\, 57'22''$? [6: Part IV, Vol. XI, p.394, 1860]

$\theta_3(3,0) - \theta_2(3,0) = 53^\circ\, 07'\, 48.''36$ — Haüy: $53^\circ\, 07'\, 50''$ [5: p.58; 5*]

$2(\theta_3(3,0) - \theta_2(3,0)) = 106^\circ\, 15'\, 36.''72$ — $106^\circ\, 17'26''$? [6: Part I, Vol. III, p.90, 1869]

$106^\circ\, 12'$ [6: Part IV, Vol. XII, p.501,1866]

average value $106^\circ\, 14'43''$

$360^\circ - 2(\theta_3(3,0) - \theta_2(3,0)) = 147^\circ\, 28'\, 46.''56$ — $147^\circ\, 29'\, 34''$ [6: ч. I, кн. III, 347, 1853]

$$\boxed{\tilde{\Theta}_{3,1}(\theta) = \sin\theta(\cos^2\theta - 1/5)}$$

---

a) Zeros repeat extremes $\tilde{\Theta}_{3,0}(\theta)$:

$O_1(3,1) = 0^\circ$, $O_2(3,1) = \arccos\left(\sqrt{\frac{1}{5}}\right)$, $O_3(3,1) = \arccos\left(-\sqrt{\frac{1}{5}}\right)$, $O_4(3,2) = 180^\circ$

b) Extremes:

$\theta_1(3,1) = \arccos\left(\sqrt{\frac{11}{15}}\right) = 31^\circ\, 05'\, 27.''35$ — $31^\circ 05'06''$ [6: Part III, Vol. VII, p.99, 1869]

$31^\circ 06'$ [6: Part. III, Vol. VII, p.108, 1869]

average value $31^\circ 05'33''$

$\theta_2(3,1) = 90^\circ$,

$\theta_3(3,1) = \arccos\left(-\sqrt{\frac{11}{15}}\right) = 148^\circ\, 54'\, 32.''65$ — $149^\circ\, 02'11''$? [6: Part IV, Vol. XI, p.283, 1866]

c) Sectors:

$2\theta_1(3,1) = 62^\circ\, 10'\, 54.''70$ — $62^\circ\, 12'54''$? [6: Part IV, Vol. XI, p.390, 1860]

$180^\circ - 2\theta_1(3,1) = 117^\circ\, 49'\, 5.''30$ — $117^\circ\, 48'43''$ [6: Vol. IV, p.110, 1870]

$\theta_2(3,1) - \theta_1(3,1) = 58^\circ\, 54'\, 32.''65$ — $58^\circ\, 57'22$? [6: Part IV, Vol. XI, p.394, 1860]

$180^\circ - (\theta_2(3,1) - \theta_1(3,1)) = 121^\circ\, 05'\, 27.''35$ — $121^\circ 05'$ [6: Part I, Vol. II, p.169, 1853]

$2(\theta_3(3,0) - \theta_2(3,0)) = 106^\circ\, 15'\, 36.''72$ — $106^\circ 17'26''$? [6: Part I, Vol. III, p.90, 1869]

$$\boxed{\tilde{\Theta}_{3,2}(\theta) = \sin^2\theta\cos\theta}$$

a) Zeros:

$O_1(3,2) = 0^\circ$, $O_2(3,2) = 90^\circ$ $O_3(3,2) = 180^\circ$

c) Extremes:

$\theta_1(3,2) = \arccos\left(\frac{1}{\sqrt{3}}\right) = 54^\circ\,44'8.''20$, $\theta_2(3,2) = \arccos\left(-\frac{1}{\sqrt{3}}\right) = 125^\circ 15'51.''80$

repeat zero $\Theta_{2,0}(\theta)$.

$$\boxed{\tilde{\Theta}_{4,0}(\theta) = \cos^4\theta - \tfrac{6}{7}\cos^2\theta + \tfrac{3}{35}}$$

a) Zeros

$$O_1(4,0) = \arccos\left(\sqrt{\frac{3}{7} + \sqrt{\left(\frac{3}{7}\right)^2 - \frac{3}{35}}}\right) = 30^\circ\,33'20.''13$$

$30^\circ 32' 48''$ [6: Part IV, Vol. XI, p.392, 1860]

$$O_2(4,0) = \arccos\left(\sqrt{\frac{3}{7} - \sqrt{\left(\frac{3}{7}\right)^2 - \frac{3}{35}}}\right) = 70^\circ\,07'27.''41$$

$70^\circ 04' 33''$ [6: Vol. VII, p.117, 1870]

$70^\circ 10' 22''$ [6: Vol. V, p.303, 1870]

average value $70^\circ 7' 28$

$$O_3(4,0) = \arccos\left(-\sqrt{\frac{3}{7} - \sqrt{\left(\frac{3}{7}\right)^2 - \frac{3}{35}}}\right) = 109^\circ\,52'32.''.59$$

$109^\circ\,52' 00''$ [6: Part IV, Vol. XI, p.404, 1860]

$109^\circ\,53' 07''$ [6: Vol. IV, p.101, 1870]

average value $109^\circ\,52' 33''$

$$O_4(4,0) = \arccos\left(-\sqrt{\frac{3}{7} + \sqrt{\left(\frac{3}{7}\right)^2 - \frac{3}{35}}}\right) = 149^\circ\,26'39.''87$$

$149^\circ\,26' 22''$ [6: p.20]

$149^\circ\,30' 56''$? [6: Part IV, Vol. XI, p.262, 1866]

$149^\circ\,22' 50''$? [6: Part IV, Vol. XI, p.262, 1866]

Average value $149^\circ\,26' 43''$

b) Sectors

$2O_1(4,0) = 61^\circ\,06'40.''26$ $61^\circ\,06'\,55''$ [6: Vol. IX, p.495, 1870]

$2O_2(4,0) = 140^\circ\,14'54.''82$ Erofeev: $140^\circ\,17' 52''$? [8: p.296]

$140^\circ\,03' 35''$? [6: Vol. IV, p.110, 1870]

$140^\circ\,25'20''$? [6: Vol. IV, p.102, 1870]

The average of the last two values $140^\circ\,14'28''$

$O_2(4,0)-O_1(4,0)=39^\circ 34'07.''28$ — $39^\circ\,32'33''$ [6: Part IV, Vol. XI, p.390, 1860]

$O_3(4,0)-O_2(4,0)=39^\circ 45'05.''18$ — $39^\circ\,45'22''$ [6: Part IV, Vol. XI, p.392, 1860]

$2(O_4(4,0)-O_1(4,0))-180^\circ=57^\circ 46'34.''56$ — $57^\circ\,44'25''$ [6: Part IV, Vol. XI, p.289, 1866]

$O_3(4,0)-O_1(4,0)=O_4(4,0)-O_2(4,0)=79^\circ 19'12.''46$ — $79^\circ\,18'10''$ [6: Vol. IV, p.99, 1870]

$180^\circ-(O_3(4,0)-O_1(4,0))=100^\circ 40'47.''54$ — $100^\circ\,41'50''$ [6: Vol. IV, p. 111, 1870,]

$O_4(4,0)-O_1(4,0)=118^\circ 53'19.''74$ — $118^\circ\,53'00''$ [6: Part III, Vol. VII, 46, 1853]

$118^\circ\,53'50''$ [6: Vol. XI, p.479, 1870]

Average value $118^\circ\,53'25''$

$360^\circ-2(O_4(4,0)-O_1(4,0))=122^\circ 13'20.''52$ — Glinka: $122^\circ 15'$ [9: 73]

$122^\circ 08'29''$ [6: Part I, Vol. III, p.346, 1853]

$122^\circ 19$ [6: Part I, Vol. II, p.169, 1853]

The average of the last two values $122^\circ 13'44''$

c) Extremes:

$\theta_1(4,0)=0^\circ$,

$\theta_2(4,0)=\arccos\left(\sqrt{\frac{3}{7}}\right)=49^\circ\,06'23.''78$ — $49^\circ 12'05''$? [6: Vol. IV, p.99, 1870]

$\theta_3(4,0)=90^\circ$

$\theta_4(4,0)=\arccos\left(-\sqrt{\frac{3}{7}}\right)=130^\circ\,53'36.''22$ — $130^\circ 50'$ [6: Part III, Vol. VIII, p.306, 1855]

$\theta_5(4,0)=180^\circ$

d) Sectors

$2\theta_2(4,0)=360^\circ-2\theta_4(4,0)=98^\circ 12'47.''56$ — $98^\circ 13'48''$ [6: Part IV, Vol. XI, p.388, 1860]

$98^\circ 10'55''$? [6: Vol. IV, p.110, 1870]

average value $98^\circ 12'21''$

$\theta_3(4,0)-\theta_2(4,0)=40^\circ 53'36.''22$ — $40^\circ 49'18''$? [6: Vol. II, N. 6, p.308, 1878]

$\theta_4(4,0)-\theta_2(4,0)=81^\circ 47'12.''44$ — $81^\circ 47'00''$ [6: Part IV, Vol. XI, p.415, 1860]

$180^\circ-(\theta_3(4,0)-\theta_2(4,0))=139^\circ 06'23.''78$ — $138^\circ 59'41''$? [6, Vol. IV, p.102, 1870]

$$\boxed{\tilde{\Theta}_{4,1}(\theta)=\sin\theta\cos\theta(\cos^2\theta-3/7)}$$

---

a) Zeros

$O_1(4,1)=0^\circ$,

$O_2(4,1)=\arccos\sqrt{\frac{3}{7}}=49^\circ\,6'23.''20$ — $49^\circ 10'42''$? [6: Vol. II, N.6, p.309, 1878]

$O_3(4,1)=90^\circ$,

$O_4(4,1) = \arccos\left(-\sqrt{\frac{3}{7}}\right) = 130^\circ\, 53'\, 36.''22$ 130°50′ ? [6: Part III, Vol. VIII, p.306, 1855]

$O_5(4,1) = 180^\circ$

b) Sectors

$2O_2(4,1) = 360^\circ - 2O_4(4,1) = 98^\circ 12' 47.''56$ 98°13′48″ [6: Part IV, Vol. XI, p.388, 1860]

98°10′55″ ? [6: Vol. IV, p.110, 1870]

Average value 98°12′21″

$O_3(4,1) - O_2(4,1) = 40^\circ 53' 36.''22$ 40°49′18″ ? [6: Vol. II, N.6, p.308, 1878]

$O_4(4,1) - O_2(4,1) = 81^\circ 47' 12.''44$ 81°47′0″ [6: Part IV, Vol. XI, p.415, 1860]

$180^\circ - (O_3(4,1) - O_2(4,1)) = 139^\circ 06' 23.''78$ 138°59′41″ ? [6: Vol. IV, p.102, 1870]

c) Extremes:

$$\theta_1(4,1) = \arccos\left(\sqrt{\frac{27}{56} + \sqrt{\left(\frac{27}{56}\right)^2 - \frac{3}{28}}}\right) = 23^\circ\, 52'\, 40.''17$$

23°59′46″ ? [6: Part III, Vol. VII, p.71, 1869]

$$\theta_2(4,1) = \arccos\left(\sqrt{\frac{27}{56} - \sqrt{\left(\frac{27}{56}\right)^2 - \frac{3}{28}}}\right) = 69^\circ\, 01'\, 29.''07$$

69°01′59″ [6: Part IV, Vol. XI, p.392, 1860]

69°01′00″ [6: Vol. IV, p.264, 1870]

Average value 69°01′29″

$$\theta_3(4,1) = \arccos\left(-\sqrt{\frac{27}{56} - \sqrt{\left(\frac{27}{56}\right)^2 - \frac{3}{28}}}\right) = 110^\circ\, 58'\, 30.''93$$ Glinka: 110°59′45″ [10: p.91]

$$\theta_4(4,1) = \arccos\left(-\sqrt{\frac{27}{56} + \sqrt{\left(\frac{27}{56}\right)^2 - \frac{3}{28}}}\right) = 156^\circ\, 07'\, 19.''83$$

156°06′00″ [6, Part IV, Vol. XI, p.392, 1860]

155°58′21″ [6, Vol. II, N.6, p.326, 1878]

Lebedev: 156°17′11″ ? [11: p.278]

Average 156°06′53″

d) Sectors

$2\theta_1(4,1) = 47^\circ 45' 20.''34$ 47°45′15″ [6: Part IV, Vol. XI, p.287, 1866]

$180^\circ - 2\theta_1(4,1) = \theta_4(4,1) - \theta_1(4,1) = 132^\circ 14' 39.''66$ 132°14′45″ [6: Part IV, Vol. XI, p.279, 1866]

$2\theta_2(4,0) = 2(180^\circ - \theta_3(4,0)) = 138^\circ 02' 58.''14$ 138°06′15″ ? [6: Vol. II, N.6, p.326,1878]

137°56′00″ ? [6: Part IV, Vol. XI, p.424, 1860]

Average value 138°01′08″

$180^\circ - 2\theta_2(4,1) = \theta_3(4,1) - \theta_2(4,1) = 41^\circ 57' 01.''86$ 42°01′13″ ? [6: Part IV, Vol. XI, p.285, 1866]

$2(\theta_3(4,1)-\theta_2(4,1)) = 83^\circ 54' 3.''72$ — $83^\circ 54' 40''$ [6: Part III, Vol. VII, p.86, 1869]

$180^\circ - 2(\theta_3(4,1)-\theta_2(4,1)) = 96^\circ 05' 56.''28$ — $96^\circ 04' 11''$ [6: Vol. IV, p.111, 1870]

$$\boxed{\tilde{\Theta}_{4,2}(\theta) = \sin^2\theta(\cos^2\theta - 1/7)}$$

---

a) Zeros:

$O_1(4,2) = 0^\circ$,

$O_2(4,2) = \arccos\left(\frac{1}{\sqrt{7}}\right) = 67^\circ 47' 32.''44$ — $67^\circ 47' 30''$ [6: Vol. VII, p.261, 1870]

$O_3(4,2) = \arccos\left(-\frac{1}{\sqrt{7}}\right) = 112^\circ 12' 27.''56$ — $112^\circ 12' 40''$ [6: Vol. VII, p.267, 1870]

$112^\circ 12' 00''$ [6: Vol. VIII, p.261, 1870]

Average value $112^\circ 12' 20''$

$O_4(4,2) = 180^\circ$.

b) Sectors

$2O_2(4,2) = 135^\circ 35' 04.''88$ — $135^\circ 35' 30''$ [6: Part IV, Vol. XI, p.382, 1860]

$O_3(4,2) - O_2(4,2) = 44^\circ 24' 55.''11$ — Goldschmidt: $44^\circ 30' 30''$? [12: **9**, p.135, 1923]

$44^\circ 11' 19''$? [6: Part IV, Vol. XI, p.286, 1866]

$44^\circ 40' 04''$? [6: Part IV, Vol. XI, p.86, 1866]

Average value $44^\circ 25' 42''$

c) Extremes:

$\theta_1(4,2) - \arccos\left(\frac{2}{\sqrt{7}}\right) = 40^\circ 53' 36.''22$ — $40^\circ 49' 18''$? [6: Vol. II, N.6, p.368, 1878]

$\theta_2(4,2) = 90^\circ$

$\theta_3(4,2) - \arccos\left(-\frac{2}{\sqrt{7}}\right) = 139^\circ 6' 23.''78$ — $138^\circ 59' 41''$? [6: Vol. IV, p.102, 1870]

d) Sectors:

$2\theta_1(4,2) = 81^\circ 47' 12.''44$ — $81^\circ 47' 13''$ [6: Part. IV, Vol. XI, p.279, 1866]

$\theta_3(4,2) - \theta_1(4,2) = 98^\circ 12' 47.''56$ — $98^\circ 13' 48''$ [6: Part. IV, Vol. XI, p.388, 1860]

$98^\circ 10' 55''$ [6: Vol. IV, p.110, 1870], Average value $98^\circ 12' 21''$

$$\boxed{\tilde{\Theta}_{4,3}(\theta) = \sin^3\theta\cos\theta}$$

Zeros: $O_1(4,3) = 0^\circ$, $O_2(4,3) = 90^\circ$, $O_3(4,3) = 180^\circ$, and

extremes: $\theta_1(4,3) = 60^\circ$, $\theta_2(4,3) = 120^\circ$ — typical angles of crystals.

$$\boxed{\tilde{\Theta}_{5,0}(\theta) = \cos\theta(\cos^4\theta - {}^{10}\!/_{9}\cos^2\theta + {}^{5}\!/_{21})}$$

a) Zeros:

$O_1(5,0) = \arccos\left(\sqrt{\frac{5}{9} + \sqrt{\left(\frac{5}{9}\right)^2 - \frac{5}{21}}}\right) = 25^\circ 01' 02.''42$ $\quad 25^\circ 00' 15''$ [6: Part. IV, Vol. XI, p.435, 1860]

$O_2(5,0) = \arccos\left(\sqrt{\frac{5}{9} - \sqrt{\left(\frac{5}{9}\right)^2 - \frac{5}{21}}}\right) = 57^\circ 25' 13.''80$ $\quad 57^\circ 30' 37''$? [6: Part. I, Vol. II, p.190, 1853]

$O_3(5,0) = 90^\circ$

$O_5(5,0) = \arccos\left(-\sqrt{\frac{5}{9} + \sqrt{\left(\frac{5}{9}\right)^2 - \frac{5}{21}}}\right) = 154^\circ 58' 57.''58$ $\quad 154^\circ 49' 39''$? [5: p.90]

b) Sectors:

$O_1(5,0) = 50^\circ 02' 0\ \ 4.''84$ $\quad 50^\circ 03' 35''$ [6: Vol. III, p.99, 1870]

$2O_2(5,0) = 114^\circ 50' 27.''60$ $\quad 114^\circ 50'$ [6: Part. III, Vol. VIII, p.305, 1855]

$180^\circ - 2O_2(5,0) = O_5(5,0) - O_1(5,0) = 129^\circ 57'\ \ 55.''16$ $\quad 129^\circ 56'$ [6: Vol. III, p.438, 1870]

$129^\circ 59' 58''$ [6: Vol. III, p.492, 1870]

$129^\circ 58' 15''$ [6: Part. II, Vol. IV, p.47, 1857]

Average value $129^\circ 58' 4''$

$O_5(5,0) - O_3(5,0) = 64^\circ 58' 57.''58$ $\quad 64^\circ 58' 46''$ [6: Part. I, Vol. II, p.190, 1853]

$180^\circ - (O_5(5,0) - O_2(5,0)) = 82^\circ 26' 16.''22$ $\quad 82^\circ 28' 56''$? [6: Vol. IV, p.431, 1870]

$O_5(5,0) - O_2(5,0) = 97^\circ 33' 43.''78$ $\quad$ Kokscharov-son: $97^\circ 38' 24''$ [6: Vol. IV, N.11, p.223, 1879]

$97^\circ 27' 49''$ [6: Vol. IV, N.11, p.256, 1879]

Average value $97^\circ 33' 6''$

c) Extremes:

$\theta_1(5,0) = 0^\circ$

$\theta_2(5,0) = \arccos\left(\sqrt{\frac{1}{3} + \sqrt{\left(\frac{1}{3}\right)^2 - \frac{1}{21}}}\right) = 40^\circ 05' 17.''11$ Average value: $40^\circ 05' 0''$ [6: Vol. IV, N.11, p.349, 1879]

$\theta_3(5,0) = \arccos\left(\sqrt{\frac{1}{3} - \sqrt{\left(\frac{1}{3}\right)^2 - \frac{1}{21}}}\right) = 73^\circ 25' 38.''32$ $\quad 73^\circ 30' 56''$? [6: Part. IV, Vol. XI, p.286, 1866]

$73^\circ 12' 14''$? [6: Vol. IV, p.113, 1870]

Average value $73^\circ 21' 35''$?

$\theta_4(5,0) = \arccos\left(-\sqrt{\frac{1}{3} - \sqrt{\left(\frac{1}{3}\right)^2 - \frac{1}{21}}}\right) = 106^\circ 34' 21.''68$ $\quad 106^\circ 34'$ [10: p.90]

$106^\circ 27' 30''$? [6: Vol. II, N.6, p.318, 1878]

$106^\circ 38' 0''$? [6: Vol. II, N.6, p.318, 1878]

The average value of the two last angles: $106^\circ 32' 45'$?

$$\theta_5(5,0) = \arccos\left(-\sqrt{\frac{1}{3}+\sqrt{\left(\frac{1}{3}\right)^2-\frac{1}{21}}}\right) = 139^\circ 54' 42.''89$$

Kokscharov-son: $139^\circ 55' 0''$ [6: Vol. IV, N.11, p.348, 1879]

$\theta_6(5,0) = 180^\circ$

d) Sectors:

$2\theta_2(5,0) = 80^\circ 10' 34.''22$ — $80^\circ 10' 15''$ [6: Part. I, Vol. III, p.343, 1853]

$2\theta_3(5,0) = 360^\circ - 2\theta_4(5,0) = 146^\circ 51' 16.''64$ — $146^\circ 48' 20''$? [6: Part. IV, Vol. XI, p.406, 1860]

Lebedev: $146^\circ 57' 00''$? [11: p.271];

Average value $146^\circ 52' 40''$

$180^\circ - 2\theta_2(5,0) = \theta_5(5,0) - \theta_2(5,0) = 99^\circ 49' 25.''78$ — $99^\circ 50' 00''$ [6: Part. I, Vol. III, p.343, 1853]

$\theta_3(5,0) - \theta_2(5,0) = 33^\circ 20' 21.''21$ — $33^\circ 17' 18''$? [6: Part. IV, Vol. XII, p.641, 1860]

$\theta_4(5,0) - \theta_2(5,0) = \theta_5(5,0) - \theta_3(5,0) = 66^\circ 29' 04.''57$ — $66^\circ 30' 08''$ [6: Part. IV, Vol. XII, p.641, 1860]

$\theta_4(5,0) - \theta_3(5,0) = 33^\circ 08' 43.''36$ — $33^\circ 04' 16''$? [6: Vol. IV, p.100, 1870]

$33^\circ 13' 21''$? [6: Vol. III, p.436, 1870]

Average value $33^\circ 08' 48''$

$$\boxed{\tilde{\Theta}_{5,1}(\theta) = \sin\theta(\cos^4\theta - \tfrac{2}{3}\cos^2\theta + \tfrac{1}{21})}$$

---

a) Zeros repeat extremes $\tilde{\Theta}_{5,0}(\theta)$.

b) Extremes:

$$\theta_1(5,1) = \arccos\left(\sqrt{\frac{3}{5}+\sqrt{\left(\frac{3}{5}\right)^2-\frac{29}{105}}}\right) = 19^\circ 24' 56.''02$$ — $19^\circ 23' 03''$ [6: Part. I, Vol. VII, p.68, 1869]

$$\theta_2(5,1) = \arccos\left(\sqrt{\frac{3}{5}-\sqrt{\left(\frac{3}{5}\right)^2-\frac{29}{105}}}\right) = 56^\circ 08' 08.''88$$ — $56^\circ 04' 57''$? [6: Vol. I, N.1, p.104, 1877]

$\theta_3(5,1) = 90^\circ$

$$\theta_4(5,1) = \arccos\left(-\sqrt{\frac{3}{5}-\sqrt{\left(\frac{3}{5}\right)^2-\frac{29}{105}}}\right) = 123^\circ 51' 51.''12$$ — $123^\circ 53' 13''$? [6: Vol. IV, p.107, 1870]

$$\theta_5(5,1) = \arccos\left(-\sqrt{\frac{3}{5}+\sqrt{\left(\frac{3}{5}\right)^2-\frac{29}{105}}}\right) = 160^\circ 35' 03.''98$$ — $160^\circ 34' 29''$ [6: Vol. IV, p.107, 1870]

c) Sectors:

$2\theta_1(5,1) = 38^\circ 49' 52.''04$ — $38^\circ 43' 53''$? [6: Part. IV, Vol. XI, p.286, 1866]

$38^\circ 51' 32''$? [6: Part. IV, Vol. XII, p.630, 1860]

Average value $38^\circ 47' 42''$

$2\theta_2(5,1) = 112^\circ 16' 17.''76$ — $112^\circ 16' 40''$ [6: Vol. VIII, p.255, 1870]

$\theta_4(5,1) - \theta_2(5,1) = 180^\circ - 2\theta_2(5,1) = 67^\circ 43' 42.''24$ — $67^\circ 43' 40''$ [6: Vol. VIII, p.261, 1870]

$180^\circ - 2(\theta_4(5,1) - \theta_2(5,1)) = 44^\circ 32' 35.''52$ — $44^\circ 40' 04''$? [6: Part. III, Vol. VII, p.86, 1869]

$\Delta\theta_5 = \theta_3(5,1) - \theta_1(5,1) = 70^\circ 35' 3.''98$	$70^\circ 35' 00''$ [6: Part. IV, Vol. XI, p.269, 1866]
$180^\circ - (\theta_3(5,1) - \theta_1(5,1)) = 109^\circ 24' 56.''02$	$109^\circ 24' 52''$ [6: Part. IV, Vol. XI, p.386, 1860]
$360^\circ - 2(\theta_5(5,1) - \theta_1(5,1)) = 77^\circ 39' 44.''08$	$77^\circ 26' 30''$? [6: Part. IV, Vol. XI, p.386, 1860]
$2(\theta_4(5,1) - \theta_2(5,1)) = 135^\circ 27' 24.''48$	$135^\circ 27' 55''$ [6: Vol. IV, p.108, 1870]
$2(\theta_3(5,1) - \theta_1(5,1)) = 141^\circ 10' 07.''96$	$141^\circ 10' 05''$ [6: Part. IV, Vol. XI, p.277, 1866

$$\boxed{\Theta_{5,2}(\theta) = \sin^2\theta\cos\theta(\cos^2\theta - 1/3)}$$

a) Zeros (the second and the fourth are equal to zeros of $\Theta_{2,0}(\theta)$):

$O_1(5,2) = 0^\circ$

$O_2(5,2) = \arccos\left(\frac{1}{\sqrt{3}}\right) = 54^\circ\, 44' 08.''20$ Haüy: $54^\circ 44'$ [5: p.27]

$O_3(5,2) = 90^\circ$

$O_4(5,2) = \arccos\left(-\frac{1}{\sqrt{3}}\right) = 125^\circ\, 15' 51.''80$ $125^\circ 15' 52''$ [6: Part I, Vol. III, p.364, 1853]

$O_5(5,2) = 180^\circ$

b) Sectors:

$O_3(5,2) - O_2(5,2) = 35^\circ\, 15' 51.''80$ $35^\circ 23' 53''$? [6: Part IV, Vol. XII, p.631, 1860]

$35^\circ 07' 52''$? [6: Part IV, Vol. XII, p.631, 1860]

Average value $35^\circ 15' 52''$

$2(O_3(5,2) - O_2(5,2)) = O_4(5,2) - O_2(5,2) = 70^\circ\, 31' 43.''60$ Haüy: $70^\circ 31' 44''$ [5: p.29; 1*]

$2O_2(5,2) = 109^\circ\, 28' 16.''40$ Haüy: $109^\circ 28' 16''$ [5: p.29; 1*]

$O_5(5,2) - O_4(5,2) = 54^\circ\, 31' 43.''60$ $54^\circ 32' 30''$ [6: Vol. V, p.304, 1870]

$2(O_4(5,2) - O_2(5,2)) = 141^\circ\, 03' 27.''20$ $141^\circ 05' 55''$ [6: Vol. IV, p.102, 1870]

$141^\circ 00' 27''$ [6: Vol. IV, p.114, 1870]

Average value $141^\circ 3' 11''$

c) Extremes:

$$\theta_1(5,2) = \arccos\left(\sqrt{\frac{2}{5} + \sqrt{\left(\frac{2}{5}\right)^2 - \frac{1}{15}}}\right) = 32^\circ\, 51'\, 57.''05,$$

$32^\circ 46' 58''$? [6: Part IV, Vol. XII, p.629, 1860]

$$\theta_2(5,2) = \arccos\left(\sqrt{\frac{2}{5} - \sqrt{\left(\frac{2}{5}\right)^2 - \frac{1}{15}}}\right) = 72^\circ\, 05'\, 50.''53,$$

$72^\circ 06' 46''$ [6: Part II, Vol. IV, p.33, 1857]

$\theta_3(5,2) = \arccos\left(-\sqrt{\frac{2}{5} - \sqrt{\left(\frac{2}{5}\right)^2 - \frac{1}{15}}}\right) = 107^\circ\, 54'\, 09.''47$, Lewis : $107^\circ 59' 30''$? [13]

$\theta_4(5,2) = \arccos\left(-\sqrt{\frac{2}{5} + \sqrt{\left(\frac{2}{5}\right)^2 - \frac{1}{15}}}\right) = 147^\circ\, 08'\, 02.''95$,

$147^\circ\, 08' 00''$ [6: Part I, Vol. II, p.298, 1870]

b) Sectors:

$2\theta_1(5,2) = 65^\circ\, 43' 54.''10$, $65^\circ\, 43' 30''$ [6: Part IV, Vol. XI, p.251, 1866]

$65^\circ\, 44' 09''$ [6: Part IV, Vol. XI, p.251, 1866]

Average value $65^\circ\, 43' 49''$

$180^\circ - 2\theta_1(5,2) = \theta_4(5,2) - \theta_1(5,2) = 114^\circ\, 16'\, 05.''90$, $114^\circ 16' 00''$ [6: Part IV, Vol. XI, p.250, 1866]

$114^\circ 16' 15''$ [6: Part IV, Vol. X, p.160, 1860]

Average value $114^\circ 16' 8''$

$2\theta_2(5,2) = 144^\circ\, 11' 41.''06$ $144^\circ 11'$ [6: Part. I, Vol. II, p.307, 1870]

$180^\circ - 2\theta_2(5,2) = \theta_3(5,2) - \theta_2(5,2) = 35^\circ\, 48' 18.''94$ $35^\circ\, 45' 10''$? [6: Vol. IX, p.495, 1870]

$\theta_2(5,2) - \theta_1(5,2) = 42^\circ\, 13' 53.''48$ $42^\circ 19' 28''$? [6: Part IV, Vol. XII, p.628, 1860]

$42^\circ 05' 51''$? [6: Part IV, Vol. XII, p.628, 1860]

Average value $42^\circ 12' 39''$

$180^\circ - (\theta_2(5,2) - \theta_1(5,2)) = 137^\circ\, 46' 6.''52$ Glinka $137^\circ 45' 30''$ [10: p.52]

$\Delta\theta_6 = \theta_3(5,2) - \theta_1(5,2) = 75^\circ\, 02' 12.''42$ Penfield: $75^\circ 02'$ [14]

$$\boxed{\Theta_{5,3}(\theta) = \sin^3\theta(\cos^2\theta - 1/9)}$$

---

a) Zeros:

$O_1(5,3) = 0^\circ$

$O_2(5,3) = \arccos\left(\frac{1}{3}\right) = 70^\circ\, 31' 43.''61$, Haüy: $70^\circ 31' 44''$ [5: p.29; 1*]

$O_3(5,3) = \arccos\left(-\frac{1}{3}\right) = 109^\circ\, 28' 16.''39$ Haüy: $109^\circ 28' 16''$ [5: p.29; 1*]

$O_4(5,3) = 180^\circ$

b) Sectors

$O_3(5,3) - O_2(5,3) = 38^\circ\, 56' 32.''78$ $38^\circ 51' 32''$? [6: Part IV, Vol. XII, p.630, 1860]

$2(O_3(5,3) - O_2(5,3)) = 77^\circ\, 53' 5.''56$ $77^\circ 53' 34''$ [6: Vol. IV, p.100, 1870]

$2O_2(5,3) = 360^\circ - 2O_3(5,3) = 141^\circ\, 03' 27.''22$, $141^\circ 05' 55''$ [6: Vol. IV, p.102, 1870]

$141^\circ 00' 27''$ [6: Vol. IV, p.114, 1870]

Average value $141^\circ 3' 11''$

c) Extremes:

$\theta_1(5,3) = \arccos\left(\sqrt{\frac{7}{15}}\right) = 46^\circ 54' 40.''60$ — $46^\circ 55'$ [6: Part III, Vol. VII, p.69, 1869]

$\theta_2(5,3) = 90^\circ$

$\theta_3(5,3) = \arccos\left(-\sqrt{\frac{7}{15}}\right) = 133^\circ 05' 19.''40$ — $133^\circ 09' 57''$? [6: Vol. IV, p.102, 1870]

$133^\circ 02'$? [6: Vol. IV, N.10, p.67, 1889]

Average value $133^\circ 05' 58''$

d) Sectors

$2\theta_1(5,3) = 93^\circ\ 49' 21.''20$ — $93^\circ 58' 0''$? [6: Part I, Vol. I, p.14, 1853]

$180^\circ - 2\theta_1(5,3) = 2(\theta_2(5,3) - \theta_1(5,3)) = \theta_2(5,3) - \theta_1(5,3) = 86^\circ\ 10' 38.''80$

Erofeev: $86^\circ 10' 38''$ [8: p.270]

$\theta_2(5,3) - \theta_1(5,3) = 43^\circ\ 05' 19.''40$ — $86^\circ 10' 38'' / 2 = 43^\circ 05' 19''$

$180^\circ - (\theta_3(5,3) - \theta_1(5,3)) = 103^\circ\ 49' 21.''20$ — $103^\circ 49' 12''$ [6: Part IV, Vol. X, p.138, 1860]

$180^\circ - (\theta_2(5,3) - \theta_1(5,3)) = 136^\circ\ 54' 40.''60$ — $136^\circ 52' 54''$ [6: Vol. I, N. 1, p.105, 1877]

$136^\circ 58' 20''$? [6: Part IV, Vol. X, p.101, 1860]

Average value $136^\circ 55' 37''$

$$\boxed{\Theta_{5,4}(\theta) = \sin^4\theta\cos\theta}$$

---

a) Zeros

$O_1(5,4) = 0^\circ$, $O_2(5,4) = 90^\circ$, $O_3(5,4) = 180^\circ$

b) Extremes

$\theta_1(5,4) = \theta_2(3,0) = O_2(3,1)$

$\theta_2(5,4) = \theta_3(3,0) = O_3(3,1)$

$$\boxed{\Theta_{6,0}(\theta) = \cos^6\theta - {}^{15}\!/_{11}\cos^4\theta + {}^{5}\!/_{11}\cos^2\theta - {}^{5}\!/_{231}}$$

---

a) Zeros

$O_1(6,0) = 21^\circ 10' 31''$ — $21^\circ 11' 21''$ [6: Part IV, Vol. XI, p.391, 1860]

$O_2(6,0) = 48^\circ 36' 28''$ — $48^\circ 31' 02''$? [6: Part IV, Vol. XI, p.285, 1866]

$O_3(6,0) = 76^\circ 11' 42''$ — $76^\circ 11' 24''$ [6: Part IV, Vol. X, p.138, 1860]

$O_4(6,0) = 103^\circ 48' 18''$ — $103^\circ 48' 36''$ [6: Part IV, Vol. XI, p.138, 1860]

$O_5(6,0) = 131^\circ 23' 32''$ — $131^\circ 24' 00''$ [6: Part IV, Vol. XI, p.252, 1866]

$O_6(6,0) = 158^\circ 49' 29''$ — $158^\circ 38' 40''$? [6: Part IV, Vol. X, p.112, 1860]

b) sectors

$2O_1(6,0) = 42^\circ 21' 02''$, — $42^\circ 19' 28''$ [6: Part IV, Vol. XII, p.630, 1860]

$180^\circ - 2O_1(6,0) = 137^\circ 38' 58''$ — $137^\circ 37' 45''$ [6: Part IV, Vol. X, p.107, 1860]

$180^\circ - 2O_2(6,0) = 82^\circ 47' 04''$ — Gordon: $82^\circ 48'$ [15]

$2O_2(6,0) = 97^\circ 12' 56''$, — $180^\circ - 82^\circ 48' = 97^\circ 12'$

$O_2(6,0) - O_1(6,0) = 27^\circ 25' 57''$, — $27^\circ 22' 30''$ [6: Part IV, Vol. X, p.159, 1860]

$180^\circ - (O_2(6,0) - O_1(6,0)) = 152^\circ 34' 3''$ — $152^\circ 34'$ [6: Part IV, Vol. X, p.161, 1860]

$152^\circ 34' 45''$ [6: Part IV, Vol. XII, p.626, 1860]

$O_3(6,0) - O_1(6,0) = 55^\circ 01' 11''$ — Goldschmidt, Peacock: $55^\circ 01' 30''$ [16]

$54^\circ 59' 52''$? [6: Part III, Vol. XII, p.626, 1860]

$180^\circ - (O_3(6,0) - O_1(6,0)) = 124^\circ 58' 49''$ — $124^\circ 57' 30''$ [6: Vol. IX, p.482,1870]

$O_4(6,0) - O_1(6,0) = 82^\circ 37' 47''$, — $82^\circ 37' 47''$ [6: Part I, Vol. III, p.431, 1870]

$180^\circ - (O_4(6,0) - O_1(6,0)) = 97^\circ 22' 13''$ — $180^\circ - 82^\circ 37' 47'' = 97^\circ 22' 13''$

$O_5(6,0) - O_1(6,0) = 110^\circ 13' 01''$, — $110^\circ 13' 14''$ [6: Part IV, Vol. XII, p.627, 1860]

$180^\circ - (O_5(6,0) - O_1(6,0)) = 69^\circ 46' 59''$ — $69^\circ 58' 47''$? [6: Part IV, Vol. XII, p.516, 1866]

$69^\circ 33' 14''$? [6: Part IV, Vol. XII, p.516, 1866]

Average value $69^\circ 46' 30''$

c) Extremes

$\theta_1(6,0) = 0^\circ$

$$\theta_2(6,0) = \arccos\left(\sqrt{\frac{5}{11} + \sqrt{\left(\frac{5}{11}\right)^2 - \frac{5}{33}}}\right) = 33^\circ\, 52' 41.''72$$

$33^\circ 56' 05''$ [6: Part IV, Vol. XII, p.516, 1866]

$33^\circ 49' 52''$ [6: Part IV, Vol. XII, p.516, 1866]

Average value $33^\circ 52' 58''$

$$\theta_3(6,0) = \arccos\left(\sqrt{\frac{5}{11} - \sqrt{\left(\frac{5}{11}\right)^2 - \frac{5}{33}}}\right) = 62^\circ 02' 25.''46$$

Goldschmidt, Palache, Peacock: $62^\circ 01'$ [17]

$62^\circ 03' 44''$ [6: Vol. III, p.100, 1870]

Average value $62^\circ 02' 22''$

$\theta_4(6,0) = 90^\circ$

$$\theta_5(6,0) = \arccos\left(-\sqrt{\frac{5}{11} - \sqrt{\left(\frac{5}{11}\right)^2 - \frac{5}{33}}}\right) = 117^\circ 57' 34.''54$$

Lebedev: $117^\circ 54'$ [11: p.270]

$$\theta_6(6,0) = \arccos\left(-\sqrt{\frac{5}{11} + \sqrt{\left(\frac{5}{11}\right)^2 - \frac{5}{33}}}\right) = 146^\circ 07' 18.''28$$

$146^\circ 06' 28''$ [6: Part IV, Vol. XI, p.383, 1860]

$\theta_7(6,0) = 180^\circ$

d) Sectors:

$2\theta_2(6,0) = 67^\circ 45' 23.''44$ — $67^\circ 43' 20''$ [6: Vol. VIII, p.255, 1870]

$67^\circ 47' 30''$ [6: Vol. VIII, p.255, 1870]

Average value $67^\circ 45' 25''$

$180^\circ - 2\theta_2(6,0) = \theta_6(6,0) - \theta_2(6,0) = 112^\circ 14' 36.''56$ $112^\circ 14' 30''$ [6: Vol. VIII, p.265, 1870]

$2\theta_3(6,0) = 124^\circ 04' 50.''92$ $124^\circ 01' 45''$ [6: Vol. IV, p.107, 1870]

Palache: $124^\circ 07'$ [18]

Average value $124^\circ 04' 22''$

$180^\circ - 2\theta_3(6,0) = 55^\circ 55' 09.''68$ $55^\circ 56' 03''$ [6: Part IV, Vol. XI, p.285, 1866]

$\theta_3(6,0) - \theta_2(6,0) = 28^\circ 09' 43.''74$ Gordon: $28^\circ 07'$ [19]

Goldschmidt: $28^\circ 11' 30''$ [12: **7**, p.139, 1922]

average value $28^\circ 09' 15''$

$180^\circ - (\theta_3(6,0) - \theta_2(6,0)) = 151^\circ 50' 16.''26$ $151^\circ 50'$ [6: Part I, Vol. II, p.296, 1870]

$\theta_4(6,0) - \theta_2(6,0) = 56^\circ 07' 18.''28$ $56^\circ 04' 57''$ [6: Vol. I, N.1, p.104, 1877]

$180^\circ - (\theta_4(6,0) - \theta_2(6,0)) = 123^\circ 52' 41.''72$ $180^\circ - 56^\circ 04' 57'' = 123^\circ 55' 03''$

$\theta_4(6,0) - \theta_3(6,0) = 27^\circ 57' 34.''54$ Goldschmidt, Shannon, Tocady, Garces: $27^\circ 55'$? [20]

$180^\circ - (\theta_4(6,0) - \theta_3(6,0)) = 152^\circ 02' 25.''46$ $180^\circ - 27^\circ 55' = 152^\circ 05'$

Kokscharov-son: $151^\circ 54' 50''$? [6: Vol. IV, N.11, p.222, 1879]

$152^\circ 17' 01''$? [6: Vol. II, N.6, p.324,1878]

Average value $152^\circ 02' 56''$

$\theta_5(6,0) - \theta_2(6,0) = 84^\circ 04' 52.''82$ Kokscharov-son: $83^\circ 54' 56''$? [6: Vol. IV, N.11. p. 223, 1879]

$180^\circ - (\theta_5(6,0) - \theta_2(6,0)) = 95^\circ 55' 7.''18$ $95^\circ 54' 50''$ [6: Part IV, Vol. XI, p.258, 1866]

$\theta_5(6,0) - \theta_3(6,0) = 55^\circ 55' 09.''08$ $55^\circ 56' 03''$ [6: Part IV, Vol. XI, p.285, 1866]

$180^\circ - (\theta_5(6,0) - \theta_3(6,0)) = 124^\circ 04' 50.''92$ Palache: $124^\circ 07'$ [18]

$124^\circ 01' 45''$ [6: Vol. IV, p.107, 1870]

Average value $124^\circ 04' 22''$

$$\boxed{\Theta_{6,1}(\theta) = \sin\theta\cos\theta(\cos^4\theta - {}^{10}\!/_{11}\cos^2\theta + {}^{5}\!/_{33})}$$

---

a) Zeros are equal to extremes $\Theta_{6,0}(\theta)$

b) Extremes:

$\theta_1(6,1) = 16^\circ 22' 15.''47$ $16^\circ 22' 58''$ [6: Part IV, Vol. XI, p.396, 1860]

$\theta_2(6,1) = 47^\circ 20' 49.''20$ $47^\circ 17' 17''$ [6: Part IV, Vol. IV, p.101, 1860]

Average value $47^\circ 21' 33''$

$\theta_3(6,1) = 75^\circ 51' 03.''44$ $75^\circ 51' 27''$ [6: Part IV, Vol. XI, p.390, 1860]

$\theta_4(6,1) = 104^\circ 08' 56.''56$ $104^\circ 08' 57''$ [6: N. IV, p.102, 1870]

$\theta_5(6,1) = 132^\circ 39' 10.''80$ $132^\circ 45' 10''$ [6: Vol. III, N.8, p.290, 1887]

$132^\circ 46' 40''$ [6: Vol. IV, N.10, p.52, 1889]

$132^\circ 21' 18''$ [6: Vol. III, N.8, p.296, 1887]
Average value $132^\circ 37' 42''$

$\theta_6(6,1) = 163^\circ 37' 44.''53$ — $163^\circ 37' 02$ [6: Part IV, Vol. XI, p.433, 1860]

c) Sectors:

$\theta_4(6,1) - \theta_3(6,1) = 28^\circ 17' 53.''12$ — $28^\circ 14' 04''$ [6: N.3, p.100, 1870]

$\theta_5(6,1) - \theta_2(6,1) = 85^\circ 18' 21.''60$ — $85^\circ 20' 16''$ [6: N.2, p.308, 1870]

$85^\circ 15' 27''$ [6: N.3, p.100, 1870]
Average value $85^\circ 17' 51''$

$\theta_6(6,1) - \theta_1(6,1) = 147^\circ 15' 29.''06$ — $147^\circ 08' 46''$ [6: Part IV, Vol. XI, p.434, 1860]

$147^\circ 23' 13''$ [6: Part I, Vol. I, p.18, 1853]
Average value $147^\circ 15' 59''$

$\theta_2(6,1) - \theta_1(6,1) = 30^\circ 58' 33.''73$ — $30^\circ 50' 35''$ [6: N.3, p.99, 1870]

$\theta_3(6,1) - \theta_1(6,1) = 59^\circ 28' 47.''97$ — $59^\circ 16'' 46'$ [6: Part I, Vol. II, p.178, 1853]

$\theta_4(6,1) - \theta_1(6,1) = 87^\circ 46' 41.''09$ — $87^\circ 45' 20''$ [6: Part I, Vol. II, p.67, 1853]

$\theta_5(6,1) - \theta_1(6,1) = 116^\circ 16' 55.''33$ — $116^\circ 17'$ [6: Part I, Vol. II, p.76, 1853]

$$\boxed{\Theta_{6,2}(\theta) = \sin^2\theta(\cos^4\theta - \tfrac{6}{11}\cos^2\theta + \tfrac{1}{33})}$$

---

a) Zeros:

$O_1(6,2) = 0^\circ$

$$O_2(6,2) = \arccos\left(\sqrt{\frac{3}{11} + \sqrt{\left(\frac{3}{11}\right)^2 - \frac{1}{33}}}\right) = 45^\circ 59' 34.''70$$

$45^\circ 57' 43''$ [6: Part IV, Vol. XI, p.287, 1866]

$46^\circ 01' 10''$ [6: Part IV, Vol. XI, p.287, 1866]

Average value $45^\circ 59' 27''$

$$O_3(6,2) = \arccos\left(\sqrt{\frac{3}{11} - \sqrt{\left(\frac{3}{11}\right)^2 - \frac{1}{33}}}\right) = 75^\circ 29' 21.''05$$

$75^\circ 28' 15''$ [6: Part IV, Vol. X, p.160, 1860]

$75^\circ 32' 24''$ [6: Vol. II, N.6, p.321, 1878]

Average value $75^\circ 30' 20''$

$$O_4(6,2) = \arccos\left(-\sqrt{\frac{3}{11} - \sqrt{\left(\frac{3}{11}\right)^2 - \frac{1}{33}}}\right) = 104^\circ 30' 38.''95$$

$104^\circ 30'$ [6: Part IV, Vol. X, p.161, 1860]

$104^\circ 31' 40''$ [6: Part IV, Vol. X, p.159, 1860]

Average value $104^\circ 30' 50''$

$$O_5(6,2)=\arccos\left(-\sqrt{\frac{3}{11}+\sqrt{\left(\frac{3}{11}\right)^2-\frac{1}{33}}}\right)=134^\circ 00'25.''30$$

$134^\circ 00'30''$ [6: Part III, Vol. VII, p.60, 1853]

$O_6(6,2)=180^\circ$

b) Sectors

$180^\circ-2O_2(6,2)=88^\circ 00'50.''60$ Lebedev: 88° [11: p.273]

$2O_2(6,2)=91^\circ 59'09.''40$ $180^\circ-88^\circ=92^\circ$

$2O_3(6,2)=150^\circ 58'42.''10$, $150^\circ 58'$ [6: Part IV, Vol. XI, p.404, 1860]

$180^\circ-2O_3(6,0)=29^\circ 01'17.''90$ $29^\circ 02'40''$ [6: Part I, Vol. III, p.421, 1870]

$O_3(6,2)-O_2(6,2)=29^\circ 29'46.''35$, $29^\circ 29'16''$ [6: Part IV, Vol. XI, p.286, 1866]

$180^\circ-(O_3(6,2)-O_2(6,2))=150^\circ 30'13.''65$ $150^\circ 29'45''$ [6: Part III, Vol. VII, p.43, 1853]

$O_4(6,2)-O_2(6,2)=58^\circ 31'04.''25$, Haüy: $58^\circ 31'04''$ [5: p.85; 2*]

$180^\circ-(O_4(6,2)-O_2(6,2))=121^\circ 28'55.''75$, Haüy: $121^\circ 28'56''$ [5: p.86; 2*]

c) Extremes:

$$\theta_1(6,2)=\arccos\left(\sqrt{\frac{17}{33}+\sqrt{\left(\frac{17}{33}\right)^2-\frac{19}{99}}}\right)=27^\circ 32'30.''54$$

$27^\circ 39'38''$? [6: Part IV, Vol. X, p.99, 1860]

$$\theta_1(6,2)=\arccos\left(\sqrt{\frac{17}{33}-\sqrt{\left(\frac{17}{33}\right)^2-\frac{19}{99}}}\right)=60^\circ 23'27.''73$$

$60^\circ 24'10''$ [6: Part IV, Vol. XI, p.261, 1866]

$\theta_3(6,2)=90^\circ$

$$\theta_4(6,2)=\arccos\left(-\sqrt{\frac{17}{33}-\sqrt{\left(\frac{17}{33}\right)^2-\frac{19}{99}}}\right)=119^\circ 36'32.''27$$ Glinka: $119^\circ 36'$ [10: p.67]

$$\theta_5(6,2)=\arccos\left(-\sqrt{\frac{17}{33}+\sqrt{\left(\frac{17}{33}\right)^2-\frac{19}{99}}}\right)=152^\circ 27'29.''46$$

$152^\circ 28'34''$ [6: Part IV, Vol. X, p.99, 1860]

d) Sectors

$2\theta_1(6,2)=55^\circ 05'01.''08$ Fletcher: $55^\circ 06'$ [21]

$180^\circ-2\theta_1(6,2)=\theta_5(6,2)-\theta_1(6,2)=124^\circ 58'58.''92$

$124^\circ 58'50''$ [6: Part IV, Vol. X, p.100, 1860]

$2\theta_2(6,2)=120^\circ 46'55.''46$ Glinka: $120^\circ 46'$ [10: p.65]

$180^\circ-2\theta_2(6,2)=59^\circ 13'04.''54$ $180^\circ-120^\circ 46'=59^\circ 14'$

$\theta_5(6,2)-\theta_1(6,2)=125^\circ 54' 58.''92$	$125^\circ 57'$ [6: Part IV, Vol. XI, p.624, 1860]
$180^\circ-(\theta_5(6,2)-\theta_1(6,2))=54^\circ 5' 01.''08$	$53^\circ 59' 37''$? [6: Part IV, Vol. XI, p.286, 1866]
$\theta_3(6,2)-\theta_1(6,2)=62^\circ 27' 29.''46$	$62^\circ 35' 16''$? [6: Part IV, Vol. XI, p.286, 1866]
	$62^\circ 12' 58''$? [6: Part IV, Vol. XI, p.286, 1866]
	Average value $62^\circ 24' 7''$
$180^\circ-(\theta_3(6,2)-\theta_1(6,2))=117^\circ 32' 30.''54$	$117^\circ 34'$? [6: Part IV, Vol. X, p.100, 1860]
$\theta_4(6,2)-\theta_1(6,2)=92^\circ 4' 1.''73$	$92^\circ 9' 30''$? [6: Part IV, Vol. X, p.87, 1860]
$180^\circ-(\theta_4(6,2)-\theta_1(6,2))=87^\circ 55' 58.''27$	$87^\circ 50' 30''$? [6: Part IV, Vol. X, p.87, 1860]
$\theta_2(6,2)-\theta_1(6,2)=32^\circ 50' 57.''19$	$32^\circ 51' 14''$ [6: Part IV, Vol. XI, p.396, 1860]
$180^\circ-(\theta_2(6,2)-\theta_1(6,2))=147^\circ 9' 2.''81$	$147^\circ 9'$ [6: Part IV, Vol. X, p.161, 1860]
$\theta_3(6,2)-\theta_2(6,2)=19^\circ 36' 32.''27$	$180^\circ-160^\circ 22' 35''$
$180^\circ-(\theta_3(6,2)-\theta_2(6,2))=160^\circ 23' 27.''73$	$160^\circ 22' 35''$ [6: Vol. IV, p.106, 1870]
$\theta_4(6,2)-\theta_2(6,2)=59^\circ 13' 04.''54$	$59^\circ 23' 30''$? [6: Vol. VII, p.254, 1870]
$180^\circ-(\theta_4(6,2)-\theta_2(6,2))=120^\circ 46' 55.''46$	$120^\circ 44'$? [6: Vol. IX, p.486, 1870]

$$\boxed{\Theta_{6,3}(\theta)=\sin^3\theta\cos\theta(\cos^2\theta-{}^{3}\!/_{11})}$$

a) Zero:

$O_1(6,3)=0^\circ$

$O_2(6,3)=\arccos\sqrt{\frac{3}{11}}=58^\circ\,31'\,04.''25$ Haüy: $58^\circ 31' 04''$ [5: p.85; 2*]

$O_3(6,3)=90^\circ$

$O_4(6,3)=\arccos\left(-\sqrt{\frac{3}{11}}\right)=121^\circ\,28'\,55.''75$ Haüy: $121^\circ 28' 56''$ [5: p.86; 6*]

$O_5(6,3)=180^\circ$

b) Sectors:

$\Delta\theta_1=2O_2(6,3)=117^\circ\,02'\,08''.50$,	Haüy: $117^\circ 02' 08''$ [5: p.85; 2*]
$180^\circ-2O_1(6,3)=62^\circ 57' 51.''1$	Eakle: $62^\circ 59'$ [22]
$O_4(6,3)-O_2(6,3)=62^\circ 37' 51.''50$	$62^\circ 38' 36''$ [6: Part III, Vol. VII, p.76, 1869]
$O_3(6,3)-O_2(6,3)=31^\circ 28' 55.''75$	$31^\circ 30' 54''$ [6: Vol. IV, p.100, 1870]
$180^\circ-(O_3(6,3)-O_2(6,3))=148^\circ 31' 04.''25$	$148^\circ 30'$ [6: Part I, Vol. III, p.341, 1853]

c) Extremes:

$$\theta_1(6,3)=\arccos\left(\sqrt{\frac{5}{11}+\sqrt{\left(\frac{5}{11}\right)^2-\frac{1}{22}}}\right)=22^\circ 18' 07.''02$$

$22^\circ 20' 55''$ [6: Part IV, Vol. XI, p.389, 1860]

$$\theta_2(6,3) = \arccos\left(\sqrt{\frac{5}{11} - \sqrt{\left(\frac{5}{11}\right)^2 - \frac{1}{22}}}\right) = 76^\circ 40' 37.''65$$

$76^\circ 42' 39''$ [6: Part I, Vol. III, p.433, 1870]

$$\theta_3(6,3) = \arccos\left(-\sqrt{\frac{5}{11} - \sqrt{\left(\frac{5}{11}\right)^2 - \frac{1}{22}}}\right) = 103^\circ 19' 22.''35$$

$103^\circ 20' 40''$ [6: Part IV, Vol. XI, p.418, 1860]

$$\theta_4(6,3) = \arccos\left(-\sqrt{\frac{5}{11} + \sqrt{\left(\frac{5}{11}\right)^2 - \frac{1}{22}}}\right) = 157^\circ 41' 52.''98$$ $157^\circ 42' 43''$ [6: Vol. IV, p.111, 1870]

$157^\circ 40' 59''$ [6: Vol. I, N.1, p.113, 1877]

Average value $157^\circ 41' 51''$

d)Sectors:

$2\theta_1(6,3) = 44^\circ 36' 14.''04$ $44^\circ 36' 20''$ [6: Vol. V, p.304, 1870]

$180^\circ - 2\theta_1(6,3) = \theta_4(6,3) - \theta_1(6,3) = 135^\circ 23' 45.''96$ $135^\circ 18' 46''$? [6: Vol. IV, p.102, 1870]

$135^\circ 29' 30''$? [6: Part I, Vol. III, p.346, 1853]

Average value $135^\circ 24' 8''$

$2\theta_2(6,3) = 153^\circ 21' 15.''30$ $153^\circ 19' 30''$ [6: Part I, Vol. III, p.428, 1870]

$153^\circ 26' 6''$? [6: Part I, Vol. III, p.334, 1853]

$153^\circ 17' 31''$? [6: Part IV, Vol. X, p.144, 1860]

average value of the last two angles $153^\circ 21' 48''$

$180^\circ - 2\theta_2(6,3) = 26^\circ 38' 44.''70$ $26^\circ 38'$ [6: Part I, Vol. III, p.428, 1870]

$\theta_2(6,3) - \theta_1(6,3) = 54^\circ 22' 30.''63$ $54^\circ 22' 04''$ [6: Part III, Vol. VII, p.99, 1869]

$180^\circ - (\theta_2(6,3) - \theta_1(6,3)) = 125^\circ 37' 29.''37$ $125^\circ 31' 32''$? [6: Part IV, Vol. XI, p.387, 1860]

$\theta_3(6,3) - \theta_1(6,3) = 81^\circ 01' 15.''33$ $81^\circ 03' 07''$ [6: Part IV, Vol. XI, p.389, 1860]

$180^\circ - (\theta_3(6,3) - \theta_1(6,3)) = 98^\circ 58' 44.''67$ $98^\circ 56' 53''$ [6: Part IV, Vol. XI, p.384, 1860]

$$\boxed{\Theta_{6,4}(\theta) = \sin^4\theta(\cos^2\theta - 1/11)}$$

---

a) Zeros:

$O_1(6,4) = 0^\circ$

$$O_2(6,4) = \arccos\left(\frac{1}{\sqrt{11}}\right) = 72^\circ 27' 05.''76$$ $72^\circ 30' 28''$ [6: Part I, Vol. III, p.349, 1853]

$$O_3(6,4) = \arccos\left(-\frac{1}{\sqrt{11}}\right) = 107^\circ\ 32' 54.''24$$ $107^\circ 33' 13''$ [6: Part IV, Vol. XI, p.281, 1866]

$O_4(6,4) = 180^\circ$

b) Sectors:

$2O_2(6,4) = 144^\circ 54' 11.''52$ — $144^\circ 50' 31''$? [6: Vol. IV, p.103, 1870]

$180^\circ - 2O_2(6,4) = 35^\circ 05' 48.''48$ — $35^\circ 06' 56''$ [6: Part IV, Vol. XI, p.389, 1860]

c) Extremes

$\theta_1(6,4) = \arccos\left(\sqrt{\frac{13}{33}}\right) = 51^\circ 07' 24.''04$ — $51^\circ 08' 28''$ [5: Part IV, Vol. XII, p.630, 1860]

$\theta_2(6,3) = 90^\circ$

$\theta_3(6,4) = \arccos\left(-\sqrt{\frac{13}{33}}\right) = 128^\circ 52' 35.''96$ — $128^\circ 54' 02''$ [6: Vol. IV, p.104, 1870]

$128^\circ 50' 50''$ [6: Vol. VIII, p.251, 1870]

Average value $128^\circ 52' 35''$

d) Sectors:

$\Delta\theta_1 = 2\theta_1(6,4) = 102^\circ 14' 48.''08$ — $102^\circ 12' 40''$ [6: Vol. IV, p.107, 1870]

$102^\circ 16' 42''$? [9: 21]

Average value $102^\circ 14' 41''$

$180^\circ - 2\theta_1(6,4) = \theta_3(6,4) - \theta_1(6,4) = 77^\circ 45' 11.''92$ — Palache: $77^\circ 44'$? [23]

$\theta_2(6,4) - \theta_1(6,4) = 38^\circ 52' 35.''96$ — $38^\circ 51' 32''$ [6: Part IV, Vol. XII, p.630, 1860]

$180^\circ - (\theta_2(6,4) - \theta_1(6,4)) = 151^\circ 07' 24.''04$ — $151^\circ 03' 16''$? [6: Part IV, Vol. XI, p.433, 1860]

$\boxed{\Theta_{6,5}(\theta) = \sin^5\theta\cos\theta}$

---

a) Zeros:

$O_1(6,5) = 0^\circ$, $O_2(6,5) = 90^\circ$, $O_4(6,5) = 180^\circ$ — typical angles of crystals

c) Extremes

$\theta_1(6,5) = \arccos\left(\frac{1}{\sqrt{6}}\right) = 65^\circ 54' 18.''67$ — $65^\circ 51' 28''$ [6: Part IV, Vol. XI, p.393, 1860]

$65^\circ 58' 13''$ [6: Part IV, Vol. XI, p.388, 1860]

Average value $65^\circ 54' 50''$

$\theta_2(6,5) = \arccos\left(-\frac{1}{\sqrt{6}}\right) = 114^\circ 05' 41.''33$ — $114^\circ 01' 47''$ [6: Part IV, Vol. XI, p.431, 1860]

d) Sectors:

$\Delta\theta_1 = 2\theta_1(6,4) = 131^\circ 48' 37.''34$ — Kokscharov-son: $131^\circ 57' 28''$? [6: Vol. IV, N.11, p.223, 1879]

$\Delta\theta_1 = \pi - 2\theta_1(6,4) = 48^\circ 11' 22.''66$ — $48^\circ 07' 41''$? [6: Part IV, Vol. XI, p.393, 1860]

$48^\circ 16' 16''$? [6: Part IV, Vol. XI, p.389, 1860]

Average value $48^\circ 11' 58''$

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4. Facet angles of some crystals: examples

Let us consider finally the geometry of some crystals (Fig. 1) from the point of view of typical angles of polar functions resting upon Haüy's works [5].

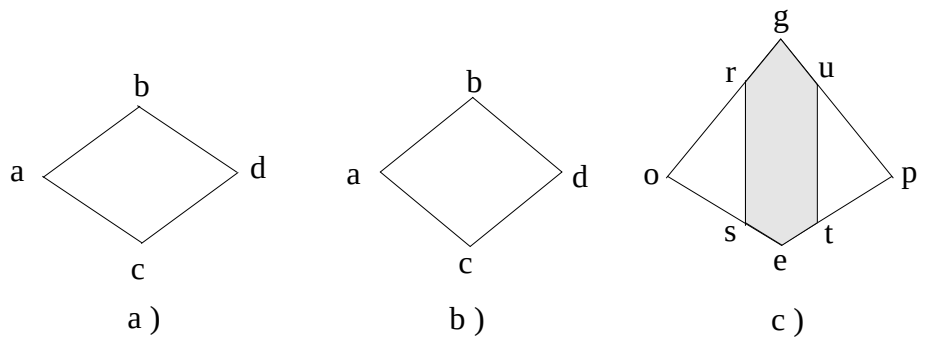

Fig. 1. Rhombic facets of some crystals.

a) The pomegranate with 24 facets [5: p.82; 2*]. The scanning is 24 rhombuses. The angles of the rhombuses (Fig. 1a) are correspondingly equal to [5: p.79; 1*]:

$\angle bac = 70^\circ 31' 44''$ → $O_2(5,3) = O_2(2,0) - O_1(2,0) = 70^\circ\, 31' 43.''60$,

$\angle acd = 109^\circ 28' 16''$ → $O_3(5,3) = 2O_1(2,0) = 109^\circ\, 28' 16.''40$

b) The lime spar [5: 36, 7*]. The scanning is 6 rhombuses (Fig. 1b) with angles:

$\angle bac = 78^\circ\, 27' 47''$ → $2O_1(3,0) = 78^\circ\, 27' 46.''94$,

$\angle acd = 101^\circ\, 32' 13''$ → $O_3(3,0) - O_1(3,0) = 2(O_3(3,0) - O_2(3,0)) = 101^\circ\, 32' 13.''06$

c) The pomegranate with 36 facets. The scanning is 12 rhombuses (Fig. 1a) and 24 prolate hexagons (“a*rgute*”, Fig. 1c) [5: 82; 2*]. The angles are:

$\angle rgu = 78^\circ\, 27' 47''$ → $2O_1(3,0) = 78^\circ\, 27' 46.''94$,

$\angle set = 117^\circ\, 02' 8''$ → $2O_2(6,3) = 117^\circ\, 02' 8.''50$,

$\angle gut = \angle grs = 140^\circ\, 46' 07''$ → $O_3(3,0) = 140^\circ\, 46' 06.''53$

$\angle rse = \angle etu = 121^\circ 28' 56''$ → $O_4(6,3) = 121^\circ 28' 55.''75$

$\angle goe = \angle gpe = 82^\circ 15' 03''$ → $180^\circ - (O_1(3,0) + O_2(6,3)) = 82^\circ 15' 02.''28$

5. Conclusion

Thus, the above-presented theoretical data are in perfect agreement with the experimental data which confirms that the minerals are the material realization of the elementary solutions of the wave equation (2) for the wave field of probability.

Characteristic angles of crystals of natural minerals and spatial angles of nodes in the wave shell-nodal structure of the atoms (see Lectures of Vol. 5) are defined by the same solution of the wave equation. This means that for both, the nodes of the atoms and crystals, these angles are the same.

This fact confirms, in particular, the wave nature of all material formations in the Universe at the *atomic* and *molecular* levels. Generalizing and taking into account the wave dynamic structure of elementary particles (according to the Dynamic Model, see Lectures of Volumes 2 and 3), we can say that all material formations at *all levels* of the Universe, being harmonically interrelated between themselves, have the wave nature as everything in the Universe.

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16.06.2015

II. Fallacy of the Nuclear Model of Atomic Structure

1. Introduction

In the light of the Wave Model (WM), which includes the Dynamic Model of Elementary Particles (DM) and the Shell-Nodal Atomic Model (SNAM), all atoms, except the hydrogen atom ($Z = 1$), are molecule-like formations. That is, these material formations, grouped in modern physics in the *Periodic Table of "Atomic Properties of the Elements"* [1] in accordance with the so-called electron configuration of the atoms, represent in reality (except hydrogen) the Z-*Nodal Elementary Molecules* of the hydrogen atoms (Z-NEM) [2], where $Z \geq 2$ is the *number of potential polar-azimuthal nodes* in an atom coinciding with the *atomic number* of an element in the Periodic Table.

Therefore, the objects regarded conventionally as atoms, but being as follows from the WM, actually, molecules, *have no superdense nuclei* in their centers. Really, in the center of most of the stable atoms, there is only an empty potential-kinetic polar node, as it is shown, for example, schematically in Fig. 1 for the helium atom ${}_2^4He$.

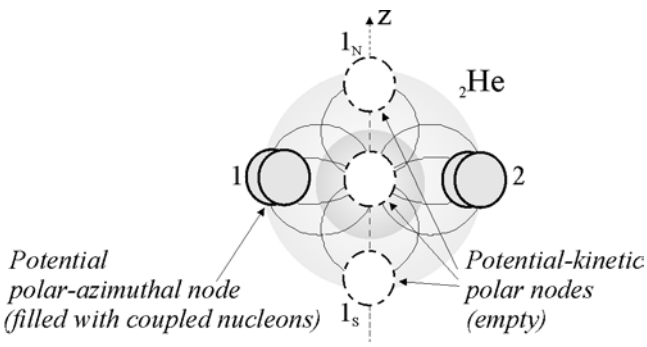

Fig. 1. The shell-nodal structure of the helium atom ${}_2^4He$, according to the Shell-Nodal Atomic Model; the diameter of an outer atomic shell of helium is about $d_{outershell}(He) \approx 1.4 \cdot 10^{-8}\ cm$

Obviously, it is nonsense talking about some nucleus in regard to a molecule, furthermore, about a *superdense* nucleus in its center. We can speak only about the center of mass of a molecule.

In synthetic short-lived atomic isotopes, the *potential-kinetic* polar nodes located along the Z-axis, including central, which are the nodes of *rest* and *motion* simultaneously, and, therefore, empty in most of the stable atoms, can be forcibly filled temporarily with single or coupled *hydrogen atoms* (remember Lecture 5 of Vol. 5). Filling of the empty central polar node with a nucleon does not lead to the appearance of a superdense nucleus in the center of a molecule-like atom, because, in accordance with the WM, hydrogen atoms (to which we refer nucleons and protium) also *have no nuclei* in their centers. The same reasoning relates to naturally occurring atomic isotopes, stable and short-lived (radioactive), having the filled central node.

Only *one-centred* hydrogen atoms are the *true atoms*, in the truest meaning applied to the modern notion of an *atom*. According to the Dynamic Model, *hydrogen atoms* are dynamic pulsating spherical formations (something like the dense three-dimensional vortices) in space from the space itself. Such formations have no nuclei in their centers. At their breaking at some external influences (for example, by bombarding them with energetic particles using linear accelerators and cyclotrons), numerous analogous but more disperse short-lived dynamic pulsating formations (yet tinier vortices) are formed.

Subjecting Universal harmony, associated masses of the formed particles (dense spatial vortices) are not arbitrary, they are *multiple to the fundamental quantum* of measure [3] (the period-quantum of the decimal code $\Delta = 2\pi \lg e$, see Lecture 11 of Vol. 3). The *g*-lepton of the mass $m_g = 68.5 m_e$ (multiple to a quarter of the fundamental period-quantum, $(1/4)\Delta$) is a highly stable particle from other ones in the ordered spectrum of the particles [4] formed at nucleon decays. Possibly, *g*-lepton is a constituent of protons, neutrons, and other elementary particles of this series like a nucleon, which is a constituent of hydrogen and rest of the atoms being nucleon molecules.

Therefore, we have reason to consider the hydrogen atoms as the formations comprising *particles of the* deeper (subatomic) level of the Universe, *i.e.*, consisting of the particles of the *subatomic level*. They also have an ordered shell-nodal *molecule-like* structure but formed from the particles of that (subatomic) level. For example, the *g-lepton structure* of a neutron with the surrounding field is identical to the *nucleon shell-nodal structure* of the silicon atom (it is depicted graphically in Fig. 8 of Lecture 9, Vol. 5). An internal ordered disposition of the *subatomic particles* in the hydrogen atoms is defined by the same particular solutions of the general ("classical") wave equation. Thus, like the rest (*multicentric*) atoms of the Periodic Table, the (*monocentric*) hydrogen atoms have no nuclei in their centers.

The atomic number of a chemical element (also known as its proton number) arranged in Mendeleev's Periodic Table [1] is conventionally represented by the symbol Z. Its numerical

value indicates the *number of protons* found in the nucleus of an atom of that element, and therefore identical to the charge number of the nucleus. In an uncharged atom, the atomic number is also equal, according to the definition, to the number of electrons.

The *number of* potential polar-azimuthal *nodes* Z in the shell-nodal structure of the atom [2, 5] (Fig. 6 in L. 3 of Vol. 5) coincides with the *atomic number* Z, *i.e.*, with the number of protons in the atomic nucleus in accordance with the definitions accepted in modern atomic physics. Hence, the number Z in both cases uniquely identifies an atom and, hence, a chemical element.

Thus, equality in value of two in principle different parameters (notions), which are denoted by the same symbol Z, related to two conceptually different models on the structure of atoms, means that thanks to the SNAM we have revealed another physical cause explaining individuality of each atom (the nature of differences between them), as compared with that cause, which is permanently considered in physics for its explaining. As a consequence, we have arrived at another view on the cause of the observed periodicity in chemical properties of the elements consisting of various atoms [2, 5, 6] (considered in Lecture 4 of Vol. 5).

Internodal bonds in molecule-like atoms are *strong*. In the formula of binding energy, which follows from the Wave Model (see Eq. (6) in Lecture 9 of Vol. 5), one of its constituent parameters is the fundamental frequency ω_e, which determines internodal exchange (interactions) at the atomic and subatomic levels and the strictly defined *internodal distances*. The roots of Bessel functions, being solutions of the radial part of the wave equation, determine these distances together with the fundamental frequency $\omega_e = \frac{c}{\lambda\!\!\!^{-}_e}$. In particular, in accordance with the radial solutions of the weave equation, the root of Bessel functions $z_{l,s} = y_{0,1} = 0.89357697$ determines an equilibrium distance

$$r_{He} = y_{0,1}\lambda\!\!\!^{-}_e = y_{0,1}\frac{c}{\omega_e} = 1.433196073\times 10^{-8}\ cm \qquad (1)$$

between two polar-azimuthal nodes 1 and 2 (Fig. 1) belonging to an external atomic shell of the *helium atom* (which is regarded in the WM as the *two-nodal elementary molecule of the hydrogen atoms*, 2-NEM). These nodes are filled with paired hydrogen atoms.

The theoretical radius of the wave shell of the proton (proton's radius) located in a node, obtained from the formula of associated mass (see Eq. (21), Vol. 2, Lecture 2) at the condition $(k_e r_p)^2 << 1$ and $\varepsilon_r = 1$, is

$$r_p(th) = (m_p / 4\pi\varepsilon_0)^{1/3} = 0.510578616\times 10^{-8}\ cm\,. \qquad (2)$$

Because associated mass of the proton $m_p = 1.67262131 \times 10^{-24}\ g$, its density is

$$\rho_p = 2.70\ g \cdot cm^{-3}. \tag{3}$$

The presented above atomic parameters, inherent in the atoms whose structure follows from the WM, substantially differ from the parameters ascribed in modern physics to an atom and its constituents in accordance with the nuclear atomic model. Really, atomic nuclei considered as made up from nucleons, in accordance with the concepts of nuclear physics, have radii in the range of

$$r_p \approx 0.87 \times 10^{-13}\ cm \tag{4}$$

for hydrogen (the radius of a *single proton*) to about $r_{U,nuc} \approx 7.5 \times 10^{-13}\ cm$ for the heaviest atoms, such as uranium. More accurately, according to the CODATA recommended values [7], the *proton rms charge radius* is $r_p = 0.8751(61) \times 10^{-13}\ cm$. Compare this value with theoretical (2) following from the WM: the difference is huge, almost 10^5 times.

Obviously, at such dimensions ascribed to nuclei (comprising, as believe, nucleons), their density have to have a giant value. For example, the *density* of a *nucleus* of the hydrogen atom, *i.e.*, the density of the *proton*, should be

$$\rho_p \approx 2.2 \times 10^{14}\ g \cdot cm^{-3}. \tag{5}$$

The difference in the fourteen decimal orders in magnitude for the same fundamental parameter of the proton (its *density*) is shocking. Really, compare two absolute values: $2.2 \times 10^{14}\ g \cdot cm^{-3}$ (5) with $2.7 \times 10^{0}\ g \cdot cm^{-3}$ (3) (relate practically as $10^{14} : 1$). So drastically two atomic models, modern *nuclear* and wave *shell-nodal* (*molecule-like*), differ. Naturally that such a gigantic value of the density (5) corresponding to the proton of the accepted size (4), raises serious doubts.

Having taken into account aforementioned and all other data accumulated to the present day (see, for example, the data gathered in the Comparative Table on pages 119-125, in Lecture 7), everyone could make sure that the nuclear concept on the atomic structure does not hold water. As if it was not so sad and unexpectedly almost for all physicists, but, ultimately, we have come to the conclusion that really the nuclear model of the atoms is erroneous.

Nevertheless, to the present time an existent of a *nucleus* in the center of an atom is considered in physics as a self-evidence truth, like a dogma. Accordingly, the aforementioned parameters of nuclei do not call doubts in their truth, despite of explicit contradictions with common sense and the appearance of the convincing data testifying not in favor of the

nuclear model. These data obtained over the past decades in result of the comprehensive constructive analysis were confirmed by numerous direct and indirect evidences.

The indicated data, published beginning from 1996 in different scientific editions, became available also online in Internet. Moreover, during the last two years (from 2013) the new basic concepts of dialectical physics generalized in the WM, with the unique data obtained on its base, were systematized and presented in the form of the given Lectures. We hope that with the lapse of time all this material will be noticed and subjected to a serious analysis by the world scientific community.

Judging by all the results obtained in the framework of the WM, most of which were discussed in our Lectures, we can state that the shell-nodal atomic model *really* reflects the *true structure* of the atoms. To what extent more or less correctly, it is another question, but the presented arguments and experimental data confirm the truthfulness of the above assertion.

Contrary to the WM, we cannot make the same conclusion (about the reflection of reality) with respect to the abstract-mathematical quantum mechanical (QM) model of the atoms, which has adopted the nuclear concept of the Rutherford-Bohr planetary model. Erroneous "solutions" and resulting explicit contradictions are characteristic features of the QM and, hence, the modern atomic model.

It is no wonder; the QM is based on numerous abstract-mathematical postulates, one of which is Schrodinger's equation. The latter was artificially created by joining unfoundedly *base* and *superstructure* of the wave process, which are inherent in this process (by ignorance of this feature or disregarding it), in one equation (see Lecture 1 of Vol. 5). Both features of the wave process (related to different, although nearby, levels in hierarchy of the levels of the Universe) should be described separately in principle that always occurred until that time. For this reason, Schrodinger's equation has no direct solutions. However, thanks to rough manipulations, the fabricated "solutions" led partially to the needed coincidence of the "calculated" data with some of the experimental results.

According to the *wave atomic model*, the SNAM, atoms (apart from hydrogen atoms) are *multicentric* molecule-like formations. The *scattering centers* of the atoms are the *hydrogen atoms*, to which we refer *neutrons*, *protons*, and *protium*. Being coupled, they are *located in the nodes* of the atomic shells (as, for example, it is illustrated in Fig. 1 for the helium atom, in the nodes 1 and 2).

In view of the stated above, the modern scattering theory of particles and waves by the atoms of matter *should be reconsidered* with taking into account the wave nature of the atoms, *i.e.*, considering their shell-nodal structure, which, in all appearances, is closer to the real atomic structure and, apparently, for this reason till now remains irrefutable.

The *reconsideration* makes sense also owing to the fact that experiments on scattering of high-speed charged particles by the atoms of matter carried out from Rutherford's time did not give a sound proof that every atom has only *one scattering site*.

According to the DM, the center of mass of a nucleon, localized in the nucleon node of an atom, performs radial oscillations with amplitude of the order $1.4 \times 10^{-13}\ cm$ at a frequency about $1.8 \times 10^{18}\ s^{-1}$. Such oscillations form in result the *dynamic spherical volume* limited by a radius equal to the amplitude of the given oscillations. This dynamic volume represents, actually, *indeterminacy* in the disposition of the *center of mass* of the nucleon being in the permanent motion (pulsating). The *spatial indeterminacy* in the disposition of the center of mass, limited in space by the spherical dynamic volume, demonstrates itself as if it were a scattering core of the nucleon, when the hydrogen atoms in the nodes are bombarded by particles (or waves) from the outside.

The same value ($\approx 10^{-13}\ cm$) that was ascribed in physics (subjectively, without firm proofs) to the nuclear sizes originates from analyzing by Rutherford the experiments on scattering of α and β particles by matter [8]. The volume of such a radius, assumed as a core of scattering, Rutherford *identified hypothetically* with a tiny solid nucleus, inside of which, as he *supposed*, are all atomic nucleons, *i.e.*, practically a whole mass of the atom (neglecting the mass of electrons) is concentrated. As a result of the above supposition, the density of such a hypothetical formation, called an atomic nucleus, should have an unbelievable high value. Currently it is accepted that the nuclear density of an atom is equal in average about $2.3 \times 10^{14}\ g \cdot cm^{-3}$.

A quantitative theory of the scattering of α-particles by the atoms of matter has begun from experiments of Geiger, Marsden and Rutherford. We will not reproduce completely this theory here (you can find all the details concerning basic concepts of the theory in the text books, *e.g.*, in [9]). In these experiments, *alpha*-particles (ionized helium atoms) in an incident beam were considered as some charged solid spherical balls. They collide with atomic nuclei of a target (the gold foil), which also were considered as the charged solid spherical balls. Such a model of the interaction, considered in the aforementioned experiments on the scattering, represents in some extent a primitive mechanical analogue of the collision of billiard balls.

The classical Rutherford scattering of alpha particles against gold nuclei is an example of "elastic scattering" because the energy and velocity of the outgoing scattered particle is the same as that with which it began. The intriguing results showed that around 1 in 8000 alpha particles were deflected by very large angles (over 90°), while the rest passed straight through with little or no deflection.

Thus, resting upon his own results and experimental data obtained by Geiger and Marsden [10] and also upon the results carried out by Crowther on scattering of β-particles

[11], Rutherford noticed [8] that an incredibly small area of an atom is responsible for the deflection of incident α- and β-particles. It was identified with a superdense atomic nucleus. A key assumption of Rutherford‘s theory was that both the positive charge and the mass of the atom were more or less “uniformly distributed” over the size of about 10^{-12} *cm* across or a little more.

Finally, on the basis of analyzing all the data accumulated to that time, related to the scattering of the particles on matter, and the resulting supposition on an existence of a minute atomic nucleus, Rutherford put forward both a *theory of scattering* of incident particles in matter and gave birth the *nuclear model* of the atoms. The given theory and the nuclear atomic model, being accepted and fully developed subsequently (in the framework of atomic physics, nuclear physics, and high energy physics), remain among the dominative concepts in contemporary physics up till now.

We proceed now to the presentation of an analysis, carried out by the authors a long time ago and published for the first time in 1996 in a book “*Alternative Picture of the World*” [12], related to the aforementioned pioneer experiments on the scattering discussed in Rutherford’s paper [8] (1911) and in the relevant publications of that time. This analysis has been done (see also [13]) for verifying an extent of the validity of Rutherford’s hypothesis on an existence of an atomic nucleus in view of the discovery of the wave shell-nodal (nuclear-free) structure of the atoms.

2. Shortcomings of Rutherford’s scattering theory

First, one should note that all experiments on the scattering, beginning from the first experiments, mentioned above, up to many others performed afterwards during about a century, did not give the firm proof that every atom has only one scattering site. These experiments state only the fact that atoms really have some *extremely small areas of scattering* of α- and β-particles, in comparison with *relatively huge atomic sizes* and interatomic distances.

Second, there is not univalent understanding, what does it mean a deflection (or scattering) on an atom of the particles (α or β), which at the same time behave themselves as waves, following the wave-particle duality. According to the latter, every elementary particle exhibits the properties of not only particles, but also waves.

Third, the origin of mass and the nature of electric charge were the great puzzles of that time (and still are in modern physics). So it makes no sense to reason about the “*uniformly distributed*” charge do not knowing what the charge is. Physicists of the papers referred above have used such an expression (concept) in their theoretical constructions, and modern physicists continue to use it now.

At the end of the 20th century, marked by an appearance in 1996 the book "*Alternative Picture of the World*" by L. Kreidik and G. Shpenkov [12], the aforementioned puzzles on the nature of mass and charge were unraveled in the framework of the Dynamic Model of Elementary Particles (DM) [14]. Simultaneously, a thorough analysis of particular solutions of the general ("classical") wave equation, carried out by the authors, has shown that an atom has the shell-nodal structure, resembling the molecule, and that the atomic nucleus, in the modern understanding of this notion, does not exist.

Therefore, basing on the discovery of the nature of mass and electric charge (and other effects originated from the DM), and on the resulting solutions concerning the structure of the atom, quite fully developed in the framework of the SNAM, we looked at pioneer works on the scattering (resulting in the nuclear atomic model) from a new point of view.

At the beginning it made sense to analyze the Rutherford's work [8], which has led him to the supposition about the nuclear structure of the atom. This work was first and principal which laid the foundation of modern nuclear physics. Let us show some data discussed in it.

The data on scattering of α-particles at large angles in thick layers of different metals, under similar conditions, obtained experimentally by Geiger and Marsden [10] (Rutherford had relied upon these results in his work [8]), are presented in Table 1, where *N* is the relative number of diffusely scattered particles. The observation was made for a deflexion of about 90°.

Table 1. The experimental data on scattering of α-particles [10]

Metal	Atomic weight, *A*	*N*	$N / A^{3/2}$
Lead	207	62	208
Gold	197	67	242
Platinum	195	63	232
Tin	119	34	226
Silver	108	27	241
Copper	64	14.5	225
Iron	56	10.2	250
Aluminum	27	3.4	243
			Average 233

The relative number of diffusely scattered α-particles, *N*, was obtained by the registration of the number of scintillations per minute on a zinc sulphide screen.

According to the theory of single scattering, the part of the total number of α-particles, scattered under some angle during passing through the thickness *t*, is proportional to the value

nA^2t (where n is the concentration of atoms). It is valid if one supposes that the central charge is proportional to the atomic weight A. In this case, the thickness of substance from which scattered α-particles can fly out and act upon screen of zinc sulfide depends on the kind of the metal.

Since Brag has shown that the braking ability ("stopping power") of an atom for an α-particle is proportional to the square root of its atomic weight, the value of nt for different elements is proportional to $1/\sqrt{A}$. Therefore, t corresponds to the greatest depth from which the scattered α-particles can leave the metal. Thus, the value N of α-particles scattered back from a thick metal plate is respectively proportional to $A^{3/2}$, *i.e.*, the ratio $N/A^{3/2}$ has to be the constant value.

Taking into consideration difficulties with experiments, conformity of the theory with the experiment (as can be seen from Table 1) is sufficient.

Another results discussed in Rutherford's paper concern the scattering of β-rays in substance carried out by J. Crowther [11]. We find there: if t_m is the thickness at which a half of all particles is deflected under the angle φ then, as J. Crowther showed, $\varphi/\sqrt{t_m}$ is the constant value for the substance at the fixed φ …. On the basis of Crowther's data concerning values $\varphi/\sqrt{t_m}$, for different elements and for β-rays with the speed of $2.68\cdot10^{10}\ cm\cdot s^{-1}$, the value of the central charge Z_ne can be computed in accordance with a theory of the single dispersion… The values Z_n, calculated on the basis of Crowther's results, are presented in Table 2.

Table 2. The experimental data on scattering of β-particles [11].

Element	Atomic weight, A	$\varphi/\sqrt{t_m}$	Z_n
Aluminum	27	4.25	22
Copper	63.2	10.0	42
Silver	108	15.4	78
Platinum	194	29.0	138

The relative values of the "*charge of nucleus*" Z_n presented in Table 2 is difficult to reduce in correspondence with the order numbers of elements Z approximately equal to $\frac{1}{2}A$ ($_{13}$Al, $_{29}$Cu, $_{47}$Ag, $_{78}$Pt).

Nevertheless, on the basis of the scattering data for β- and α-rays, presented in Tables 1 and 2, Rutherford concluded "… *that the central charge in an atom is approximately proportional to its atomic weight*". He decided that the scattering observed was from a

positively charged small single nucleus. He stated that, in accordance with his theory of scattering, the number of deflecting α-particles was proportional to the squared charge of the nucleus equal, approximately, to a half of the atomic weight [8, 15].

An original formula for scattering of α-particles derived by Rutherford can be presented in various forms. We present here one of its possible variants (taken from [9]), which is convenient for comparison with experiment. If the number of α-particles incident per a second on the surface of scattered leaf one denotes by the symbol *N*, then Rutherford's formula for the mean number *dN* of α-particles scattered at the angle ϑ within a solid angle dϑ, takes the following form:

$$dN = nN\left(\frac{Ze^2}{M\upsilon^2}\right)^2 \frac{d\Omega}{\sin^4\frac{\vartheta}{2}}, \qquad (6)$$

where *n* is the number of scattering nuclei in 1 cm^3, *M* is the mass of an α-particle and υ is its speed at the large distance from a nucleus. As can be seen, the number of scattered particles is highly dependent on the angle ϑ and increases rapidly with decreasing this angle.

However, the experimental data shows that deflection of α-particles does not obey completely to this formula. Therefore, Rutherford noted initially [8] in this regard during his analysis resulted in the supposition on the existence of the nucleus, "*The large and small angle scattering could not then be explained by the assumption of a central charge of the same value*".

Nevertheless, he changed immediately his initial opinion and continued further: "*Considering the evidence as a whole, it seems simplest to suppose that the atom contains a* ***central charge distributed through a very small volume****, and that the large single deflections are due to the central charge as a whole, and not to its constituents. At the same time, the experimental evidence is not precise enough to negative the possibility that a small fraction of the positive charge may be carried by satellites extending some distance from the center. Evidence on this point could be obtained by examining whether the same central charge is required to explain the large single deflections of α- and β-particles; for the α-particle must approach much closer to the center of the atom than the β-particle of average speed to suffer the same large deflexion*".

An expression "*… a central charge distributed…*" calls the principal question, what is the electric charge? Whether is it a kind of matter, if it can be distributed "*through a ... volume*"? What is the nature of the electric charge?

Strictly speaking, all the data, including presented above, shows that it is unconvincing to speak about the confluence of all positively charged nucleons in an atom in the one small drop-nucleus. Actually, as follows from the WM, the above-considered examples, analyzed

in Rutherford's paper, testify that centers of the α- and β-particles scattering are the hydrogen atoms (proton, neutron, and protium), constituting the atom having the shell-nodal (molecule-like) structure [6]. A collision of a microparticle with matter is its interaction not only with an individual hydrogen atom located in a node of an atom of substance, but also with all of the overlapped hydrogen atoms, belonging to the nearby atoms, located in this node, because of overlapping these nodes.

We will show this here relaying on the alternative theory of scattering [12, 13], consistent with the experimental data, which takes into account the shell-nodal (multicenter, nuclear-free) atomic model [6, 16, 17]. We relay also on the uncovered nature of the electric charge [14].

3. A theory of scattering on nuclear-free nucleons

Recall at the beginning, according to the theory of scattering, the *probability of scattering* is

$$dw = -\frac{dN}{N}, \tag{7}$$

where N is the number of particles impinging upon a thin foil sheet, and dN is the number of scattered particles; the sign "–" indicates that dN is the loss of particles from the total flow. The probability (7) is proportional to the thickness of the material layer dx passed by the beam of particles:

$$-\frac{dN}{N} = \alpha dx, \tag{8}$$

where $\alpha = \frac{dw}{dx}$ is the density of probability of scattering. Hence, the *scattering law* has the form

$$N = N_0 e^{-\alpha x}. \tag{9}$$

In accordance with the shell-nodal atomic model, α-particles scatter on nucleon nodes of the atoms of substance. The number of nodes per atom is approximately equal to a half of the atomic weight. An incident α-particle interacts by its nucleon node (1 or 2, see Fig. 1) with all nucleons located in a node of substance to which the α-particle approaches and scatters. The number of hydrogen atoms in the node of substance depends on the multiplicity of overlapping the potential polar-azimuthal nodes of the individual nearby atoms bound between themselves in the given substance (see, *e.g.*, Lecture 6 of Vol. 5).

A nucleon of every node has the relative freedom of motion within its potential volume. The center of mass of a nucleon oscillates within the spherical volume with the amplitude

$$\Psi = \frac{A_m}{z_{m,n}} = \frac{r_0}{z_{m,n}} \sqrt{\frac{2hR}{m_0 c}}, \tag{10}$$

where $h = 2\pi m_e \upsilon_0 r_0 = 6.6260693(11) \cdot 10^{-27}\, erg \cdot s$ is the Planck constant,

$R = \dfrac{R_\infty}{(1 + m_e / m_0)} = 109677.5833\, cm^{-1}$ is the Rydberg constant, m_0 is the proton mass,

$r_0 = 0.5291772108(18) \cdot 10^{-8}\, cm$ is the Bohr radius, $c = 2.99792458 \cdot 10^{10}\, cm \cdot s^{-1}$, and $z_{m,n}$ are roots of Bessel functions [18].

The first maximum of the kinetic component of the zero-order spherical function, $z_{m,n} = b'_{0,1} = 2.79838605$, defines the displacement of the following value,

$$\Psi = 3.219483546 \times 10^{-13}\, cm. \tag{11}$$

According to (10), the particular sphere of scattering correspond to every root $z_{m,n}$. For example, if $z_{m,n} = a'_{0.1} = 4.49340945$, that corresponds to the maximum of the potential component of the zero-order spherical function, we have $\Psi = 2.005016 \cdot 10^{-13}\, cm$.

Zeros of potential and kinetic components of the zero-order Bessel spherical functions are, respectively,

$$z_{0,n} = \pi n \text{ and } z_{0,n} = \frac{\pi}{2}(2n - 1) \tag{12}$$

In view of the very high frequency of pulsations of the nucleon spherical shell, $\omega_e = 1.869162505 \cdot 10^{18}\, s^{-1}$ [14], the displacement (10) determines the spherical volume of oscillations of the center of mass of a nucleon [19]. A sphere, confining this volume, is the sphere of the center of mass of the nucleon. It is the core (nucleus) of nucleon scattering.

The cross-section of the scattering sphere,

$$\sigma_n = \pi \Psi^2 \tag{13}$$

is the measure of scattering of particles and waves.

Let the effective area of the center of scattering is equal to σ_n, then the *total scattering area* of falling microparticles by atoms of the metal foil is

$$S_{tot} = A_{ef} \sigma_n n S d, \tag{14}$$

where A_{ef} is the number of nucleons in an atom participating in scattering of particles or waves, n is the concentration of atoms, S is the area of the foil, and d is its thickness.

The density of probability of scattering is determined as

$$\alpha = -\frac{\Delta N}{Nd} = \frac{S_{tot}}{Sd} = A_{ef}\sigma_n n, \tag{15}$$

hence, the specific density of scattering is

$$\alpha_s = \frac{\alpha}{\varepsilon_0 \varepsilon} = \frac{A_{ef}\sigma_n n}{A_r m_0 n} = \frac{A_{ef}}{A_r}\frac{\sigma_n}{m_0}, \tag{16}$$

where A_r is the total number of the hydrogen atoms located in the nodes of shells of an atom (relative atomic mass), $\varepsilon_0 = 1\, g \cdot cm^{-3}$ is the unit density, ε is the relative density.

If one introduces an element of the scattering mass $\Delta m = \varepsilon_0 \varepsilon s x$ in terms of the specific thickness of scattering,

$$x_s = \frac{\Delta m}{s} = \varepsilon_0 \varepsilon x, \tag{17}$$

the law of scattering (9) takes the form

$$N = N_0 e^{-\alpha_s x_s}. \tag{18}$$

The effective number of nucleons, scattering the incident particles or waves, is determined by the extent of their mutual overlapping in matter of a foil and by the character of their collective interaction with incident particles and waves. Ignoring the overlapping, we have $A_{ef} = A_r$.

In the case when the scattering object is an atomic volume, the density of probability must be proportional to the relative atomic mass, $\alpha \sim A_r$.

If scattering takes place on an atomic area, $\alpha \sim A_r^{2/3}$; if it is realized on an atomic line, $\alpha \sim A_r^{1/3}$. Such an approximate estimation allows writing a series of possible values of the effective number of nucleons participating in the scattering of incident particles or waves:

$$A_{ef} = A_r, \quad A_r^{2/3}, \quad A_r^{1/3}. \tag{19}$$

With due account of (10) and (13), the *effective section of scattering* per atom will be defined by the formula

$$\sigma_{ef} = A_{ef}\sigma_n = \pi A_{ef}\left(\frac{A_m}{z_{m,n}}\right)^2. \tag{20}$$

In the case of *scattering of waves* of a relatively short length (with respect to the size of a nucleon), the volume scattering will prevail, so that we should accept $A_{ef} = A_r$. Then, the specific density of scattering (16) takes the form

$$\alpha_s = \frac{\sigma_n}{m_0} = \frac{\pi}{m_0}\left(\frac{A_m}{z_{m,n}}\right)^2. \tag{21}$$

Hence, for the maximum of the first kinetic shell, $z_{m,n} = b'_{0,1}$ (see (11)), we have

$$\alpha_s = 0.1955\ g^{-1} \cdot cm^2. \tag{22}$$

The value obtained precisely coincides with the experimental magnitude of $\alpha_s = 0.2\ g^{-1} \cdot cm^2$ holding practically for all targets in the case of short X-rays [20]. The good agreement of (22) with the experimental data indicates on the validity of the theoretical approach presented here.

For the case of *scattering of particles*, the atomic plane of scattering manifests itself. Accordingly, the effective section of scattering per atom is equal to

$$\sigma_{ef} = \pi A_r^{2/3}\left(\frac{A_m}{z_{m,n}}\right)^2. \tag{23}$$

Effective roots $z_{m,n}$ depend on the structure of nucleonic shells and on the energy of falling particles or intensity of waves directed to the space of the being investigated matter. In spite of this uncertainty, it is reasonable to compare theoretical cross-sections calculated by the formula (23) with the experimental data.

Table 3 presents the experimental data on scattering cross-sections, taken from [21] (in barn, $1barn\,(b) = 10^{-24}\ cm^2$), in comparison with the data calculated by the above formula for the roots of Bessel functions lying within the central part of the experimental values. Since scattering is a mass process, experiment determines an effective value of the scattering cross-section corresponding to the mean value of a series of roots of Bessel functions.

Table 3. A comparative list of the scattering cross-sections data

Experiment, [21]		The data of the Wave Model, Eq. (23) [12, 13]		
Element	σ_{tot}, b	σ_{ef}, b	$Z_{m,n}$ [18]	$Z_{m,n}$ values
1	2	3	4	5
He	1.0 ± 0.7	1.11	$j_{0,1}$	2.40482556
Li	1.4 ± 0.3	1.604	$j_{0,1}$	2.40482556
Be	7 ± 1	8.129	$j'_{1/2,1}$	1.16556119
C	4.8 ± 0.2	5.420	$y_{1/2,1}$	1.57079633

N	10 ± 1	10.90	$j'_{1/2,1}$	1.16556119
O	4.2 ± 0.3	4.776	$j'_{1,1}$	1.84118378
F	3.9 ± 0.2	3.761	$y'_{0,1}$	2.19714133
Ne	2.4 ± 0.3	2.135	$y'_{1/2,1}$	2.97508632
Na	4.0 ± 0.5	4.271	$y'_{0,1}$	2.19714133
Mg	3.6 ± 0.4	3.699	$j_{0,1}$	2.40482556
Al	1.4 ± 0.1	1.287	$b'_{1,1}$	4.22227640
Si	1.7 ± 0.3	1.737	$y'_{1,1}$	3.68302286
P	5 ± 1	5.100	$y'_{0,1}$	2.19714133
S	1.1 ± 0.2	1.159	$y_{1/2,2}$	4.71238898
Cl	16 ± 3	20.257	$j'_{1/2,1}$	1.16556119
Ar	1.5 ± 0.5	1.476	$a'_{0,2}$	4.49340946
K	1.5 ± 0.3	1.455	$a'_{0,2}$	4.49340946
Sc	24 ± 2	23.73	$j'_{1/2,1}$	1.16556119
Ti	4 ± 1	3.799	$y'_{1/2,1}$	2.97508632
V	4 ± 1	4.475	$b'_{0,1}$	2.79838605
Cr	3.0 ± 0.5	3.18	$a'_{2,1}$	3.34209366
Mn	2.3 ± 0.3	2.353	$y_{0,2}$	3.95767842
Fe	11 ± 1	10.99	$j'_{1,1}$	1.84118378
Co	7 ± 1	6.677	$j_{0,1}$	2.40482556
Ni	17.5 ± 1	15.6	$y_{1/2,1}$	1.57079633
Cu	7.2 ± 0.7	8.41	$y'_{0,1}$	2.19714133
Zn	3.6 ± 0.4	3.54	$y_{2,1}$	3.38424177
Ga	4 ± 1	3.868	$a'_{2,1}$	3.34209366
Ge	3 ± 1	3.023	$j_{1,1}$	3.83170597
As	6 ± 1	5.787	$b'_{0,1}$	2.79838605
Se	11 ± 2	10.83	$a'_{1,1}$	2.08157598
Br	6 ± 1	5.344	$y'_{1/2,1}$	2.97508632
Kr	7.2 ± 0.7	8.066	$j'_{3/2,1}$	2.46053557
Rb	12 ± 2	11.42	$a'_{1,1}$	2.08157598
Sr	10 ± 1	10.42	$y_{1,1}$	2.19714133
Y	3 ± 2	3.24	$y_{5/2,1}$	3.95952792
Zr	8 ± 1	8.535	$j'_{3/2,1}$	2.46053557
Nb	5 ± 1	4.683	$a'_{2,1}$	3.34209366
Mo	7 ± 1	6.824	$b'_{0,1}$	2.79838605
Ru	6 ± 1	5.93	$j'_{2,1}$	3.05423693
Rh	5 ± 1	5.007	$a'_{2,1}$	3.34209366
Pd	3.6 ± 0.6	3.656	$y_{0,2}$	3.95767842
Ag	6 ± 1	5.855	$j_{1/2,1}$	3.14159265
Cd	7 ± 1	6.829	$y'_{1/2,1}$	2.97508632
In	2.2 ± 0.5	2.284	$j_{2,1}$	5.13562230
Sn	4.9 ± 0.5	4.667	$j'_{5/2,1}$	3.63279732
Sb	4.3 ± 0.5	4.266	$j_{1,1}$	3.83170597
Te	5 ± 1	4.897	$j'_{5/2,1}$	3.63279732

J	3.6 ± 0.5	3.648	$j'_{3,1}$	4.20118894
Xe	4.3 ± 0.4	4.205	$y_{0,2}$	3.95767842
Cs	20 ± 10	19.59	$j'_{1,1}$	1.84118378
Ba	8 ± 1	7.668	$y'_{1/2,1}$	2.97508632
La	15 ± 5	14.17	$y'_{0,1}$	2.19714133
Ce	9 ± 6	8.784	$b'_{0,1}$	2.79838605
Eu	8 ± 1	7.784	$j'_{2,1}$	3.05423693
Er	15 ± 4	16.04	$y'_{0,1}$	2.19714133
Tm	7 ± 3	6.977	$a'_{2,1}$	3.34209366
Yb	12 ± 5	13.08	$j'_{3/2,1}$	2.46053557
Hf	8 ± 2	8.173	$j_{1/2,1}$	3.14159265
Ta	5 ± 1	5.208	$y_{0,2}$	3.95767842
W	5 ± 1	5.264	$y_{0,2}$	3.95767842
Re	14 ± 4	13.73	$j'_{3/2,1}$	2.46053557
Os	11 ± 1	10.77	$y_{3/2,1}$	2.79838605
Pt	10 ± 1	9.69	$y'_{1/2,1}$	2.97508632
Au	9.3 ± 1	9.25	$j'_{2,1}$	3.05423693
Hg	20 ± 5	20.17	$a'_{1,1}$	2.08157598
Tl	14 ± 2	14.61	$j'_{3/2,1}$	2.46053557
Pb	11 ± 1	11.4	$y_{3/2,1}$	2.79838605
Bi	9 ± 1	9.099	$j_{1/2,1}$	3.14159265

As follows from (23), the effective parameter of scattering is

$$L = \sqrt{\frac{\sigma_{ef}}{\pi}} = A_r^{1/3} \frac{A_m}{z_{m,n}}. \qquad (24)$$

In the modern atomic theory, the latter parameter is called the *effective radius of an atomic nucleus*. But in the shell-nodal atomic model (based on the Dynamic Model of elementary particles, DM), L is the parameter of scattering bound up with the *number of nucleons in an atom* and the *scattering sphere of the nucleon* [13].

The scattering sphere (volume) of the nucleon is defined by the amplitude (10) of pulsations of its center of mass which has an associated character. Recall, the rest mass of the nucleon does not exist (as of all microparticles in the DM).

Accordingly, there is no necessity to introduce the notion of a solid atomic nucleus (of the unbelievable gigantic density herein) in the theory in question; like there is no sense to speak, as was mentioned above, about *"a central charge distributed through a volume…"* not knowing, what does it mean, the charge [22, 23]?

Experimentally, the atomic cross-section of scattering is determined by the formula,

$$\sigma_{tot} = \frac{1}{nd} \ln\left(\frac{I_0}{I}\right), \tag{25}$$

where I_0 and I are intensities of flows of incident and passed particles or waves, d is the thickness of a target.

On the basis of (23) and (25), taking into account the practical equality (coincidence) of experimental and theoretical cross-sections of scattering, $\sigma_{tot} = \sigma_{ef}$, we find the experimental radius of the *nucleon* sphere of scattering,

$$\Psi = A_r^{-1/3}\left(\frac{\sigma_{tot}}{\pi}\right)^{1/2}, \tag{26}$$

which well agrees with the theory of scattering presented here. For example, for gold, ${}^{197}_{79}Au$, the experimental cross-section of scattering $\sigma_{tot} = 9.3\times10^{-24}\ cm^2$ (see Table 3, [21]), $A_r = 79$. Accordingly, from (26) it follows that radii of the *nucleon* spheres of scattering in gold are about $\Psi = 2.95\times10^{-13}\ cm$. Thus, the center of mass of a nucleon in the gold atom oscillates in all directions within the spherical volume with the amplitude limited by this radius.

In the case of a neutron flux, experiments confirm, with a certain degree of approximation, the following equality:

$$\sigma_{tot} = A_r^{2/3}\sigma_n. \tag{27}$$

The latter is also consistent with the scattering theory based on the WM.

4. Conclusion

Rutherford's supposition that the scattering site of α- and β-particle on substance is a positively charged small single atomic nucleus, where practically all nucleons of an atom are concentrated (therefrom, an unbelievably high density of the nucleus, $10^{14}\ g\cdot cm^{-3}$ above), is not convincing and, in all appearances, erroneous.

In accordance with the Wave Model, within which it were discovered the origin of mass, the nature electric charge, and the shell-nodal structure of atoms, *superdense nuclei* in the centers of the atoms *do not exist*. Naturally therefore, in view of the above discoveries, that the modern scattering theory of particles and waves in matter has been subjected to reconsideration. This was carried out by the authors of the aforementioned discoveries.

As can be seen, the derivation of the formula (23) of the *effective section of scattering per atom* (having the shell-nodal structure) has been done simply enough and logically

perfect. The data that were obtained within the scattering theory presented above, using the notions of the WM, turned out to be well-agreed with the experiment. This confirms, along with other arguments discussed in our Lectures, the rightfulness of the *wave concept* on the origin of atoms, which *excludes in principle* an existence of a superdense nucleus in their centers.

A nucleon is a wave pulsating spherical microformation of space (like all elementary particles, in accordance with the DM), therefore its rest mass does not exist. The conventional mass of a particle, as we perceive it physically, has the *associated* (dynamic) character. The center of associated mass of a nucleon performs continuous radial oscillations in all spatial directions within the solid angle with the amplitude of the order $1.4\times10^{-13}\,cm$ and a frequency of $1.8\times10^{18}\,s^{-1}$.

As a result, in the center of a nucleon, it is distinguished a small dynamic spherical space, covering a volume limited by the radius equal to the aforementioned amplitude of the oscillations. Just this dynamic spatial volume can be considered solely, judging by the results, as a scattering site of the nucleon (the *nucleon* sphere of scattering). New scattering theory presented above confirmed this supposition. Because all nucleons in an atom (of the molecule-like structure, according to the SNAM) are bound between themselves by strong interactions, the scattering on one nucleon occurs so as if the scattering were on the whole atom.

Thus, the data presented here as supplementary to numerous other data discussed in Lectures of Volume 5 and in References to them (as, *e.g.*, [2, 24-26]) confirm once more the conclusion to which the authors of the theories (DM and SNAM) of the Wave Model have come that the modern nuclear model of atomic structure is completely inadequate to reality. Accordingly, no doubt about it, sooner or later it will be replaced.

At the end, summarizing, it makes sense to remind some of the *main direct proofs*, which were obtained by the present author, testifying in favor of the nuclear-free shell-nodal atomic model (SNAM). They were the subject of discussion in the Lectures. Here they are:

1. Discovery of the *cause* that creates the condition to the natural process of the formation in Nature of the strictly *certain distances between atoms* in substance. This cause, as it turned out, is the *wave nature* of substances and the *wave nature of their interaction* on the atomic and subatomic levels realized at the *fundamental frequency* $\omega_e = 1.869162559\times10^{18}\,s^{-1}$, discovered within the DM. And, as an effect of the aforesaid discovery, the discovery of the *fundamental wave radius* $\lambda\!\!\!^{-}_e = \dfrac{c}{\omega_e} = 1.603886492\times10^{-8}\,cm$, double quantity of which, the fundamental wave diameter, $2\lambda\!\!\!^{-}_e \approx 3.2\times10^{-8}\,cm$, defines an average value of *lattice parameters* in crystals. The product of $\lambda\!\!\!^{-}_e$ with the roots of Bessel functions $z_{m,n}$, which are solutions of the radial part of the wave equation, defines the

distances r, $z_{m,n}\lambda\!\!\!^{-} = r$, between atomic nodes, filled with nucleons, in solids and liquids (crystals and molecules).

2. Discovery of unknown earlier information about the *shell-nodal structure* of the atoms contained, as it was found, in the three-dimensional *particular solutions* of the general wave equation (its spatial part, the Helmholtz equation, $\Delta\hat{\psi} + k^2\hat{\psi} = 0$) in spherical polar coordinates, where $\hat{\psi}(\rho,\theta,\varphi) = \hat{R}(\rho)\Theta(\theta)\hat{\Phi}(\varphi)$ and $\rho = kr$,.

3. Discovery of the wave shell-nodal structure of all possible *atomic isotopes* generalized in the Table of "*The complete set of the isotopes derived from the particular solutions of the wave equation*" (see Fig. 11 in Lecture 5 of Vol. 5).

4. Discovery of *crystallographic anisotropy* in a two-dimensional hexagonal lattice of unstrained pristine graphene.

5. Discovery of the fact that *characteristic angles of facets* in crystals of natural minerals are defined by the same particular solutions of the wave equation as the spatial angles of nodes in the wave shell-nodal structure of the atoms, that testified in favor of the *wave nature of natural minerals*.

6. Development of the *theory of scattering* of particles and waves on *nuclear-free* substances (*i.e.*, having the shell-nodal structure). Being conceptually and logically perfect, this theory leads to the results that completely agree to the experiment.

7. Derivation of *binding energy* of nucleons in deuterium, tritium, helium ${}^{4}_{2}He$, and carbon ${}^{12}_{6}C$ atoms, and interatomic bindings in molecules in the light of the shell-nodal structure of the atoms. This was realized with use of the *Universal Law of the Central Exchange*, discovered in the WM, as applied to the atomic and subatomic levels, $F_e = \omega_e^2 \dfrac{m_1 m_2}{4\pi\varepsilon_0 r^2}$, where ω_ε is the *fundamental frequency* of exchange, m_1 and m_2 are *associated masses* defined by the formula $m = \dfrac{4\pi r^3 \varepsilon_0 \varepsilon_r}{1 + k_e^2 r^2}$, $\varepsilon_0 = 1\, g \cdot cm^{-3}$ is the *absolute unit density*, $k = \dfrac{\omega_e}{c}$ is the wave number.

As the readers could see, we have not considered in our Lectures some of the "subjects" of the modern "zoo" formed in the pseudo-scientific framework of the Standard Model and placed in a nucleus, such as *quarks*, *gluons*, and other similar *fantastic essences*. We leave this for history. Our descendants will write dissertations and humorous essays, chuckling indulgently over the physicists of our time, which, instead of developing the science of Nature, have developed science fiction, reaching of the outstanding results in this field.

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