

ON NEW PHYSICAL REALITY (ON Ψ ETHER)¹

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It is shown that there exists a new physical reality — the Ψ ether. All the achievements of quantum mechanics and quantum field theory are due to the fact that both the theories include the influence of Ψ ether on the physical processes occurring in the Universe.

Physics of the 20th century was first of all the physics of Ψ ether.

Показано, что существует новая физическая реальность — Ψ -эфир. Все достижения квантовой механики и квантовой теории поля связаны с тем, что обе теории включают влияние Ψ -эфира на все физические процессы, проходящие во Вселенной.

Физика XX в. прежде всего была физикой Ψ -эфира.

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... When you follow any of our physics too far, you find that it always gets in some kind of trouble. . .

Feynman R., Leighton R., Sanders M. Feynman Lectures on Physics. V. II. P. 28-1. Reading, Massachusetts; Palo Alto; London: Addison–Wesley Publ. Comp. Inc., 1964.

... There are so many things about elementary particles that we still don't understand. . .

Ibid. P. 28-5.

As soon as the Einstein special theory of relativity was created, the existence of the Maxwell–Lorentz ether was no longer discussed. The world scientific community accepted Einstein's point of view: «There is no room for the ether in the special relativity». At school lessons and university courses of physics departments, children and students were taught during the 20th century that the Maxwell–Lorentz ether does not exist, and there exist only «fields» in vacuum. However, many physicists, including the world famous ones (Dirac, Schwinger), have not eliminated the possibility for ether to exist.

Dirac in the paper «The Evolution of the Physicist's Picture of Nature» [1] makes a series of critical remarks concerning modern physics. He considers that: 1) The requirement of four-dimensional symmetry of the world is not obligatory. «A few decades ago, it seemed quite certain that one had to express the whole of physics in four-dimensional form. But now it seems that four-dimensional symmetry is not of such overriding importance, since the

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description of nature sometimes gets simplified when one departs from it»; 2) «We are led to a theory that does not predict with certainty what is going to happen in the future but gives us information only about the probability of occurrence of various events. This giving up of determinacy has been a very controversial subject, and some people do not like it at all. Einstein in particular never liked it. Although Einstein was one of the great contributors to the development of quantum mechanics, he still was rather hostile to the form that quantum mechanics evolved into during his lifetime and that it still retains»; 3) «Everyone is agreed on the formalism. It works so well that nobody can afford to disagree with it. But still the picture that we are to set up behind this formalism is a subject of controversy»; 4) «The physics of the future, of course, cannot have the three quantities \hbar , e and c all as fundamental quantities. Only two of them can be fundamental, and the third must be derived from those two». In Dirac's opinion, the quantities e and c will remain fundamental quantities, and the quantity \hbar will be expressed via e and c ; 5) «I am inclined to suspect that the renormalization theory is something that will not survive in the future, and that the remarkable agreement between its results and experiment should be looked on as a fluke».

Further Dirac writes: «I might perhaps discuss some ideas I have had about how one can possibly attack some of these problems. None of these ideas has been worked out very far, and I do not have much hope for anyone of them. . . ».

I) «. . . One of these ideas is to introduce something corresponding to the luminiferous ether which was so popular among the physicists of the 19th century. . . When I talk about reintroducing the ether, I do not mean to go back to the picture of the ether that one had in the 19th century, but I do mean to introduce a new picture of the ether that will conform to our present ideas of quantum theory. . . »

II) «The picture I propose goes back to the idea of Faraday lines. . . We can suppose that the continuous distribution of Faraday lines of forces that we have in the classical picture is replaced by just a few discrete lines of force with no lines of force between them . . . We can picture the lines of force as strings. . . »

III) «I might mention a third picture with which I have been dealing lately. It involves departing from the picture of the electron as a point and thinking of it as a kind of sphere with a finite size. . . »

Schwinger also tries to revive the idea of the ether. As an epigraph to the paper «A Magnetic Model of Matter» [2], Schwinger takes a quotation from «Mathematical Principles of Natural Philosophy» by Newton: «And now we might add something concerning a certain most subtle spirit, which pervades and lies hid in all gross bodies». Schwinger assumes dual-charged particles as a basis of the magnetic model of matter. And, perhaps, Schwinger considered it possible to construct the Newton ether mentioned in the epigraph to his paper from «dyons» — elementary constituents of magnetic matter. This attempt by Schwinger demonstrates him being dissatisfied with the state of physical theory at his time.

How was the ether conceived at the end of the 19th century? A rather complete idea of it was given by Maxwell. He said [3]: «The vast interplanetary and interstellar regions will no longer be regarded as waste places in the Universe, which the Creator has not seen fit to fill with the symbols of the manifold order of His kingdom. We shall find them to be already full of this wonderful medium; so full that no human power can remove it from the smallest portion of space, or produce the slightest flaw in its infinite continuity. It extends unbroken from star to star; and when a molecule of hydrogen vibrates in the Dog-star, the medium receives the impulses of these vibrations; and after carrying them in its immense bosom for

three years, delivers them in due course, regular order, and full tale into the spectroscope of Mr. Huggins, at Tulse Hill.

But the medium has other functions and operations besides bearing light from man to man, and from world to world, and giving evidence of the absolute unity of the metric system of the Universe. Its minute parts may have rotatory as well as vibratory motions, and the axes of rotation form those lines of magnetic force which extend in unbroken continuity into regions which no eye has seen, and which, by their action on our magnets, are telling us in language not yet interpreted, what is going on in the hidden underworld from minute to minute and from century to century».

In the paper «Ether» [4], Maxwell wrote: «... Ether is a material substance of a more subtle kind than visible bodies, supposed to exist in those parts of space which are apparently empty... Newton himself, however, endeavored to account for gravitation by differences of pressure in an ether (see Art. Attraction*. V.III P.64); but he did not publish his theory, «because he was not able from experiment and observation to give a satisfactory account of this medium, and the manner of its operation in producing the chief phenomena of nature»... We therefore conclude that light is not a substance but a process going on in a substance, the process going on in the first portion of light being always the exact opposite of the process going on in the other at the same instant, so that when the two portions are combined no process goes on at all».

In the Maxwell opinion, the ether possesses elasticity, hardness, finite density, but it is different from the usual matter. The vibrations of light are transverse. «... We know that the ether transmits transverse vibrations to very great distances without sensible loss of energy by dissipation... If there is any motion of rotation, it must be a rotation of very small portions of the medium each about its own axis, so that the medium must be broken up into a number of molecular vortices...» [5].

So, according to Maxwell, «the unity of the metric system of the Universe» is inseparable from the idea of the ether he has introduced: the ether functions as a carrier of the electromagnetic field, and possibly, of the gravitational field, and light is not a substance but a process going on in a substance... and if there is any motion of rotation in the ether it must be a rotation of very small portions of the medium each about its own axis, so that the medium must be broken up into a number of molecular vortices.

However, the Michelson experiments (1881) and the Michelson–Morli experiments (1885–1887) (M; M–M) have shown that there is no «ether wind» when the Earth moves through the ether, and it turned out to be impossible to reveal the motion of the Earth through the ether with an accuracy up to terms V^2/c^2 , where V is the velocity of the Earth and c is the velocity of light. A poetic picture of the ether presented by Maxwell was either a failure or required a serious theoretical substantiation. In order to make the hypothesis of stationary ether be consistent with the negative result of the experiments (M; M–M), Fitzgerald and Lorentz put forward the hypothesis of contraction of bodies in the direction of their motion by a factor $\sqrt{1 - V^2/c^2}$.

In 1895 [6], Lorentz said that this hypothesis is not so strange if we assume that molecular forces are also transferred through the ether. The form and sizes of a solid body are ultimately conditioned by the strength of molecular interactions, so the sizes are changed in this case; therefore, from a theoretical point of view, there are no objections against this hypothesis.

In 1905, Poincare wrote that Lorentz considered it necessary to supplement his hypothesis so that the postulate of relativity hold valid also in the presence of other forces in addition

to magnetic ones. According to Lorentz, all the forces irrespective of their origin, owing to the Lorentz transformation (and, consequently, owing to translational motion), behave just in the same way as electromagnetic forces do. It turned out necessary to examine this hypothesis more carefully and to investigate which changes are introduced by it in the laws of gravity.

If propagation of the gravitational forces occurs with the velocity of light, this cannot be a result of any random circumstances, this should rather be conditioned by one of the functions of the ether, and then, there arises the problem of a deeper investigation of the nature of that function and to connect it with other properties of the ether [7].

Poincare also wrote that the Fitzgerald–Lorentz hypothesis seems strange at first sight. All we can say at present in favor of it is that it is an immediate expression of the Michelson experimental results if we determine distances by the time necessary for light to cover them.

It is impossible to get out of impression that the relativity principle is a universal law of the nature. We can never discover anything except for relative velocities. By this I mean not only the velocities of bodies with respect to the ether, but also the velocities of bodies with respect to each other [8].

In 1912, in the paper «Hypothesis of Quanta», Poincare wrote that none of experiments can reveal whether a body is at rest or in absolute motion with respect to the absolute space or with respect to the ether [9].

So, Newton, Faraday, Fizeau, Maxwell, Lorentz, Poincare, Planck, and others (I cannot cite all the names, of course) considered the ether to be a real substance in their studies.

Poincare proved the group properties of Lorentz transformations; Minkowski introduced the 4-dimensional space-time. In this way, there arose the relativistic representation of basic laws, Lagrangians, and equations of motion (and even the relativistic form of calculations) in modern theory. Relativity arose and was substantiated on the basis of existence of the ether.

The Einstein special theory of relativity disclaims the existence of the ether. In 1905, Einstein in the paper «On the Electrodynamics of Moving Bodies» wrote [10]: «... the unsuccessful attempts to discover any motion of the earth relative to the «light medium», suggest that the phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest. They suggest rather that, as has already been shown to the first order of small quantities, the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics hold good. (The preceding memoir by Lorentz was not at that time known to the author.) We will raise this conjecture (the purport of which will hereafter be called the «Principle of Relativity») to the status of a postulate, and also introduce another postulate, which is only apparently irreconcilable with the former, namely, that light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body. These two postulates suffice for the attainment of a simple and consistent theory of the electrodynamics of moving bodies based on Maxwell's theory for stationary bodies. The introduction of a «luminiferous ether» will prove to be superfluous inasmuch as the view here to be developed will not require an «absolutely stationary space» provided with special properties...»

It is appropriate to accompany this statement with the question: How can one construct the dynamics of moving bodies on the basis of the Maxwell theory for bodies at rest if in the special theory of relativity there is no definition of a body at rest?

At the same time, Einstein said that the absolute space in the Newton mechanics is just the ether and that only by introducing the conception of ether as absolute space, one can distinguish the uniform linear motion from the accelerated, rotational motion.

Then, one more question arises: The relativistic mechanics in the limit of small velocities reduces to the Newton mechanics. Which is the origin of the ether recognized by Einstein in the Newton theory if the special theory of relativity disclaims its existence?

Einstein said the influence of the ether in the Newton theory is included into the formulation of laws of the Newton dynamics, and therefore, the space according to Newton turned out to be absolute and empty. Analogous situation arose with including the ether into the second postulate of special relativity about constancy of the «velocity c which is independent of the state of motion of an emitting body», and the ether turned out to be unnecessary, and the space became empty.

It is to be stressed that Einstein was not an opponent of the ether. In his speech «Ether and Relativity Theory» at the Leiden University on May 5, 1920, on the occasion of his election as honorary Professor, he said that the recognition of the fact that the empty space is not uniform and isotropic in physical aspects forces us to describe its state with ten functions — gravitational potentials $q_{\mu\nu}$. However in doing so, the notion of the ether again acquires a definite content that is completely different from the content of the concept of the mechanical theory of light. The ether of general relativity is a medium that is deprived of all mechanical and kinematic properties, but at the same time, defines mechanical (and electromagnetic) processes. Also, he said that we know that it defines metric relations in the space-time continuum (see [11]).

So, we are faced with two points of view:

1) Lorentz and Poincaré think that the Lorentz transformations are an immediate expression of the Michelson experimental results if distances are defined by the time necessary for light to cover them. So, the Lorentz transformations reflect the properties of a medium in which light propagates and include the influence of the medium (ether) on physical properties occurring in the Universe.

2) In the special theory of relativity it is considered that there is no ether, but there is empty space, and that light in vacuum always propagates with a definite velocity c independent of the state of motion of an emitting body. As we see, this postulate of the special theory of relativity expresses in words the physical content of the Lorentz transformations published earlier.

From comparison of these points of view, it follows that the relativistic form of writing all the laws and equations of elementary particle physics can be considered, on the one hand, as a way of including the influence of the ether on physical processes occurring in microcosm, but, on the other hand, since the influence of the ether is taken into account in the process of relativization of formulae, it is as though the ether is absent, it does not exist, as the special theory of relativity states.

In this paper, I advocate the thesis that the ether as a physical reality does exist, show how the influence of the ether entered into formulae of quantum mechanics and quantum field theory, and construct a model of the real Ψ ether.

The model of the Ψ ether I proposed here satisfies modern requirements of quantum field theory, as was said by Dirac. *The Ψ ether is defined as the Bose–Einstein condensate of neutrino–antineutrino pairs of the Cooper type.*

How can one arrive at this definition? The Klein–Gordon relativistic equations for a scalar particle with mass m without interaction (or, as is written in books at present, in vacuum — emptiness) are of the form

$$\left(\hbar^2 \nabla^2 - \frac{\hbar^2}{c^2} \frac{\partial^2}{\partial t^2} - m^2 c^2 \right) \Psi(x, t) = 0,$$

where

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}, \quad \square \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} - \frac{\partial^2}{c^2 \partial t^2}.$$

The equation for a vector field for a particle with mass m is written in the same form, but $\Psi(x, t)$ is now a multicomponent function.

Since I assert that any relativistic equation for a free particle with mass m should be understood not as an equation in vacuum but as an equation for a particle with mass m in the ether, setting the mass m equal to zero, we obtain the simplest equation for the ether described by the scalar function $\Psi(x, t)$:

$$\left[\hbar^2 \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right) - \frac{\hbar^2}{c^2} \frac{\partial^2}{\partial t^2} \right] \Psi(x, t) = 0. \quad (1)$$

Hence, it is clear why I call my model of the ether the model of Ψ ether: first, in a language conventional for physicists, the ether is described by the $\Psi(x, t)$ function; second, as we will see below, the Ψ ether differs in its properties from the Lorentz–Maxwell ether, and it is necessary to supply it with a special name.

Consider the case of the electromagnetic field. We denote the strengths of electric and magnetic fields, respectively, by \mathbf{E} and \mathbf{H} [12]. If we introduce the vector \mathbf{A} and scalar φ potentials with the use of the relations

$$\begin{aligned} \mathbf{H} &= \text{rot } \mathbf{A}, \\ \mathbf{E} &= -\frac{1}{c} \frac{\partial \mathbf{A}}{\partial t} - \text{grad } \varphi, \end{aligned} \quad (2)$$

and make use of the Lorentz condition

$$\text{div } \mathbf{A} + \frac{1}{c} \frac{\partial \varphi}{\partial t} = 0, \quad (3)$$

then the potentials \mathbf{A} and φ , as is known, obey the equations

$$\begin{aligned} \square \mathbf{A} &= \nabla^2 \mathbf{A} - \frac{1}{c^2} \frac{\partial^2 \mathbf{A}}{\partial t^2} = 0, \\ \square \varphi &= \nabla^2 \varphi - \frac{1}{c^2} \frac{\partial^2 \varphi}{\partial t^2} = 0. \end{aligned} \quad (4)$$

In limits of the Lorentz gauge (3), the scalar potential can be taken zero. Then the charge-independent part of the potentials \mathbf{A} and φ is determined by the equation

$$\begin{aligned} \square \mathbf{A} &= 0, \quad \text{div } \mathbf{A} = 0, \quad \varphi = 0, \\ \mathbf{E} &= -\frac{1}{c} \frac{\partial \mathbf{A}}{\partial t}, \quad \mathbf{H} = \text{rot } \mathbf{A}. \end{aligned} \quad (5)$$

The system of equations (5) turns out to be completely equivalent to the Maxwell–Lorentz equations. In this case, the general solution of equations (5) is given by a superposition of transverse waves [12].

The vector \mathbf{A} and scalar φ potentials for a more symmetric representation can be combined into one four-dimensional vector Ψ_i . Then equations (4) are written in the form

$$\square\Psi_i(x, t) = 0. \quad (6)$$

I define these equations as equations for the real Ψ ether.

I would like to emphasize something unusual in the transition from the Maxwell equations to the equations for electromagnetic potentials \mathbf{A} and φ , i.e., to equation (6) for the Ψ ether.

No attention is paid in any textbook or monograph to the fact that, introducing auxiliary electromagnetic potentials \mathbf{A} and φ by formulae (2), we equate physical observables \mathbf{H} and \mathbf{E} to nonphysical auxiliary functions \mathbf{A} and φ . This is impermissible in physics! If one side of an equation contains a physical observable, the other should also contain a physical observable.

As a matter of fact, the potentials \mathbf{A} and φ in relation (2) describe a physical reality — it is the Ψ ether, and this physical reality is observable.

The Klein–Gordon operator can be represented as a product of two commuting matrix operators

$$I_{\alpha\beta}(\square - m^2) = \sum_{\delta} \left(i\gamma^n \frac{\partial}{\partial x_n} + m \right)_{\alpha\delta} \left(i\gamma^k \frac{\partial}{\partial x_k} - m \right)_{\delta\beta},$$

and in order that the field function obey the Klein–Gordon equation

$$(\square - m^2)\Psi = 0, \quad (a)$$

we can require that it satisfy also one of the first-order equations

$$\left(i\gamma^n \frac{\partial}{\partial x_n} + m \right) \Psi = 0 \quad \text{or} \quad \left(i\gamma^n \frac{\partial}{\partial x_n} - m \right) \Psi = 0. \quad (b)$$

Equations (b) are less general than equation (a), and though any solution of one of equations (b) satisfies equation (a), the reverse does not hold.

A common property of all solutions of the Klein–Gordon equation corresponding to single-valued representations of the Lorentz group is that the corresponding particles possess integer spins (0, 1, ...). Particles with a half-integer spin are described by a spinor representation [13]. Putting $m = 0$ in equations (b), we derive equations for the neutrino–antineutrino field. So, returning to relations (2) and (6), we can assert that the electromagnetic potentials are not merely auxiliary functions, but they are connected by definite relations with the physical reality — Ψ ether — by neutrino–antineutrino pairs.

The Ψ ether forms a superconducting medium filling the whole world space, does not manifest itself in the heat capacity of bodies, permits propagation of transverse waves (it is a carrier of electromagnetic waves) and of spinor and boson waves (it is their carrier), does not prevent the motion of elementary particles, nuclei, and cosmic bodies including stars in the world space. We are fairly aware of that the neutrino (a neutrino wave) penetrates the thicknesses of stars, the Sun, and the Earth without essential change of the direction

and energy losses. It can be assumed that the scalar component of the Ψ ether serves as a transmitter of gravitational forces. We can add to all the aforesaid that a continuous oscillating system is dynamically equivalent to a set of harmonic oscillators. There is the Weyl–Kurant theorem: If the wavelength is small as compared to linear sizes of an oscillating system, and limiting conditions are uniform, the frequency spectrum does not depend on a particular form of limiting conditions and on the shape of a cavity.

The model of Ψ ether as a continuous oscillating system obeys the conditions of the Weyl–Kurant theorem, and the Ψ ether can, in principle, be considered as a set of harmonic oscillators.

Now, let us point to an indissoluble connection of the Ψ ether with quantum mechanics.

Let us recall how the problem of a hydrogen atom is solved in quantum mechanics. When the potential energy $V(\mathbf{r})$ is time-independent and spherically symmetric, so that $V(\mathbf{r})$ depends only on the absolute value r of vector \mathbf{r} , the solution to the Schrödinger wave equation

$$-i\hbar \frac{\partial \Psi}{\partial t} = -\frac{\hbar^2}{2m} \nabla^2 \Psi + V(\mathbf{r}, t) \Psi \quad (7)$$

is derived by separating the variables

$$\Psi(\mathbf{r}, t) = u(\mathbf{r})f(t), \quad u(\mathbf{r}) = u(r, \theta, \varphi) = R(r)Y(\theta, \varphi). \quad (8)$$

Since the problem of a hydrogen atom is considered as the problem of two-body interaction (a proton and an electron) and is solved with the purpose to find stationary states with a constant value of energy E , so that $\Psi(x, t) = C \exp\left(-i\frac{Et}{\hbar}\right)$, where C is a normalization constant, for the functions $R(r)$ and $Y(\theta, \varphi)$ from Eq.(7) we derive the following equations [14]:

$$\frac{1}{\sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial Y}{\partial \theta} + \frac{1}{\sin^2 \theta} \frac{\partial^2 Y}{\partial \varphi^2} \right) + \lambda Y = 0, \quad (9)$$

$$\frac{1}{r^2} \frac{d}{dr} \left(r^2 \frac{dR}{dr} \right) + \left\{ \frac{2\mu}{\hbar^2} [E - V(r)] - \frac{\lambda}{r^2} \right\} R = 0, \quad (10)$$

where λ is the constant of separation of variables in the functions $R(r)$ and $Y(\theta, \varphi)$, μ is the reduced mass of the system of proton (p) + electron (e); E is the energy of a level for the bound state $p + e$ ($E < 0$), $V(r)$ is the potential energy of proton–electron interaction equal to e^2/r . Equation (9) is also solved by separating the variables

$$Y(\theta, \varphi) = \Theta(\theta)\Phi(\varphi),$$

as a result of which we arrive at the equations

$$\frac{\partial^2 \Phi(\varphi)}{\partial \varphi^2} + \nu \Phi(\varphi) = 0, \quad (11)$$

$$\frac{1}{\sin \theta} \frac{d}{d\theta} \left(\sin \theta \frac{\partial \Theta(\theta)}{\partial \theta} \right) + \left(\lambda - \frac{\nu}{\sin^2 \theta} \right) \Theta(\theta) = 0. \quad (12)$$

The solution for $\Phi(\varphi)$ is of the form

$$\Phi_m(\varphi) = \frac{1}{2\pi} e^{im\varphi}, \quad \nu = m^2$$

(the value of « m » can be any integer positive or negative number); and physically admissible solutions to the equation for the function $\Theta(\theta)$ are those that satisfy the conditions

$$\lambda = l(l+1), \quad |m| \leq l.$$

These solutions are expressed through the associated Legendre polynomials. In the end, the radial part $R(r)$ of the Schrödinger equation obeys the following equation:

$$\frac{1}{r^2} \frac{d}{dr} \left(r^2 \frac{dR}{dr} \right) + \frac{2\mu e^2}{\hbar^2 r} R(r) + \frac{2\mu}{\hbar^2} E R(r) - \frac{l(l+1)}{r^2} R = 0. \quad (13)$$

Here, I draw attention to one of the critical moments of quantum mechanics.

The radial equation (13) is one-dimensional in which the potential energy $V(r)$ is dependent on two parts:

$$V(r) = + \frac{2\mu e^2}{\hbar^2 r} - \frac{l(l+1)}{r^2}. \quad (14)$$

If the term $\sim e^2/r$ is responsible for the Coulomb interaction of a proton with an electron in a hydrogen atom, the second term $l(l+1)/r^2$ does not depend on any physical interaction. The latter term originates from angular variables of the wave function. Nevertheless, Schiff wrote: «The additional “potential energy” can be seen physically to be connected with the angular momentum» [14].

However, if one puts the Coulomb interaction e^2/r in the radial equation (13) to be zero, so that there is no interaction between a proton and an electron, the term $l(l+1)/r^2$ does not disappear, and it makes no sense to relate its origin with the angular momentum.

In fact, the term $l(l+1)/r^2$ appears in Eq. (13) because of its Ψ -ether origin. To verify this, let us turn to the theory of wave guides.

Let us consider the problem of finding the natural electromagnetic vibrations of a hollow sphere resonator [15].

For the Borgnis function $U(r, \theta, \varphi)$, we can write the equation

$$\frac{\partial^2 U}{\partial r^2} + \frac{1}{r^2 \sin \theta} \left[\frac{\partial}{\partial \theta} \sin \theta \frac{\partial U}{\partial \theta} + \frac{\partial}{\partial \varphi} \frac{1}{\sin \varphi} \frac{\partial U}{\partial \varphi} \right] + k^2 U = 0. \quad (15)$$

The Borgnis function is connected by definite relations with the electric \mathbf{E} and magnetic \mathbf{M} fields, and when it obeys Eq. (15), the Maxwell equations hold also valid. On the other hand, the function U is connected by definite relations with the potentials \mathbf{A} and φ , i.e., with the Ψ ether. Solution to Eq. (15) is derived like in quantum mechanics by the method of separation of variables:

$$U(r, \theta, \varphi) = F_1(r) F_2(\theta, \varphi).$$

(I keep the notation from the monograph by de Broglie deliberately.) The functions $F_1(r)$ and $F_2(\theta, \varphi)$ satisfy the equations

$$\frac{1}{\sin \theta} \frac{\partial}{\partial \theta} \sin \theta \frac{\partial F_2}{\partial \theta} + \frac{1}{\sin^2 \theta} \frac{\partial^2 F_2}{\partial \varphi^2} + \gamma F_2 = 0, \quad (16a)$$

$$r^2 \frac{\partial^2 F_1}{\partial r^2} + k^2 r^2 F_1 - \gamma F_1 = 0. \quad (16b)$$

In the problem, we consider electromagnetic waves harmonic in time and characterized either by the frequency ν

$$\nu = \frac{kc}{2\pi}$$

or by the wave vector

$$k = \frac{2\pi\nu}{c}, \quad [k] = 1/\text{cm}.$$

Equation (16b) contains the quantity k^2 , the quantity γ in Eq.(16a) — the constant of separation of variables.

Equation (16a) completely coincides with Eq. (9), and solutions of Eq. (16a) are spherical functions. The regular solution of Eq. (16b) for all Θ and φ exists only when $\gamma = n(n+1)$. Thus, equation (16b) assumes the form

$$\frac{d^2 F_1}{dr^2} + \left[k^2 - \frac{n(n+1)}{r^2} \right] F_1 = 0. \quad (17)$$

If we set $F_1(r) = r f(r)$, Eq.(17) is written in the form

$$\frac{d^2 f}{dr^2} + \frac{2}{r} \frac{df}{dr} + \left[k^2 - \frac{n(n+1)}{r^2} \right] f(r) = 0. \quad (18)$$

Upon simple computations, Eq. (13) from quantum mechanics can be written as follows:

$$\frac{d^2 R}{dr^2} + \frac{2}{r} \frac{dR}{dr} + \left(\frac{2\mu E}{\hbar^2} + \frac{2\mu e^2}{\hbar^2 r} - \frac{l(l+1)}{r^2} \right) R = 0. \quad (19)$$

If we put the term in (19) responsible for the Coulomb interaction of a proton with an electron ($= 2\mu e^2/\hbar^2 r$) equal to zero and replace E by $E = p^2/2\mu$, Eq.(19) is rewritten in the form

$$\begin{aligned} \frac{d^2 R}{dr^2} + \frac{2}{r} \frac{dR}{dr} + \left(k^2 - \frac{l(l+1)}{r^2} \right) R = 0 \\ \left(\frac{2\mu p^2}{2\mu \hbar^2} = \frac{k^2 \hbar^2}{\hbar^2} = k^2, \quad k — \text{wave vector} \right). \end{aligned} \quad (20)$$

Equations (18) and (20) are identical and are solved under the same boundary conditions: like in quantum mechanics, a solution to Eq. (18) is sought for $f(r)$ such that $f(r)$ is a finite function as $r \rightarrow 0$, and when $r \rightarrow \infty$ the function $f(r) \rightarrow 0$ (on the boundary of a sphere). The corresponding solutions to Eq. (18) describe standing waves inside the sphere at values

$$n = 0, 1, 2, \dots, \quad m \leq n.$$

Since electromagnetic waves are nothing else than oscillations of the Ψ ether, the term $n(n+1)/r^2$ in Eq. (18) is responsible for standing waves of the Ψ ether in a sphere resonator.

Thus, we conclude that the problem of finding the energy levels in a hydrogen atom with the use of the Schrödinger equation is in physical content equivalent to the problem of finding natural electromagnetic oscillations inside a sphere resonator; one of the basic postulates of quantum mechanics — quantization of orbits in a hydrogen atom (the Bohr

postulate $mvr = nh/2\pi$) — is equivalent to the determination of conditions for existence of standing waves of the Ψ ether in a sphere resonator.

We see that quantum mechanics is equivalent to «mechanics» of the Ψ ether. The equation for the Ψ ether is directly connected with the Maxwell equations. The relativistic form of the equation for Ψ ether is in all the equations of elementary particle physics and in all the Lagrangians of quantum field theory. So, the physics of the 20th century has been physics of the Ψ ether. The genius of Maxwell anticipated almost all properties of the ether but that the ether consists of neutrino–antineutrino pairs ($\nu\bar{\nu}$ pairs). However, we know that the neutrino was discovered experimentally only in 1953–1956 by Raines and Coen. Especially surprising is the Maxwell genius prevision in the following aspects:

1) Smallest parts of this medium can have not only oscillatory motions but also rotational ones, the axes of rotation being the corresponding magnetic lines of force. If there exists the rotational motion, it should be the rotation of very small parts of the medium, each around its own axis, so that the medium should disintegrate into a great number of molecular vortices. At present, we know that the neutrino has spin $\hbar/2$, so that the Maxwell prediction is justified.

2) «. . . We therefore conclude that light is not a substance but a process going on in a substance, the process going on in the first portion of light being always the exact opposite of the process going on in the other at the same instant, so that when the two portions are combined no process goes on at all». Indeed, the decay of a « Ψ -ether molecule» consisting of a Cooper $\nu\bar{\nu}$ pair in the simplest case completely corresponds to the Maxwell description in which, instead of light, one should mean physical properties of the $\nu\bar{\nu}$ pair.

Schwinger in paper [2] called the fundamental dual-charged particle introduced by him the «dyon». By analogy, I propose to call the neutrino–antineutrino pair the «psyon» and use it in what follows.

3) The Ψ ether, being a homogeneous medium, ensures the unity of measure and number in the Universe, which cannot be done by various fields of quantum field theory.

Now, we need not develop the picture of the world constructed in the framework of the Standard Model. We construct another picture of the world. The whole visible known Universe is immersed in the all-embracing and all-penetrating Ψ ether and lives, and develops according to its laws. The Ψ ether is an abyss in which the known physical world negligible as compared to the ether is immersed. Which are the relations between these two worlds — our physical world and the Ψ ether — and which is the interaction between them are still open questions, to be solved in the new century or new millenium.

The world consisting of protons, electrons and neutrinos is stable; we see it and study it. In particular, we study the neutrino with the help of the neutron and unstable particles. We do not see the world composed only of neutrinos, but it can be supposed that it is infinite and diverse.

Until now, only a small part of the Ψ -ether properties is observed; in particular, they can be seen in the phenomena of superfluidity and superconductivity. The Ψ ether takes part in formation of all the chemical elements in the Universe, in production of all unstable elementary particles, in the formation and possibly spontaneous appearance of life on the Earth, brings back the energy, momentum, angular momentum that it obtains from our physical world — we do not observe violation of the conservation laws of these quantities. If the state of the ether surrounding us changes, then our physical world immersed in it should also change so as to remain in a certain «equilibrium» state with the ether. If parts, maybe giant, of the Ψ ether possess various energy states, and our Solar system can pass from one layer of the

Ψ ether to another, then in the vicinity of the Solar system including the Earth, there can occur dramatic phenomena of global rise or fall of temperature of the climate, which can result in the change of forms of life on the Earth, in heating or cooling the Earth itself, etc.

Restoration of the Ψ ether to its rights after its «expulsion» from physics in the special theory of relativity allows us to answer some critical question posed earlier by Einstein and de Broglie:

1. The dualism «wave–particle» vanishes. The function Ψ that describes, in modern language, a «free» particle is actually a wave function of the particle taking into account its motion through the ether; wave processes in the ether accompanying a moving particle determine «wave properties» of the particle, and when the particle collides, for instance, with a thin metallic film, they generate a diffraction pattern. It is not surprising that the probability of finding a particle (an electron, a proton, etc.) after a collision with a metallic film is defined by the square of the Ψ -ether wave function (i.e., $|\Psi(x, t)|^2$), by analogy with light whose intensity is given by the amplitude squared.

2. The very essence of all world processes is now defined by the Ψ -ether interaction. All electromagnetic processes are proportional to an integer value of the Planck constant \hbar , since an electromagnetic wave in the Ψ -ether theory is described by the vector component of the Ψ ether.

3. The plane-wave solution

$$\Psi \sim \exp \left[\frac{i}{\hbar} (Et - \mathbf{k}\mathbf{x}) \right]$$

should not be interpreted within the Born statistical approach, as was said in item 1. The particle remains localized in the wave, as de Broglie supposed, and thus, the principle of determinism is restored on which Einstein insisted. Theoretical physics returns to the possibility of the Einstein description of a single system rather than an artificial ensemble of single systems. De Broglie wrote that prominent scientists Planck, Einstein, and Schrödinger, who belong to founders and pioneers of quantum theory from the moment of its creation, always rejected the purely probabilistic interpretation that was subsequently acquired by quantum physics.

De Broglie said that he was disappointed with the reaction, to his theory, of other theoretical physicists seduced by the purely probabilistic interpretation of Born, Bohr, and Heisenberg, refused his attempt, and in subsequent years adhered to the generally accepted interpretation [16].

4. One more prediction by Einstein was realized: The Nature does not require our choice between quantum and wave theory, it only requires the synthesis of these theories, which is not yet achieved by physicists. In the proposed model of the Ψ ether this synthesis is obtained.

Acknowledgment of the Ψ ether allows a new look onto a series of physical phenomena in microcosm and astrophysics, extends the understanding of physical, chemical, and biological processes in the Nature, and points to some limits of our cognition.

1. The relict radiation can now be interpreted as age-long luminescence of a weakly excited world Ψ ether, or in other words, as eternal oscillations of psyons forming the ether.

2. Equations of the type $\square\Psi_i = 0$ (a) and $(\square - \mu^2)\varphi_i = 0$ (b) are today determining equations in elementary particle physics. It would be desirable to elucidate how the mass

of elementary particle arises. One of the answers can be found in the monograph by de Broglie «Electromagnetic Waves in Wave Guides and Hollow Resonators». He said that all the considered waves are characterized by the «propagation factor»

$$P = e^{i(kct - k_z t)}, \quad \text{where} \quad k^2 = k_z^2 + \alpha^2 \quad (\text{see formula 2.75 [17]}).$$

Every possible wave is characterized by one of the eigenvalues of constant α corresponding to the type of considered wave guides. The photon wave should correspond to $k = k_z$, i.e., to the propagation with velocity c . This corresponds to the propagation of an electromagnetic wave in vacuum. But if the electromagnetic wave is confined inside a wave guide, then k and k_z are connected by the relation (2.75) where α differs from zero and equals one of its eigenvalues corresponding to the form of the wave guide under consideration. From the point of view of wave mechanics, in this case, all occurs as if the photon had a proper mass determined by the form of a wave guide and a given eigenvalue α_i . So, it can be said that in a given wave guide, the photon can possess a number of possible proper masses [17].

Thus, if we assume that in the process of collision of protons and electrons with other protons and electrons, in an excited ether, there arise «wave guide» conditions of propagation of the Ψ -ether waves, then under certain conditions, there appears the whole spectrum of masses of unstable particles. The particles will consist only of protons, electrons, and neutrinos — there are no other constituents in the Nature. It is not surprising (this is an experimental fact!) that all the unstable particles and resonances detected till now decay only into protons, electrons, and neutrinos (and their antiparticles). It is natural that all the «wave guide» particles can be classified according to the parameters of Ψ -ether wave guides. A great number of elementary particles are no longer exotic and become a trivial consequence of the properties of the Ψ ether. This notion of the origin of the mass spectrum of elementary particles and resonances suggests that, first, their number can be arbitrarily large, much larger than the number discovered until now, and, second, their search can hardly be of the scientific interest that is attached to it at present in connection with the ideology of the Standard Model (this naturally concerns the search of the Higgs boson).

We have considered one of the possible models of origin of masses of elementary particles. It seems that it is difficult to explain in this way the process of production of pairs of particles e^+e^- , $p\bar{p}$ and all other pairs of fermions that occurs in processes of multiparticle production, though the nature of psyons consisting of $\nu\bar{\nu}$ pairs suggests to relate their decay with the production of e^+e^- , $p\bar{p}$ pairs and others.

Clearly, the origin of symmetries in the world of elementary particles (for instance, $SU(3)$ symmetries) is also determined by the symmetry properties of the Ψ ether. Establishment of the $SU(3)$ symmetry was not simple. I recall that in the fifties, when the mass of the Λ^0 particle was thoroughly measured, experimenters assured that there exist two values rather than one of the Λ^0 -particle mass; i.e., it was assumed that there exist two different Λ^0 particles, which was inconsistent with the $SU(3)$ symmetry model.

People told of the so-called «Eastern–Western effect». However, theorists who believed in «sanctity» of $SU(3)$ symmetry insisted upon the fact that there should be only one Λ^0 particle. Nevertheless, in booklets «Review of Particle Properties» (especially in earlier publications), one can clearly see a double-humped curve for the measured mass of the Λ^0 particle.

The KARMEN collaboration published data [18] which were interpreted by Gninenko and Krasnikov [19] as the presence of two different modes of the μ^+ -meson decay:

the conventional mode

$$\mu^+ \rightarrow e^+ + \tilde{\nu}_e + \nu_\mu$$

and an additional rarely encountered mode $\mu^+ \rightarrow e^+ + X$, where X is a new boson with mass $103.9 \text{ MeV}/c^2$.

In the Ψ -ether model, these two decay modes can be explained in a natural way. Representing spins of μ , e and ν by arrows, we can show the following two schemes of the μ^+ structure:

$$\begin{array}{ccccccc} \uparrow & \rightarrow & \uparrow & + & \uparrow\downarrow & \text{or} & \uparrow & \rightarrow & \downarrow & + & \uparrow\uparrow \\ \mu^+ & & e^+ & & \nu_\mu\tilde{\nu}_e & & \mu^+ & & e^+ & & \nu_\mu\tilde{\nu}_e \\ & & & & \text{(a)} & & & & & & \text{(b)} \end{array}$$

In the scheme (a), the helicities of ν_μ and $\tilde{\nu}_e$ coincide, and the pair $\nu_\mu\tilde{\nu}_e$ forms a more stable system with a possible more delayed decay $\tau_\mu \sim 3.6 \mu\text{s}$ than in the scheme (b), in which ν_μ and $\tilde{\nu}_e$ have opposite helicities, and the pair $\nu_\mu\tilde{\nu}_e$ decays more rapidly with the lifetime of a three-body decay of μ^+ meson $\tau_\mu \sim 2.6 \mu\text{s}$. This is only qualitative considerations, and they can be used for a qualitative analysis of the schemes of production and decay of other unstable particles.

From this example it is seen that from the standpoint of the Ψ -ether model, modern ideas of the structure components of matter should look different than is postulated in the Standard Model.

In the Standard Model, structure components of matter are families of quarks and leptons (fermions):

$$\begin{pmatrix} u \\ d \end{pmatrix} \begin{pmatrix} c \\ s \end{pmatrix} \begin{pmatrix} t \\ b \end{pmatrix} \begin{pmatrix} e \\ \nu_e \end{pmatrix} \begin{pmatrix} \mu \\ \nu_\mu \end{pmatrix} \begin{pmatrix} \tau \\ \nu_\tau \end{pmatrix}.$$

Interaction carriers are bosons: gluons, γ quanta, W and Z^0 bosons.

The «pressure» of theoretical physicists on the development of modern elementary particle physics turned out to be so large, and the admiration for the statement: «To be correct, a theory should be slightly mad» appeared to be so great that the physical interpretation of phenomena within the framework of the Standard Model went far beyond the limits of natural understanding of the observed phenomena. Elementary particle physics becomes more and more a hostage of mathematics. It is sufficient to point to the fact that quarks «nonobservable in essence» and rapidly decaying μ and τ leptons are, on equal status with stable electrons and neutrinos, elevated to the class of structure components of matter. Is this really that «mad spot» of the standard theory which we intend to raise to the rank of «theory» after the discovery of the Higgs boson?

As one of the most important properties of the Ψ ether, we point out the limits of validity of relativization of all formulae and calculations in modern physics following from the structure of Ψ ether. The principle of relativization is essentially connected with the wave properties of the Ψ ether. Where the wave properties of the Ψ ether come to an end, there end electromagnetic waves, and this puts an end to our comprehension of secrets of the Universe with the help of optical instruments and radiotelescopes. The length of electromagnetic waves in the Ψ ether is limited from the side of both short and long waves.

From the side of short wavelengths, this limitation sets in when the «mean free path» of psyons becomes smaller than the distance between psyons. So, the density of psyons in 1 cm^3

becomes decisive in the determination of this critical limit. This density also determines the reliability of information accepted and transferred by the Ψ ether. If two or more impulses come to a psyon, the gained information will be distorted in further transmission.

From the side of large wavelengths, the limitations of relativization set in when large wavelengths of the Ψ ether lose their wave configuration, becoming a chaotic motion of huge masses of the Ψ ether («noises»).

So, where the wave properties of the Ψ ether come to an end, there ends our cognition of secrets of the Universe through the electromagnetic interaction. Man becomes blind and deaf. Evidently, there exist phenomena whose description requires studies of the microscopic properties of constituents of the Ψ ether, psyons.

It is not clear which are the velocities of propagation of signals in the Ψ ether. If psyons can be arranged as strings, lattices, pyramidal formations, cubes and parallelepipeds and so on and in the form of long chains, the velocities of propagation of perturbations in them can be both larger and smaller than the velocity of light. It is known that a neutrino signal from the Supernova 1987 A came to the Earth several hours earlier than the signal of light. In «Physics Today» (April 1999. P. 9 and July 1999. P. 17–18), it was reported that the velocity of the light impulse passing through the Bose–Einstein condensate lowers down to 17 m/s, which is millions of times lower than the light velocity in the ether. This slowing down of the velocity of a light impulse can be produced not only by possible optical effects but also by effects of the change of the ether structure in the experiments.

The above-assumed forms of combinations of neutrinos and antineutrinos in various geometrical forms do not go beyond the scope of 3-dimensional space. We will assume this picture of the space surrounding us.

Any changes of the state of the Ψ ether in the Universe reach the Earth, and consequently, the man from the moment of his conception up to his death. Such sentences as «a man was born under the Jupiter star», or «yesterday I had a dream, but today...», or «I foresaw this...» can now be substantiated not only psychologically, but also physically. It becomes obvious that in the Nature, there can exist physical objects which cannot be detected with the help of our five organs of sense, no matter how we strengthen them. The man is a child of the Nature immersed into the Ψ ether, and it seems that he should possess the possibilities, yet not discovered by science, of detecting the ether oscillations and of their analysis. But it is very likely that the man is not perfect. Then, science is faced with an honored responsibility to render assistance in the discovery of new possibilities of the man up to his more full merging with the Universe surrounding him.

Of course, in this way, the road opens towards occultism. But we should temporarily reconcile ourselves to this, till scientific knowledge of the Ψ -ether properties establishes new data on the man's nature.

So, I assert that the Ψ ether does exist! Further negation of it will only hamper the development of physical, chemical, biological, and philosophical knowledge.

To summarize:

1. A historical review of the problem is given, from which it follows that the Ψ ether exists and its elimination from physical reality is impossible, since without it, one cannot introduce the unity of measure and number in the Universe, cannot physically substantiate the term $l(l+1)/r$ in the radial part of the equation in the problem of a hydrogen atom, and cannot physically explain the necessary requirement of invariance of the equations of

the Maxwell classical electrodynamics and equations of modern quantum field theory under the Lorentz transformations. Just as the Galilei transformations (the Galilei principle of relativity) are based on experimental data, so the Lorentz transformations are based on the Michelson–Morly experimental data.

2. The model of Ψ ether is defined as the Bose–Einstein condensate of neutrino–antineutrino pairs of the Cooper type; the physical grounds for the model are given. The equation for the state of Ψ ether as a continuous medium is of the form

$$\square\Psi_i = 0,$$

where Ψ_i is a 4-dimensional vector.

The model provides propagation of transverse electromagnetic waves in the Ψ ether and waves of other types. It is not obligatory that the velocities of propagation of different waves of the Ψ ether would all be equal to the light velocity.

A list of some properties of the Ψ ether is presented.

3. The limit of applicability of equations of classical and quantum electrodynamics is formulated. These equations are valid as long as the Ψ ether is considered as a continuous medium where oscillations of the Ψ ether can propagate. However, when the wavelength of the Ψ ether becomes comparable with or smaller than sizes of the psyon, a molecule of the Ψ ether, or when in the region of long wavelengths, a wave-shaped character of motions of the Ψ ether is broken and transforms into a chaotic motion of its large masses, the formation of electromagnetic waves ceased, the man stops to register them with the optical instruments and radio installations. The man does not «hear» the full voice of the Universe, becomes «blind» and «deaf» in the Universe.

4. The contribution of the Ψ ether can be detected, in particular, in precision measurements of masses and lifetimes of a number of unstable particles (hyperons, muons, pions, and other mesons) aimed at searching for the «exact structure» of masses and lifetimes of those particles. These experiments could shed new light upon the composition of particles from protons, electrons, and neutrinos (and the corresponding antiparticles) into which unstable particles ultimately decay. In this connection, the confirmation of data obtained by the KARMEN collaboration is important.

5. The next step in cognition of secrets of the Universe and the secret of life on the Earth is to study the properties of the Ψ ether and its constituents, psyons. This is evidently a task of the physics of the 21st century.

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