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Wave and particle – from dualism to unity

Examples are given when a macroscopic object manifests itself both as a wave and as a tangible object. It is proven that elementary particles are both waves and particles at the same time, and not alternately. This proof is obtained as new solutions to Maxwell's equations. The proof is not comprehensive - only cubic, spherical and disk particles are considered. This publication is a review and addition to already published articles and books.

Content

1. Introduction

In quantum physics, there are postulates that relate only to phenomena and objects of the microworld and cannot be applied in the world of macroobjects.

And this approach gave brilliant results (we will not list them).

We will focus on only one (but the main one for distinguishing quantum physics from classical) postulate, which declares the existence of corpuscular-wave duality, properties of nature, consisting in the fact that material microscopic objects can, under some conditions, exhibit the properties of classical waves, and under others, the properties of classical particles. Just in case, it was announced that this property is also inherent in large objects, only it is invisible to them.

But then macroscopic ball lightning was discovered [11, 12, 13, 14], which passes through the glass like an electromagnetic wave, and a stationary and solid wave of water appears [20], on which ships are broken. There are many things in the world that sages never dreamed of am! We have to admit that corpucular-wave dualism is a property of all physical objects. And the philosophical principle of duality will not help in understanding this property, because we are no longer in the magical world of micro-objects, where we can hope for the help of postulated spells.

Any physical object can manifest itself both as a wave and as a tangible object. And this fact requires explanation (despite the successes of quantum physics).

Below we will prove that particles are both waves and particles at the same time, and not alternately. The particle is a "wave-AND-particle", not a "wave-OR-particle". In what follows, we will use the abbreviation WAP for wave-AND-particle.

This proof will be obtained as new solutions to Maxwell's equations [1]. The proof will not be comprehensive: we will only consider the cubic particle, the spherical particle, and the disk particle. This publication is a review and addition to already published articles.

The very idea that such a model should exist is not new. Etkin in [7] reviews a brief history of this idea. In 1900, the famous physicist and astronomer J. Jeans argued that “in nature there are waves and only waves: closed waves, which we call matter, and open waves, which we call radiation or light” [8]. E. Schrödinger held the same views until the end of his life, who wrote: “what we now take for particles are actually waves” [9]. And the author of the concept of “wave-particle” dualism, de Broglie, initially also proceeded from the fact that “the waves described by quantum mechanics are the system itself” [10].

2. Cubic WAP [2].

2.1. Mathematical model of cubic WAP

Consider some volume V with magnetic permeabilityμ and dielectric ε constant. Let, as a result of some influence, an electromagnetic wave with energy W_o arise in this volume. There is no heat loss in volume V and there is no radiation from it. After some time, the wave parameters will take on stationary values, determined by the values μ, ε, W_o and volume size. These parameters are the electric field strength and the magnetic field strength as a function of Cartesian coordinates and time, i.e. $E(x, y, z, t)$ and $H(x, y, z, t)$. Naturally, they satisfy the system of Maxwell equations of the form

$$\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z} - \varepsilon\frac{\partial E_x}{\partial t} = 0, \quad (1)$$

$$\frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x} - \varepsilon\frac{\partial E_y}{\partial t} = 0, \quad (2)$$

$$\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} - \varepsilon\frac{\partial E_z}{\partial t} = 0, \quad (3)$$

$$\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z} + \mu\frac{\partial H_x}{\partial t} = 0, \quad (4)$$

$$\frac{\partial E_x}{\partial z} - \frac{\partial E_z}{\partial x} + \mu\frac{\partial H_y}{\partial t} = 0, \quad (5)$$

$$\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y} + \mu\frac{\partial H_z}{\partial t} = 0, \quad (6)$$

$$\frac{\partial E_x}{\partial x} + \frac{\partial E_y}{\partial y} + \frac{\partial E_z}{\partial z} = 0, \quad (7)$$

$$\frac{\partial H_x}{\partial x} + \frac{\partial H_y}{\partial y} + \frac{\partial H_z}{\partial z} = 0. \quad (8)$$

Consider the following functions (proposed in [3]) that satisfy this system of equations:

$$E_x(x, y, z, t) = e_x\cos(\alpha x)\sin(\beta y)\sin(\gamma z)\sin(\omega t), \quad (9)$$

$$E_y(x, y, z, t) = e_y\sin(\alpha x)\cos(\beta y)\sin(\gamma z)\sin(\omega t), \quad (10)$$

$$E_z(x, y, z, t) = e_z\sin(\alpha x)\sin(\beta y)\cos(\gamma z)\sin(\omega t), \quad (11)$$

$$H_x(x, y, z, t) = h_x\sin(\alpha x)\cos(\beta y)\cos(\gamma z)\cos(\omega t), \quad (12)$$

$$H_y(x, y, z, t) = h_y\cos(\alpha x)\sin(\beta y)\cos(\gamma z)\cos(\omega t), \quad (13)$$

$$H_z(x, y, z, t) = h_z\cos(\alpha x)\cos(\beta y)\sin(\gamma z)\cos(\omega t), \quad (14)$$

where$e_x, e_y, e_z, h_x, h_y, h_z$- constant amplitudes of functions, - constants. Differentiating (9-14) and substituting the result into (1-8), after reducing the common factors, we obtain:$\alpha, \quad \beta, \quad \lambda, \quad \omega$

$$h_z\beta - h_y\gamma + e_x\varepsilon\omega = 0, \quad (15)$$

$$h_x\gamma - h_z\alpha + e_y\varepsilon\omega = 0, \quad (16)$$

$$h_y\alpha - h_x\beta + e_z\varepsilon\omega = 0, \quad (17)$$

$$e_z\beta - e_y\gamma - h_x\mu\omega = 0, \quad (18)$$

$$e_x\gamma - e_z\alpha - h_y\mu\omega = 0, \quad (19)$$

$$e_y\alpha - e_x\beta - h_z\mu\omega = 0, \quad (20)$$

$$e_x\alpha + e_y\beta + e_z\gamma = 0, \quad (21)$$

$$h_x\alpha + h_y\beta + h_z\gamma = 0. \quad (22)$$

Let us consider the solution to the resulting system of equations found in [4]. Since the system is symmetric, we accept

$$\alpha = \beta = \lambda. \quad (23)$$

In this case, the system of equations (15-22) takes the form:

$$h_z - h_y + e_x\varepsilon\omega/\alpha = 0, \quad (24)$$

$$h_x - h_z + e_y\varepsilon\omega/\alpha = 0, \quad (25)$$

$$h_y - h_x + e_z\varepsilon\omega/\alpha = 0, \quad (26)$$

$$e_z - e_y - h_x\mu\omega/\alpha = 0, \quad (27)$$

$$e_x - e_z - h_y\mu\omega/\alpha = 0, \quad (28)$$

$$e_y - e_x - h_z\mu\omega/\alpha = 0, \quad (29)$$

$$e_x + e_y + e_z = 0, \quad (30)$$

$$h_x + h_y + h_z = 0. \quad (31)$$

In the system of equations (24-31), equations (30, 31) follow directly from the previous ones. Indeed, adding equations (27-29), we get (31), and adding (24-26), we get (30). The first 6 equations in the system (24-31) with 6 unknowns are independent and from them the amplitudes of the functions $e_x, e_y, e_z, h_x, h_y, h_z$ can be found. We will look for a solution to system (24-29) at

$$h_z = 0. \quad (32)$$

In this case we find:

$$h_y = -h_x, \tag{33}$$
$$e_x = -\frac{h_x\alpha}{\varepsilon\omega}, \tag{34}$$
$$e_y = e_x, \tag{35}$$
$$e_z = -2e_x, \tag{36}$$
$$e_x = -\frac{h_x\mu\omega}{3\alpha}. \tag{37}$$

From (34, 37) we find:

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{3}}. \tag{38}$$

From (34, 38) we find:

$$e_x = -\frac{h_x}{\varepsilon\omega}\omega\sqrt{\frac{\mu\varepsilon}{3}} = -h_x\sqrt{\frac{\mu}{3\varepsilon}}, \tag{39}$$

or

$$h_x = -e_x\sqrt{\frac{3\varepsilon}{\mu}}. \tag{40}$$

2.2. Energy WAP

Let us write the tensions (9-14) in the form

$$E = \begin{bmatrix} E_x(x,y,z,t) \\ E_y(x,y,z,t) \\ E_z(x,y,z,t) \end{bmatrix} = \begin{bmatrix} e_x \\ e_y \\ e_z \end{bmatrix} \begin{bmatrix} \cos(\alpha x)\sin(\beta y)\sin(\gamma z) \\ \sin(\alpha x)\cos(\beta y)\sin(\gamma z) \\ \sin(\alpha x)\sin(\beta y)\cos(\gamma z) \end{bmatrix} \sin(\omega t), \tag{41}$$

$$H = \begin{bmatrix} H_x(x,y,z,t) \\ H_y(x,y,z,t) \\ H_z(x,y,z,t) \end{bmatrix} = \begin{bmatrix} h_x \\ h_y \\ h_z \end{bmatrix} \begin{bmatrix} \sin(\alpha x)\cos(\beta y)\cos(\gamma z) \\ \cos(\alpha x)\sin(\beta y)\cos(\gamma z) \\ \cos(\alpha x)\cos(\beta y)\sin(\gamma z) \end{bmatrix} \cos(\omega t). \tag{42}$$

Let us denote the time-independent parts of these expressions:

$$\breve{E} = \begin{bmatrix} \breve{E}_x(x,y,z) \\ \breve{E}_y(x,y,z) \\ \breve{E}_z(x,y,z) \end{bmatrix} = \begin{bmatrix} e_x \\ e_y \\ e_z \end{bmatrix} \begin{bmatrix} \cos(\alpha x)\sin(\beta y)\sin(\gamma z) \\ \sin(\alpha x)\cos(\beta y)\sin(\gamma z) \\ \sin(\alpha x)\sin(\beta y)\cos(\gamma z) \end{bmatrix}, \tag{43}$$

$$\breve{H} = \begin{bmatrix} \breve{H}_x(x,y,z) \\ \breve{H}_y(x,y,z) \\ \breve{H}_z(x,y,z) \end{bmatrix} = \begin{bmatrix} h_x \\ h_y \\ h_z \end{bmatrix} \begin{bmatrix} \sin(\alpha x)\cos(\beta y)\cos(\gamma z) \\ \cos(\alpha x)\sin(\beta y)\cos(\gamma z) \\ \cos(\alpha x)\cos(\beta y)\sin(\gamma z) \end{bmatrix}. \tag{44}$$

Let us now find the squared modulus of the total tensions:

$$E^2 = \left(E_x^2 + E_y^2 + E_z^2\right), \tag{45}$$
$$H^2 = \left(H_x^2 + H_y^2 + H_z^2\right). \tag{46}$$

From (45-46) we find:

$$E^2 = \left(\left(\breve{E}_x^2 + \breve{E}_y^2 + \breve{E}_z^2\right)\sin^2(\omega t)\right), \tag{49}$$
$$H^2 = \left(\left(\breve{H}_x^2 + \breve{H}_y^2 + \breve{H}_z^2\right)\cos^2(\omega t)\right). \tag{50}$$

Let's denote:

$$|E^2| = \left(\breve{E}_x^2 + \breve{E}_y^2 + \breve{E}_z^2\right), \tag{51}$$
$$|H^2| = \left(\breve{H}_x^2 + \breve{H}_y^2 + \breve{H}_z^2\right)/ \tag{52}$$

Then we get:

$$E^2 = (|E^2|\sin^2(\omega t)), \tag{53}$$
$$H^2 = (|H^2|\cos^2(\omega t)). \tag{54}$$

Let us find $|E^2|$ and $|H^2|$. First of all, we will show that there exists a parallelepiped in which the total energy remains constant in time. Let the segments OA and OB on the oz axis have equal length Z, which meets the condition.

$$\frac{\alpha\cdot Z}{2\pi} = m,. \tag{55}$$

where m is integer. Obviously, the condition is satisfied

$$\int_z \cos^2(\alpha z)dz = \int_z \sin^2(\alpha z)dz = m\pi. \tag{56}$$

Let us consider a volume in which conditions similar to (55, 56) are satisfied along any coordinate, and we will call such a volume a agreed volume. Let's find the value of the agreed volume. From (55) we find the length from the coordinates:

$$2Z = 2\pi m_z/\alpha,\ 2X = 2\pi m_x/\alpha\ ,\ 2Y = 2\pi m_y/\alpha. \tag{57}$$

Then the total agreed volume

$$V = 8XYZ = 8m_x m_z m_y \pi^3/\alpha^3, \tag{58}$$

and the minimum agreed volume

$$V = 8\pi^3/\alpha^3 \tag{59}$$

or, taking into account (38),

$$V = 8\pi^3 \left(\frac{3}{\mu\varepsilon}\right)^{1.5}/\omega^3. \tag{60}$$

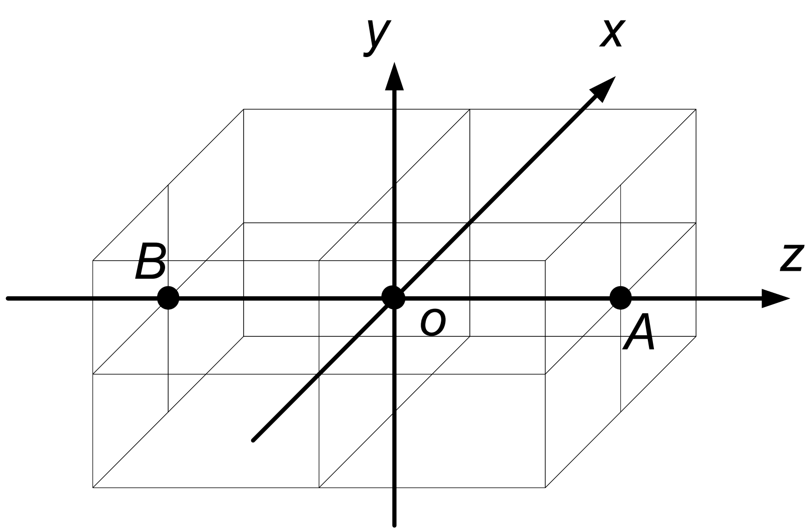

Fig. 1.

Let us write expressions (43, 44) using the solution obtained above (32, 33, 35, 40):

$$\breve{E} = \begin{bmatrix} \breve{E}_x(x,y,z) \\ \breve{E}_y(x,y,z) \\ \breve{E}_z(x,y,z) \end{bmatrix} = e_x \hat{E} \begin{bmatrix} 1 \\ 1 \\ -2 \end{bmatrix}, \tag{61}$$

$$\breve{H} = \begin{bmatrix} \breve{H}_x(x,y,z) \\ \breve{H}_y(x,y,z) \\ \breve{H}_z(x,y,z) \end{bmatrix} = e_x \sqrt{\frac{3\varepsilon}{\mu}} \hat{H} \begin{bmatrix} -1 \\ 1 \\ 0 \end{bmatrix}, \tag{62}$$

where

$$\hat{E} = \begin{bmatrix} \hat{E}_x(x,y,z) \\ \hat{E}_y(x,y,z) \\ \hat{E}_z(x,y,z) \end{bmatrix} = \begin{bmatrix} \cos(\alpha x)\sin(\beta y)\sin(\gamma z) \\ \sin(\alpha x)\cos(\beta y)\sin(\gamma z) \\ \sin(\alpha x)\sin(\beta y)\cos(\gamma z) \end{bmatrix}, \tag{63}$$

$$\hat{H} = \begin{bmatrix} \hat{H}_x(x,y,z) \\ \hat{H}_y(x,y,z) \\ \hat{H}_z(x,y,z) \end{bmatrix} = \begin{bmatrix} \sin(\alpha x)\cos(\beta y)\cos(\gamma z) \\ \cos(\alpha x)\sin(\beta y)\cos(\gamma z) \\ \cos(\alpha x)\cos(\beta y)\sin(\gamma z) \end{bmatrix} \tag{64}$$

From (51, 61, 63) we obtain:

$$|E^2| = \left(\breve{E}_x^2 + \breve{E}_y^2 + \breve{E}_z^2\right) = e_x^2 \left(\hat{E} \begin{bmatrix} 1 \\ 1 \\ -2 \end{bmatrix}\right)^2 = e_x^2 \hat{E}^2 \begin{bmatrix} 1 \\ 1 \\ 4 \end{bmatrix} = e_x^2 \begin{bmatrix} \cos(\alpha x)\sin(\beta y)\sin(\gamma z) \\ \sin(\alpha x)\cos(\beta y)\sin(\gamma z) \\ \sin(\alpha x)\sin(\beta y)cos(\gamma z) \end{bmatrix}^2 \begin{bmatrix} 1 \\ 1 \\ 4 \end{bmatrix} =$$

$$e_x^2 \begin{Bmatrix} \left(\cos(\alpha x)\sin(\beta y)\sin(\gamma z)\right)^2 + \\ \left(\sin(\alpha x)\cos(\beta y)\sin(\gamma z)\right)^2 + \\ 4\left(\sin(\alpha x)\sin(\beta y)cos(\gamma z)\right)^2 \end{Bmatrix}$$

or

$$|E^2| = e_x^2 6(m\pi)^3. \tag{65}$$

The last transformation follows from (56). Similarly, from (52, 62, 64, 56) we obtain:

$$|H^2| = \left(\breve{H}_x^2 + \breve{H}_y^2 + \breve{H}_z^2\right) = e_x^2 \left(\sqrt{\frac{3\varepsilon}{\mu}} \widehat{H} \begin{bmatrix} -1 \\ 1 \\ 0 \end{bmatrix}\right)^2 = e_x^2 \widehat{H}^2 \frac{3\varepsilon}{\mu} \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} = e_x^2 \begin{bmatrix} \sin(\alpha x)\cos(\beta y)\cos(\gamma z) \\ \cos(\alpha x)\sin(\beta y)\cos(\gamma z) \\ \cos(\alpha x)\cos(\beta y)\sin(\gamma z) \end{bmatrix}^2 \frac{3\varepsilon}{\mu} \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} =$$

$$e_x^2 \frac{3\varepsilon}{\mu} \begin{Bmatrix} \left(\sin(\alpha x)\cos(\beta y)\cos(\gamma z)\right)^2 + \\ \left(\cos(\alpha x)\sin(\beta y)\cos(\gamma z)\right)^2 + \\ 0 \end{Bmatrix} \tag{66}$$

or

$$|H^2| = e_x^2 \frac{3\varepsilon}{\mu} 2(m\pi)^3. \tag{66}$$

Thus, for the agreed volume from (65, 66) we obtain:

$$|E^2|/|H^2| = \frac{\mu}{\varepsilon}. \tag{67}$$

From (65-67) it follows:

$$U = \varepsilon|E^2| = \mu|H^2| = \varepsilon e_x^2 6(m\pi)^3. \tag{68}$$

The energy density is

$$W = \varepsilon E^2 + \mu H^2. \tag{69}$$

From (53, 54, 69) we get:

$$W = \varepsilon|E^2| \sin^2(\omega t) + \mu|H^2| \cos^2(\omega t). \tag{70}$$

From (68, 70) it follows that

$$W = U(\sin^2(\omega t) + \cos^2(\omega t)) = U, \tag{71}$$

i.e. in a agreed volume, the energy density in the volume does not depend on time and has a constant value throughout the entire WAP volume. In other words, a standing wave is created in a agreed volume that does not radiate. The value U is a constant. Therefore, for a agreed volume, the expression for the energy W_o in the entire volume V is

$$W_o = U \cdot V. \tag{72}$$

For a minimum volume of WAP, as follows from (68),

$$U = U_o = 6\varepsilon e_x^2 \pi^3. \tag{72a}$$

From (72, 72a, 60) we find the energy of the minimum volume of WAP:

$$W_{omin} = \varepsilon e_x^2 6\pi^3 \cdot 8\pi^3 \left(\frac{3}{\mu\varepsilon}\right)^{1.5} / \omega^3 = \sigma \cdot e_x^2/\omega^3, \tag{73}$$

where

$$\sigma = 48\pi^6 3^{1.5} \varepsilon^{-0.5} \mu^{-1.5} = 2.4 \cdot 10^5 \varepsilon^{-0.5} \mu^{-1.5}. \tag{74}$$

Consequently, in a constant agreed volume, the energy of an electromagnetic wave does not depend on time, i.e. remains constant. This means that under the specified conditions,

Statement 1. WAP, like a standing electromagnetic wave, can exist in a agreed volume.

2.3. Flows of energy

Energy flux densities along coordinates are determined by the formula

$$S = \begin{bmatrix} S_x \\ S_y \\ S_z \end{bmatrix} = (E \times H) = \begin{bmatrix} E_y H_z - E_z H_y \\ E_z H_x - E_x H_z \\ E_x H_y - E_y H_x \end{bmatrix}, \tag{75}$$

where the functions $\boldsymbol{E}, \boldsymbol{H}$ are determined from (9-14). Obviously, in a consistent volume at the boundaries of the coordinate axes the following conditions are satisfied:

$$\sin(\alpha x) = \sin(\beta y) = \sin(\gamma z). \tag{76}$$

The function is present in the definition of one of the functions specified in condition (75). Therefore, from (75, 76) it follows that energy flows directed perpendicular to the faces are equal to zero, i.e. this volume does not exchange energy with the environment.sin

Statement 2. WAP can exist within an agreed volume.

In addition, for such a volume, Statement 1 is satisfied. Thus, WAP can exist in such a volume. First of all, let us consider the cubic form proposed in [4]. Consider, for example, the energy flux density along the axis z . From (75) we find:

$$S_z = E_x H_y - E_y H_x \tag{77}$$

Combining this formula with formulas (9, 10, 12, 13, 23), we find:

$$S_z = (e_x \sin(\alpha x)\cos(\alpha y)\cos(\alpha z) h_y \sin(\alpha x)\cos(\alpha y)\sin(\alpha z) \\ - e_y \cos(\alpha x)\sin(\alpha y)\cos(\alpha z) h_x \cos(\alpha x)\sin(\alpha y)\sin(\alpha z))\sin(2\omega t)$$

Taking into account (33, 35, 40), from (77) we obtain:

$$S_z = \begin{pmatrix} e_x \sin(\alpha x)\cos(\alpha y)\cos(\alpha z) e_x \sqrt{3\varepsilon/\mu} \sin(\alpha x)\cos(\alpha y)\sin(\alpha z) \\ - e_x \cos(\alpha x)\sin(\alpha y)\cos(\alpha z) e_x \sqrt{3\varepsilon/\mu} \cos(\alpha x)\sin(\alpha y)\sin(\alpha z) \end{pmatrix} \sin(2\omega t)$$

or

$$S_z = e_x^2 \sqrt{\frac{3\varepsilon}{\mu}} \begin{pmatrix} \sin(\alpha x)\cos(\alpha y)\cos(\alpha z)\sin(\alpha x)\cos(\alpha y)\sin(\alpha z) \\ + \cos(\alpha x)\sin(\alpha y)\cos(\alpha z)\cos(\alpha x)\sin(\alpha y)\sin(\alpha z) \end{pmatrix} \sin(2\omega t)$$

or

$$S_z = e_x^2 \sqrt{\frac{3\varepsilon}{\mu}} \sin(2\alpha z) \begin{pmatrix} \sin^2(\alpha x)\cos^2(\alpha y) \\ + \cos^2(\alpha x)\sin^2(\alpha y) \end{pmatrix} \sin(2\omega t) \tag{78}$$

or

$$S_z = e_x^2 \frac{\pi}{2} \sqrt{\frac{3\varepsilon}{\mu}} \sin(2\alpha z)\sin(2\omega t)$$

or

$$S_z = e_x^2 \frac{\pi}{2} \sqrt{\frac{3\varepsilon}{\mu}} \sin(4\omega t + 4\alpha z), \tag{79}$$

We have obtained an equation for the energy flux density along the axis z. This flux varies with time. It is equal to zero on the faces of the cube in the case when on the faces of the cube, i.e. when $z = Z$ (see Fig. 1) conditions of the form $\sin(2\alpha z) = 0$ are met. These conditions are met to the agreed extent - see (55). Let us consider the energy flux density along the axis x. From (75) we find:

$$S_x = E_y H_z - E_z H_y \tag{80}$$

Combining this formula with formulas (10, 11, 13, 23), we find:

$$S_x = \frac{1}{2}\left(-e_z \sin(\alpha x)\sin(\alpha y)\cos(\alpha z) h_y \cos(\alpha x)\sin(\alpha y)\cos(\alpha z)\right)\sin(2\omega t)$$

Taking into account (35, 32, 36, 33, 40), from (80) we obtain:

$$S_x = \frac{1}{2}\left(-2 e_x \sin(\alpha x)\sin(\alpha y)\cos(\alpha z) e_x \sqrt{3\varepsilon/\mu} \cos(\alpha x)\sin(\alpha y)\cos(\alpha z)\right)\sin(2\omega t)$$

or

$$S_x = -\frac{1}{8} e_x^2 \sqrt{\frac{3\varepsilon}{\mu}} \sin(2\alpha x)\sin^2(\alpha y)\sin(2\alpha z)\sin(2\omega t) \tag{81}$$

Since on the faces of the cube $\sin(2\alpha x) = 0$, then on the faces of the cube $S_x = 0$. Consider the energy flux density along the axis y. From (75) we find:

$$S_y = E_z H_x - E_x H_z \tag{82}$$

Combining this formula with formulas (9, 11, 12, 23), we find:

$$S_y = \left(e_z \sin(\alpha x)\sin(\alpha y)\cos(\alpha z) h_x \sin(\alpha x)\cos(\alpha y)\cos(\alpha z)\right)\sin(2\omega t)$$

Taking into account (36, 33, 40), from (82) we obtain:

$$S_y = \left(2e_x \sin(\alpha x)\sin(\alpha y)\cos(\alpha z) e_x \sqrt{\frac{3\varepsilon}{\mu}} \sin(\alpha x)\cos(\alpha y)\cos(\alpha z) \right) \sin(2\omega t)$$

or

$$S_y = \frac{1}{2} e_x^2 \sqrt{\frac{3\varepsilon}{\mu}} \sin^2(\alpha x) \sin(2\alpha y) \cos^2(\alpha z) \sin(2\omega t) \quad (83)$$

From equations (78, 81, 83) it follows that flows of electromagnetic energy circulate in the cube along all axes. species (78, 84, 85).

Consider the vector sum

$$\vec{S} = \overrightarrow{S_x} + \overrightarrow{S_y} + \overrightarrow{S_z}. \quad (84)$$

Obviously, many vectors $\vec{S}$ circulate in the cube and at each point of the cube there is a certain vector $\vec{S}$ that has a module $|\vec{S}|$ - the density of the total vector of the electromagnetic energy flow. From (78, 81, 83, 75, 63, 64) it follows that

$$S = \begin{bmatrix} S_x \\ S_y \\ S_z \end{bmatrix} = \begin{bmatrix} \hat{E}_y \hat{H}_z - \hat{E}_z \hat{H}_y \\ \hat{E}_z \hat{H}_x - \hat{E}_x \hat{H}_z \\ \hat{E}_x \hat{H}_y - \hat{E}_y \hat{H}_x \end{bmatrix} \sin(2\omega t). \quad (85)$$

From (78, 81, 83, 85) it follows that

$$|\vec{S}| = |\overrightarrow{S_o}| \sin(2\omega t), \quad (86)$$

where

$$|\overrightarrow{S_o}| = \left(\hat{E}_y \hat{H}_z - \hat{E}_z \hat{H}_y\right)^2 + \left(\hat{E}_z \hat{H}_x - \hat{E}_x \hat{H}_z\right)^2 + \left(\hat{E}_x \hat{H}_y - \hat{E}_y \hat{H}_x\right)^2. \quad (87)$$

Thus, inside the cube there are lines formed by vectors $|\vec{S}|$. Obviously, such a line represents some kind of "spatial entangled spiral" (hereinafter simply a spiral). Such spirals are closed. Through every point where $|\overrightarrow{S_o}| \neq 0$ there is a single spiral, and through every point where $|\overrightarrow{S_o}| \neq 0$ there are many spirals. At each point of this spiral, the magnitude of the flow $|\vec{S}|$ fluctuates in time, as $\sin(2\omega t)$. The amplitude of these fluctuations changes at a given point and depends on the location of this point in the cube.

You can consider the development of this spiral. Let us denote the coordinate of a point on this scan as . Then we get a sinusoid with an amplitude that is a function of this coordinate:u

$$A(u, t) = A_o(u) \cdot \sin(2\omega t), \quad (88)$$

where A, A_o is a more convenient notation for functions $|\vec{S}|, |\overrightarrow{S_o}|$, respectively.

Let's expand the function $A_o(u)$ into a trigonometric series:

$$A_o(u) = A_{oo} + \sum_{k=1}^{n} (A_{ok} \sin(ku)) \quad (89)$$

Accordingly, function (88) will take the form:

$$A = A_{oo} \sin(2\omega t) + \sum_{k=1}^{n} (A_{ok} \sin(ku) \sin(2\omega t)). \quad (90)$$

Each term of this sum can be represented as:

$$A_{ok} \sin(ku) \sin(2\omega t) = A_{ok} \sin(ku) \cos\left(2\omega t - \frac{\pi}{2}\right) = Q_1 + Q_2, \quad (91)$$

Where

$$Q_1 = \frac{1}{2} A_{ok} \sin\left(ku - \frac{\pi}{2} + 2\omega t\right), \quad (92)$$

$$Q_2 = \frac{1}{2} A_{ok} \sin\left(ku + \frac{\pi}{2} - 2\omega t\right). \quad (93)$$

Each of these two features a traveling wave. Consequently, the function under consideration (90) represents the sum of many traveling waves of electromagnetic energy flow. So, many running waves of energy flow circulate along each spiral. These waves have a common frequency, but differ in direction of movement, phase and amplitude. The total amplitude of the flow of these waves is equal to

$$A_{\text{спираль}} = \sum_{k=1}^{n} A_{ok} \quad (94)$$

2.4. Weight

In the existing theory, electromagnetic mass is the mass of an electromagnetic wave that is created by a moving particle [5]. In our case, it is the wave that creates the WAP particle, and in this wave there are no particles that form it. But at the same time, we cannot use this approach to determine the mass.

We will use the well-known Umov formula, which connects the energy density and energy flow with the speed of energy movement:

$$v = \frac{S}{W}. \tag{95}$$

It is also known that the pulse density

$$p = \frac{W}{v}, \tag{96}$$

and the mass

$$m = \frac{p}{v} = \frac{W}{v^2}. \tag{97}$$

Hence,

$$m = \frac{w^3}{S^2}. \tag{98}$$

In this case, for a wave with known intensities, one can find the energy density W, electromagnetic energy flux density S and mass density m according to (98).

It is shown above that in the cube there are trajectories along which flows of electromagnetic energy propagate. At the same time, many such flows pass through each point of the WAP cube. Let us denote the total power density of such flows as S. Then, using (98), we find the density of the electromagnetic mass, which is generated at this point by the very existence of the electromagnetic wave in the WAP. The sum of these masses is the electromagnetic mass of WAP.

Consequently, WAP can be considered both as a standing wave and as a volume having a certain mass.

2.5. Conclusion

We have established two conditions that must be satisfied by the region in which

- WAP can exist within a closed and continuous boundary.
- WAP, like a standing electromagnetic wave, can exist in a consistent volume

We have established that WAP forms a closed area and has a certain shape and volume. The results obtained can be applied to any arbitrarily small units of length. The shape of the WAP region is such that multiple WAPs can be adjacent to each other without gaps. Consequently, WAP groups can occupy any volume. Thus, WAP of any size and areas of WAP of any size can exist. WAP does not have its own speed and its mechanical energy is determined by its mass and the speed that it received when interacting with other masses (including other WAP). The internal pressure on the WAP border is equal to the energy density at the border, although WAP does not have any envelope. It can be assumed that WAP behaves like an absolutely elastic body and transmits the received impulse without changing its magnitude. Then the WAP region also behaves as a conductor of the impulse. Obviously, WAP can form elementary particles and larger structures. But we can assume that the vacuum is also woven from WAP.

3. Spherical WAP[6].

3.1. Maxwell's equations in spherical coordinates

In [1], a solution to Maxwell's equations in spherical coordinates was found. The known solution for a spherical electromagnetic wave does not satisfy the law of conservation of energy (it is conserved only on average), the electric and magnetic intensities of the same name (in coordinates) are in phase, only one of Maxwell's system of equations is satisfied, the solution is not a wave one, there is no energy flow with a real value. The proposed solution is free from these shortcomings. Maxwell's system of equations, being a system of partial differential equations, has many solutions. The applicability of a solution to physics is determined by a single criterion: it must satisfy the law of conservation of energy (LEC). The existing solution does NOT satisfy this law.

So, let's consider the system of Maxwell's equations for vacuum, which has the form

$$\mathrm{rot}(E) + \frac{\mu}{c}\frac{\partial H}{\partial t} = 0, \tag{1}$$

$$\mathrm{rot}(H) - \frac{\varepsilon}{c}\frac{\partial E}{\partial t} = 0, \quad (2)$$
$$\mathrm{div}(E) = 0, \quad (3)$$
$$\mathrm{div}(H) = 0. \quad (4)$$

where E is the electric field strength, H is the magnetic field strength, μ is the absolute magnetic permeability, ε is the absolute dielectric constant. Next, spherical coordinates are considered - see Fig. 1. Maxwell's equations in spherical coordinates in the absence of charges and currents have the form given in table. 1.

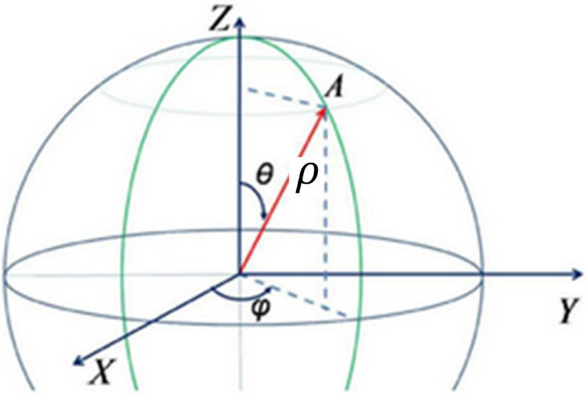

Fig. 1.

Table 1.

1	3
1	$\frac{E_\varphi}{\rho \mathrm{tg}(\theta)} + \frac{\partial E_\varphi}{\rho \partial \theta} - \frac{\partial E_\theta}{\rho \sin(\theta) \partial \varphi} + \frac{\mu}{c}\frac{\partial H_\rho}{\partial t} = 0$
2	$\frac{\partial E_\rho}{\rho \sin(\theta) \partial \varphi} - \frac{E_\varphi}{\rho} - \frac{\partial E_\varphi}{\partial \rho} + \frac{\mu}{c}\frac{\partial H_\theta}{\partial t} = 0$
3	$\frac{E_\theta}{\rho} + \frac{\partial E_\theta}{\partial \rho} - \frac{\partial E_\rho}{\rho \partial \varphi} + \frac{\mu}{c}\frac{\partial H_\varphi}{\partial t} = 0$
4	$\frac{E_\rho}{\rho} + \frac{\partial E_\rho}{\partial \rho} + \frac{E_\theta}{\rho \mathrm{tg}(\theta)} + \frac{\partial E_\theta}{\rho \partial \theta} + \frac{\partial E_\varphi}{\rho \sin(\theta) \partial \varphi} = 0$
5	$\frac{H_\varphi}{\rho tg(\theta)} + \frac{\partial H_\varphi}{\rho \partial \theta} - \frac{\partial H_\theta}{\rho sin(\theta) \partial \varphi} - \frac{\varepsilon}{c}\frac{\partial E_\rho}{\partial t} = 0$
6	$\frac{\partial H_\rho}{\rho sin(\theta) \partial \varphi} - \frac{H_\varphi}{\rho} - \frac{\partial H_\varphi}{\partial \rho} - \frac{\varepsilon}{c}\frac{\partial E_\theta}{\partial t} = 0$
7	$\frac{H_\theta}{\rho} + \frac{\partial H_\theta}{\partial \rho} - \frac{\partial H_\rho}{\rho \partial \varphi} - \frac{\varepsilon}{c}\frac{\partial E_\varphi}{\partial t} = 0$
8	$\frac{H_\rho}{\rho} + \frac{\partial H_\rho}{\partial \rho} + \frac{H_\theta}{\rho tg(\theta)} + \frac{\partial H_\theta}{\rho \partial \theta} + \frac{\partial H_\varphi}{\rho sin(\theta) \partial \varphi} = 0$

In the solutions found, the tensions are determined by formulas of the following form:

$$E_\varphi = \frac{e_\varphi}{\rho}\mathrm{Khm}(\theta, \propto)\sin(\propto \varphi + \chi\rho + \omega t), \quad (5)$$
$$E_\theta = \frac{e_\theta}{\rho}\mathrm{Khm}(\theta, \propto)\cos(\propto \varphi + \chi\rho + \omega t), \quad (6)$$
$$E_\rho = \frac{e_\rho}{\rho}\mathrm{Khm}(\theta, \propto)\sin(\propto \varphi + \chi\rho + \omega t), \quad (7)$$
$$H_\varphi = \frac{h_\varphi}{\rho}\mathrm{Khm}(\theta, \propto)\cos(\propto \varphi + \chi\rho + \omega t), \quad (8)$$
$$H_\theta = \frac{h_\theta}{\rho}\mathrm{Khm}(\theta, \propto)\sin(\propto \varphi + \chi\rho + \omega t), \quad (9)$$
$$H_\rho = \frac{h_\rho}{\rho}\mathrm{Khm}(\theta, \propto)\cos(\propto \varphi + \chi\rho + \omega t), \quad (10)$$

where Khm is some function, $\propto, \chi, \omega, e_\varphi, h_\varphi$ are constants. We will consider a special case when

$$\propto = 20. \tag{11}$$

In this case

$$\mathrm{Khm}(\theta, 20) = \sin(\theta) \tag{12}$$

and the system of equations (5-10) is simplified:

$$E_\varphi = \frac{e_\varphi}{\rho}\sin(\theta)\ \sin(\propto\varphi + \chi\rho + \omega t), \tag{13}$$

$$E_\theta = \frac{e_\theta}{\rho}\sin(\theta)\ \cos(\propto\varphi + \chi\rho + \omega t)\ , \tag{14}$$

$$H_\varphi = \frac{h_\varphi}{\rho}\sin(\theta)\ \cos(\ \propto\varphi + \chi\rho + \omega t), \tag{15}$$

$$H_\theta = \frac{h_\theta}{\rho}\sin(\theta)\ \sin(\ \propto\varphi + \chi\rho + \omega t), \tag{16}$$

In [3] it is shown that

$$e_\varphi = e_\theta, \tag{17}$$

$$h_\varphi = -h_\theta. \tag{18}$$

$$h_\varphi = \sqrt{\frac{\varepsilon}{\mu}}e_\theta, \tag{19}$$

$$h_\theta = -\sqrt{\frac{\varepsilon}{\mu}}e_\varphi. \tag{16}$$

3.2. Energy sphere

Energy Density

$$W = \frac{1}{8\pi}(\varepsilon H^2 + \mu E^2) \tag{21}$$

From the previous formulas it follows that

$$W = \frac{\varepsilon e_\varphi^2}{4\pi\rho^2}\sin^2(\theta). \tag{22}$$

All the energy of an electromagnetic wave in a sphere of radius:R

$$W = \frac{\pi\varepsilon e_\varphi^2}{2R}. \tag{23}$$

3.3. Flows of energy in the sphere

In [1] it is shown that in a sphere there are only energy flows passing along a radius inclined at an angle θ. The density of this energy

$$S_\rho = \frac{c}{4\pi\rho^2}\sqrt{\frac{\varepsilon}{\mu}}\left(\sin(\theta)\cdot e_\varphi\right)^2. \tag{24}$$

This means that the energy flow passing along the radius remains constant over time, which corresponds to the law of conservation of energy. This also means that on each circle defined by the values of θ and ρ (see the green circle in Fig. 1), there is a standing electromagnetic wave. Let us find the ratio of energy flux density (24) to energy density (22):

$$S_\rho/W = \frac{c}{4\pi\rho^2}\sqrt{\frac{\varepsilon}{\mu}}\left(\sin(\theta)e_\varphi\right)^2\Big/\sin^2(\theta)\frac{\varepsilon e_\varphi^2}{4\pi\rho^2} = \sqrt{\frac{\varepsilon}{\mu}}\Big/\frac{\mathrm{c}}{\varepsilon} = \frac{\mathrm{c}}{\sqrt{\varepsilon\mu}}, \tag{23}$$

Because $\mathrm{c} = \frac{1}{\sqrt{\varepsilon\mu}}$, then

$$S_\rho/W = \mathrm{c}^2. \tag{26}$$

3.4. Standing wave rotation

Let's look at the green circle again in Fig. 1, on which there is a standing electromagnetic wave. In this wave, magnetic and electrical intensities fluctuate (in time) - see (13-16).

Let's find the speed of rotation of this circle when changing φ. Obviously, this speed is equal to the derivative of the function given implicitly in the form of these equations. Consider, for example, function H_φ (15). We have:$\varphi.H_\varphi$

$$\frac{d(H_\varphi)}{d\varphi} = h_\varphi\frac{d}{d\varphi}(\cos(\ \alpha\varphi + \chi z + \omega t)) = -\alpha h_\varphi\sin(\ \alpha\varphi + \chi z + \omega t),$$

$$\frac{d(H_\varphi)}{dt} = h_\varphi\frac{d}{dt}(\cos(\ \alpha\varphi + \chi z + \omega t)) = -\omega h_\varphi\sin(\ \alpha\varphi + \chi z + \omega t).$$

Then the angular velocity of rotation of the spherical electromagnetic wave

$$\omega_\varphi = \frac{d\varphi}{dt} = \frac{d(H_\varphi)}{dt} \Big/ \frac{d(H_\varphi)}{d\varphi} = \frac{\omega}{\alpha}. \tag{27}$$

Thus, there is a rotation speed of the electromagnetic wave pulsating on the green circle. This speed does NOT depend on the radius of the circle. This means that the entire circle in which the green circle is located rotates, and therefore the entire spherical electromagnetic wave rotates with angular velocity ω_φ around the axis z.

3.5. Spherical wave mass

We will use the well-known Umov formula, which connects the energy density and energy flow with the speed of energy movement:

$$v = \frac{S}{W}. \tag{28}$$

It is also known that the pulse density

$$p = \frac{W}{v}, \tag{29}$$

and the mass

$$m = \frac{p}{v} = \frac{W}{v^2}. \tag{30}$$

Hence,

$$m = \frac{W^3}{S^2}. \tag{31}$$

In (26) it was shown that

$$\frac{S}{W} = \mathrm{c}^2. \tag{32}$$

From (31, 32) we find;

$$m = \frac{W}{\mathrm{c}^2}. \tag{33}$$

We have obtained a known ratio.

3.6. Rotation energy

The previous section shows that a spherical electromagnetic wave rotates with angular velocity

$$\omega_\varphi = \frac{\omega}{\alpha}. \tag{34}$$

Density of the moment of inertia of the wave relative to the central axis

$$j = mr^2, \tag{35}$$

where the radius of rotation of the mass m is determined by a formula of the form

$$r = \rho \sin(\theta) \tag{36}$$

- see fig. 1. Therefore,

$$j = m\rho^2 \sin^2(\theta). \tag{37}$$

Energy density of the rotational motion of the wave

$$Q(r) = mr^2\omega_\varphi^2 = m\rho^2 \sin^2(\theta)\left(\frac{\omega}{\alpha}\right)^2 \tag{38}$$

or, taking into account (33),

$$Q(r) = \frac{\mathrm{W}}{\mathrm{c}^2}\rho^2 \sin^2(\theta)\left(\frac{\omega}{\alpha}\right)^2. \tag{39}$$

or, taking into account (22),

$$Q(r) = \frac{\varepsilon e_\varphi^2}{4\pi \mathrm{c}^2}\left(\frac{\omega}{\alpha}\right)^2 \sin^4(\theta). \tag{40}$$

Thus, similar to mass m and energy W, in a spherical wave there is a moment of inertia j and energy Q of rotational motion. Let us find the energy of the rotational motion of the wave in a sphere of radius R:

$$W_o = \frac{\varepsilon e_\varphi^2}{4\pi \mathrm{c}^2}\left(\frac{\omega}{\alpha}\right)^2 \int_0^R \left(\int_0^{2\pi} \left(\int_0^{2\pi} (\sin^4(\theta) d\theta) \right) d\varphi \right) d\rho =$$

$$= \frac{\varepsilon e_\varphi^2}{4\pi \mathrm{c}^2}\left(\frac{\omega}{\alpha}\right)^2 R \int_0^{2\pi} \left(\int_0^{2\pi} (\sin^4(\theta) d\theta) \right) d\varphi = \frac{\varepsilon e_\varphi^2}{4\pi \mathrm{c}^2}\left(\frac{\omega}{\alpha}\right)^2 R \left(2\pi \frac{3}{4}\pi\right)$$

or

$$W_o = \frac{3\pi\varepsilon}{8}\left(\frac{\omega}{\alpha c}\right)^2 e_\varphi^2 R. \tag{41}$$

3.7. Spherical WAP

So, we have obtained a mathematical description of a spherical wave in which

- There are no radial tensions,
- There are radial energy flows,
- Tensions form standing electromagnetic waves,
- The wave energy has a constant value,
- Energy flows have a constant value,
- There is an electromagnetic mass created by an oscillating flow of electromagnetic energy,
- An electromagnetic wave rotates around a certain axis,
- There is wave rotational energy created by the rotation of electromagnetic mass.

All these characteristics of a wave allow it to be identified with a particle, which is both a particle and a wave. We have obtained a mathematical description of a spherical WAP. This particle is rotating. This phenomenon is observed (most likely) in experiments and is described as spin - a certain quality of elementary particles that has no analogue in the macrocosm.

3.8. Ball lightning

There is no apparent limitation on the size of the spherical rotating WAP. Such a formation appears to be some types of ball lightning. In [11] we read: *A large number of testimonies described in detail in the literature*[12, 13, 14], *allow us to identify a number of properties of ball lightning that are repeatedly repeated in various documents and therefore have a high degree of reliability*:

1. *high energy density - thousands of joules per cubic centimeter.*
2. *abnormally high specific energy density [12],*
3. *ndoes not interact with powerful air flow,*
4. *are attracted to pipes, ... holes, cracks,*
5. *break plastic objects into small pieces,*
6. *at a distance of several meters they are capable of melting part of the glass in the closed aluminum frame of the camera's sighting hole, they heat the rings put on the finger,*
7. *pass freely through glass and wire insulation without damaging them, sometimes evaporating or melting small holes,*
8. *usually do not have thermal radiation,*
9. *are observed as luminous plasma or corona discharge-emitting balls, sometimes having a gray or black color; transparent BLs have been described [14],*
10. *often there is strictly parallel movement along walls, ground, metal surfaces,*
11. *when the CMM is destroyed, an explosion is heard, an electric shock, or a powerful discharge into the ground may occur; the appearance of a luminous crown,*
12. *the lifetime of a BL can be tens of seconds; black BLs exist for several days [14].*
13. *can occur instantly inside enclosed spaces at considerable distances from surrounding objects.*

You may notice that many of the items on this list can be explained by the fact that ball lightning is a spherical wave.

4. Disk WAP [15].

4.1. Introduction

The existing theory of a standing wave considers it as interference waves propagating in opposite directions. Where in the following is stated [16]: When interference occurs *energy waves are redistributed in space. This does not contradict law of conservation of energy, because on average, for a large region of space, the energy of the resulting wave is equal to the sum of the energies of the interfering waves.* Such references to unknown distances can explain a lot. And essentially this means that in the theory of a standing wave the law of conservation of energy is violated (LCE). This is not the only case in modern electrodynamics: a traveling wave is described by a wave equation, and the wave equation violates the LCE - it is satisfied on the average, which is essentially not permissible in the LCE. This only proves that the wave equation cannot be a solution to Maxwell's equations. Likewise, the existing standing wave equation cannot be a solution to Maxwell's equations.

4.2. Cylindrical wave

In [1] a cylindrical wave is described as a new solution to Maxwell's equations. In it, the law of conservation of energy is preserved. In [1] it is proved that the cylindrical wave rotates with angular velocity:

$$\omega_\varphi = \frac{\omega}{\alpha} \tag{1}$$

and has rotational energy as a third (in addition to magnetic and electric) type of energy. The rotational energy density on a circle of radius r is equal to

$$Q(r) = \frac{\mathrm{W}(r)}{\mathrm{c}^2} r^2 \left(\frac{\omega}{\alpha}\right)^2. \tag{2}$$

Electromagnetic energy density

$$\mathrm{W}(r) = m(r) \cdot \mathrm{c}^2 \tag{3}$$

can be considered the kinetic energy of mass $m(r)$. Density of total total energy - <u>mechanical energy of the wave</u>

$$\exists(r) = \mathrm{W}(r) + Q(r) = \mathrm{W}(r)\left(1 + \frac{1}{\mathrm{c}^2} r^2 \left(\frac{\omega}{\alpha}\right)^2\right) \tag{4}$$

or, taking into account (2),

$$\exists(r) = \mathrm{W}(r) + Q(r) = m(r)\left(\mathrm{c}^2 + r^2 \left(\frac{\omega}{\alpha}\right)^2\right). \tag{5}$$

The densities of the listed mechanical energies at the wave cross section are equal (as shown in[1])

$$\overline{\mathrm{W}} = 2\pi\varepsilon \int_r \left(e_r^2 \cdot r \cdot dr\right), \tag{6}$$

$$\overline{Q} = \frac{\varepsilon}{\mathrm{c}^2}\left(\frac{\omega}{\alpha}\right)^2 \int_r \left(e_r^2 r^3 dr\right), \tag{7}$$

$$\overline{\exists} = \overline{\mathrm{W}} + \overline{Q}. \tag{8}$$

The mass density at the wave cross section is determined by the formula:

$$\overline{m} = \frac{\overline{\exists}}{\mathrm{c}^2} = \frac{\overline{\mathrm{W}}}{\mathrm{c}^2} + \frac{\overline{Q}}{\mathrm{c}^2}. \tag{9}$$

Then, taking into account (6, 7) we find

$$\overline{\mathrm{m}} = 2\pi \frac{\varepsilon}{\mathrm{c}^2} \int_r \left(e_r^2 r \cdot dr\right) + \frac{\varepsilon}{\mathrm{c}^4}\left(\frac{\omega}{\alpha}\right)^2 \int_r \left(e_r^2 r^3 dr\right). \tag{10}$$

In [1] it is shown that

$$e_r = A r^{\alpha - 1}. \tag{11}$$

Moreover, from (6, 7, 9) we find:

$$\overline{\mathrm{W}} = 2\pi\varepsilon A^2 \int_0^R \left(r^{2\alpha - 1} \cdot dr\right) = \pi\varepsilon A^2 \frac{1}{\alpha} R^{2\alpha}, \tag{12}$$

$$\overline{Q} = \frac{\varepsilon}{\mathrm{c}^2}\left(\frac{\omega}{\alpha}\right)^2 A^2 \int_0^R \left(r^{2\alpha+1} \cdot dr\right) = \frac{\varepsilon}{\mathrm{c}^2}\left(\frac{\omega}{\alpha}\right)^2 \frac{1}{2\alpha+2} A^2 R^{2\alpha+2}, \tag{13}$$

$$\overline{\mathrm{m}} = \pi \frac{\varepsilon}{\mathrm{c}^2} A^2 \frac{1}{\alpha} R^{2\alpha} + \frac{\varepsilon}{\mathrm{c}^4}\left(\frac{\omega}{\alpha}\right)^2 \frac{1}{2\alpha+2} A^2 R^{2\alpha+2}. \tag{14}$$

Let us also find the momentum density in the rotational motion of the cylinder. To do this, we use [1], where the energy flux density is determined by (2, 3), and the speed by (1):

$$p(r) = \frac{Q(r)^2}{\omega_\varphi r}. \tag{15}$$

Finally, let's find the angular momentum density

$$L(r) = r \cdot p(r) = \frac{Q(r)^2}{\omega_\varphi} = \frac{\alpha}{\omega} Q(r)^2. \tag{13}$$

Then the angular momentum of the cross section of the cylinder

$$\overline{L} = \frac{\alpha}{\omega} \overline{Q}^2. \tag{14}$$

4.3. Standing cylindrical wave

If some obstacle stops the wave, its kinetic energy disappears. In accordance with the LCE, this energy complements the rotational energy: the wave stops and begins to rotate faster. This means that the parameter $\boldsymbol{\alpha}$ decreases. We denote its new value as $\boldsymbol{\alpha_s}$. Then, based on equation (4), we can write the equation for energy conservation when the wave stops:

$$\overline{\mathrm{W}}(\alpha) + \overline{Q}(\alpha) = \overline{Q}(\alpha_s)\,. \tag{18}$$

From (18, 12, 13) we obtain:

$$\pi\varepsilon A^2 \frac{1}{\alpha} R^{2\alpha} + \frac{\varepsilon}{c^2}\left(\frac{\omega}{\alpha}\right)^2 \frac{1}{2\alpha+2} A^2 R^{2\alpha+2} = \frac{\varepsilon}{c^2}\left(\frac{\omega}{\alpha_s}\right)^2 \frac{1}{2\alpha_s+2} A^2 R^{2\alpha_s+2}$$

or

$$\pi c^2 \frac{1}{\alpha} R^{2\alpha} + \left(\frac{\omega}{\alpha}\right)^2 \frac{1}{2\alpha+2} R^{2\alpha+2} = \left(\frac{\omega}{\alpha_s}\right)^2 \frac{1}{2\alpha_s+2} R^{2\alpha_s+2}. \tag{19}$$

From equation (19) one can find the value α_s. In a stopped standing wave, the values of all intensities are preserved. A standing wave creates pressure on an obstacle. The magnitude of this pressure is determined in [2]according to the formula:

$$d(r) = \varepsilon e_r^2. \tag{20}$$

4.4. Two cylinders

Let us assume that the wave is located in the volume of a cylinder with length $\boldsymbol{L}$ and radius $\boldsymbol{R}$. Let us further assume that two cylinders fly towards each other along their axes, while, of course, rotating in opposite directions... and finally connected at their opposite ends. After this, each cylinder will hold the counter cylinder with its pressure (20). These pressures prevent the cylinders from touching and at the same time are the forces that bring the cylinders together. In this case, a standing wave will arise in each cylinder. Nothing prevents this pair of cylinders from existing indefinitely. In other words, this pair of cylinders forms a particle that has mass. The particle consists of two cylindrical parts rotating in different directions.

In another case, the cylinders could have different kinetic energies before meeting. Then the combined particle will have a kinetic energy equal to the difference in the kinetic energies of the opposing cylinders, and will continue to move as a single whole.

In the third case, the cylinders could have different sizes. This would not prevent them from merging together and continuing to move with a difference in kinetic energies (as in the second case).

4.5. Some analogies

It is shown above that there is WAP, which is a standing wave in a limited space of vacuum, shaped like a cube. It does not have its own speed and can, like a particle, move at an arbitrarily low speed; it has energy, an internal flow of energy and mass. The wave model of the particle obtained above is another version of WAP, having the shape of a cylinder. Thus, disk WAP - DWAP was obtained.

For DWAP (unlike WAP), the mechanism of its occurrence is clear: many interfering rays create many different particles.

There is a rare case where two mating cylinders are connected to a third cylinder. In this case, the two outer cylinders rotate in the same direction, and the inner cylinder rotates in the opposite direction.

If the inner cylinder has insignificant length and density, then in some experiments such a particle can be observed as a single whole.

If the inner cylinder has an apparent length, but insignificant density, then in some experiments two particles can be observed that exist together but do not approach each other.

Such phenomena are observed in astronomy[17]: There are contact binaries, which consist of two asteroids in contact with each other, and separated binaries, which are at some distance from each other, see fig. 1. Apparently, to explain them, it is necessary to use the idea of gravitational masses as properties of the gravitational field.

In [18] the history of the appearance of neutrinos in physics is examined in detail. When analyzing the Dirac equation for a fermion, it was shown that in the case of a neutrino, this particle decays into two separate components rotating in opposite directions. Although this bifurcated particle as a whole is constantly moving in one direction, its ring components relative to each other are constantly moving in opposite directions. In [18] to explain the properties of such a particle, a model is proposed Helmholtz. In article [19], Helmholtz, solving the equations of hydrodynamics of an ideal fluid, considered, in particular, the joint dynamics of the behavior of a pair of coaxial or coaxial rings and discovered a remarkable effect, now referred to as “leapfrog of vortex rings.” He showed the following.

Fig. 1

When two identical vortex rings move along a common axis in the same direction with the same speeds, they begin to attract each other. At the same time, the first ring 1 stretches and slows down, and the second ring 2 contracts and accelerates, slipping through ring 1. As soon as this happens, now ring 2 begins to expand and slow down, and ring 1, on the contrary, narrows and accelerates. When the sizes and speeds of the rings are equalized, this same leapfrog is repeated again and again.

But to recognize this model, it is necessary to assume that there is an ether that has the properties of an incompressible and inviscid fluid.

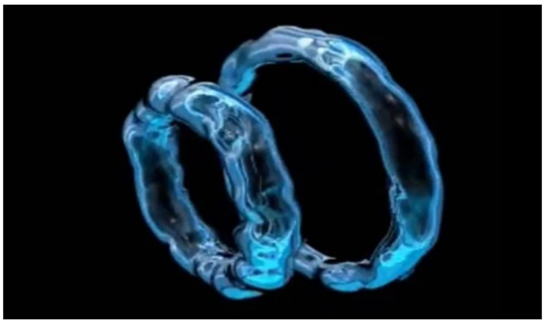

Fig. 2.

There is also a theory of neutrinos, which was proposed by Landau, Salam, Lee and Young [19]. However, this theory assumes that neutrinos have zero rest mass, which contradicts experiments.

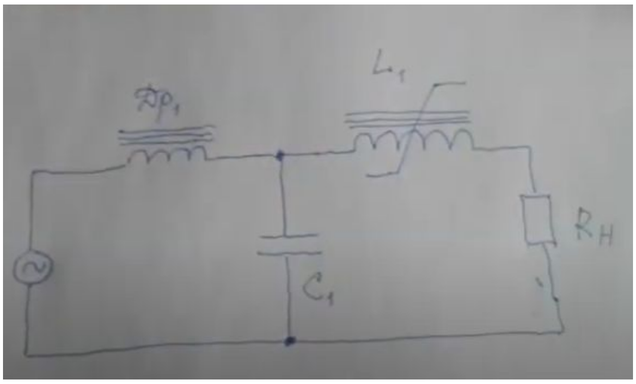

Fig. 3.

In [24] a magnetic pulse generator is considered, which creates a high-voltage pulse with a steep leading edge in a capacitor - the circuit is shown in Fig. 3. In this case, a bright area appears in the center of the capacitor, which can be touched painlessly - see Fig. 4. This phenomenon is called cold current.

We will not consider the existing explanations for this phenomenon. But this experiment is amazing: a bright spherical radiant cold area, the appearance of which is inexplicable.

A pulse with a steep leading edge can be expanded in a Fourier series, where a sinusoidal function with a high frequency will prevail. Thus, it can be assumed that the capacitor is connected to a high-voltage and high-frequency generator. No elements are connected in series with the capacitor, i.e. it is located absolutely symmetrically relative to the generator terminals. In this case, the energy flow into the capacitor comes from two sides. Two equal and oppositely directed energy flows meet exactly at the center of the capacitor. Above we considered a neutrino that was formed when two identical waves met. The object we observe in this experiment can be called a "giant neutrino."

Fig. 4.

It is proposed to consider neutrinos as DWAP. It fully corresponds to the above description of neutrinos. Above we defined for it (more precisely, for the cylinder-disk, which makes up half of the neutrino)

- energy $\overline{Q}$ according to (13),
- mass $\overline{m} = \frac{\overline{Q}}{c^2}$ – see (9),
- angular momentum $\overline{m} = \frac{\overline{Q}}{c^2}$ according to (17).

4.6. More about neutrinos

Above, we examined a neutrino, which was formed when two identical waves met, in which all characteristics coincided, except for the direction of flight and direction of rotation. This is, of course, an unlikely case. Now consider the general case when the parameters A, R, α differ and denote them for the first and second waves as A_1, R_1, α_1 and A_2, R_2, α_2. In this case, from (12, 13) we obtain:

$$\overline{W_1}(\alpha_1) = \pi \frac{\varepsilon}{\alpha_1} A_1^2 R_1^{2\alpha_1}, \tag{21}$$

$$\overline{Q_1}(\alpha_1) = \frac{\varepsilon}{c^2} \left(\frac{\omega}{\alpha_1}\right)^2 \frac{1}{2\alpha_1+2} A_1^2 R_1^{2\alpha_1+2}, \tag{22}$$

$$\overline{W_2}(\alpha_2) = \pi \frac{\varepsilon}{\alpha_2} A_2^2 R_2^{2\alpha_2}, \tag{23}$$

$$\overline{Q_2}(\alpha_2) = \frac{\varepsilon}{c^2} \left(\frac{\omega}{\alpha_2}\right)^2 \frac{1}{2\alpha_2+2} A_2^2 R_2^{2\alpha_2+2}. \tag{24}$$

After the waves meet, the newly formed particle flies towards a more massive wave (with the same speed c), and both halves of it (rotating, as before, in opposite directions with the same speeds) acquire a new parameter value α_s and a new value of the angular velocity of rotation $\frac{\omega}{\alpha_s}$ that is common to both halves .

We assume that the newly formed neutron flies towards the first wave. In this case, the kinetic power of the second half $\overline{W_{2s}} = 0$. According to the law of conservation of energy, similarly to (3.1), we find:

$$\overline{W_1}(\alpha_1) + \overline{Q_1}(\alpha_1) + \overline{W_2}(\alpha_2) + \overline{Q_2}(\alpha_2) = \overline{W_1}(\alpha_s) + \overline{Q_1}(\alpha_s) + \overline{Q_2}(\alpha_s)\,, \tag{25}$$

where

$$\overline{W_1}(\alpha_s) = \pi \frac{\varepsilon}{\alpha_s} A_1^2 R_1^{2\alpha_s}, \tag{26}$$

$$\overline{Q_1}(\alpha_s) = \frac{\varepsilon}{c^2}\left(\frac{\omega}{\alpha_s}\right)^2 \frac{1}{2\alpha_s+2} A_1^2 R_1^{2\alpha_s+2}, \tag{27}$$

$$\overline{Q_2}(\alpha_s) = \frac{\varepsilon}{c^2}\left(\frac{\omega}{\alpha_s}\right)^2 \frac{1}{2\alpha_s+2} A_2^2 R_2^{2\alpha_s+2}. \tag{28}$$

Formula (25) is an equation with one unknown $\boldsymbol{\alpha_s}$. In this case, the total energy of the pair remains constant. From here and from (9) it follows that the total mass of the pair also remains constant, i.e. the appearance of a neutron does not change the ratio of mass and energy.

5. Vacuum, dark matter, dark energy [21].

5.1. Introduction

The structure of the vacuum is studied by quantum field theory, which never gets tired make it look very complicated and, indeed, does not offer anything to describe the structure of the vacuum that is consistent with the ideas of classical physics. Below we propose such a structure, which follows only from the solution of Maxwell's equations - no additional assumptions are made. This structure can be the structure of vacuum, dark matter, dark energy, any region of space... Here we will not establish the scope of application of this structure. On the contrary, the author would like to hear a discussion of this idea, which was outlined back in 2020 [22] (Chapter 5). But the public is sternly silent.

It was proven above that there can be a cubic WAP, which is a cubic volume of vacuum, and in which a standing volumetric wave pulsates. It is important to note that this volume does NOT have any boundaries - physical or formed by the heterogeneity of the environment. WAP does NOT radiate through the faces of the cube, but on each face there is an electrical intensity, the vector of which is directed perpendicular to this face. The amount of energy, frequency, and tension at the cube's faces are functions of the size of the cube only. Apparently, there is a smallest volume of a cube, determined by the minimum energy quantum.

Many of these WAP can fill the space entirely, without gaps. And it is precisely this structure that is described below. This structure occurs in nature [20] – in Fig. 1 and Fig. 2 show so-called square waves on the sea.

Fig. 1.

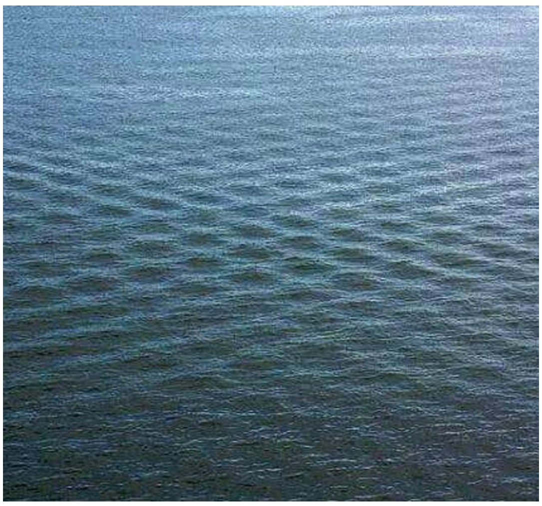

Fig. 2.

In [21, 22], Chapter 5, it is shown that there are several variants of square WAP. In Fig. Figure 1 shows one of the options - magnetic strength H_z emerging from the faces of the cube are shown. It is important to note that there is no tension in this case, although it is shown in Fig. 3. On faces with a negative value, the stress coordinates are directed in the negative direction.

The energy flow does not leave the face perpendicular to the x axis, but circulates along this face, because flux densities S_y and S_z on this face are not equal to zero. For example, $S_y = E_z H_x - E_x H_z$. Here $S_y \neq 0$. Consequently, on this face, as well as in the entire volume, there is energy with a density that does not change over time. Consequently, on this face and, in general, on all faces, there is a constant pressure equal to the energy density.

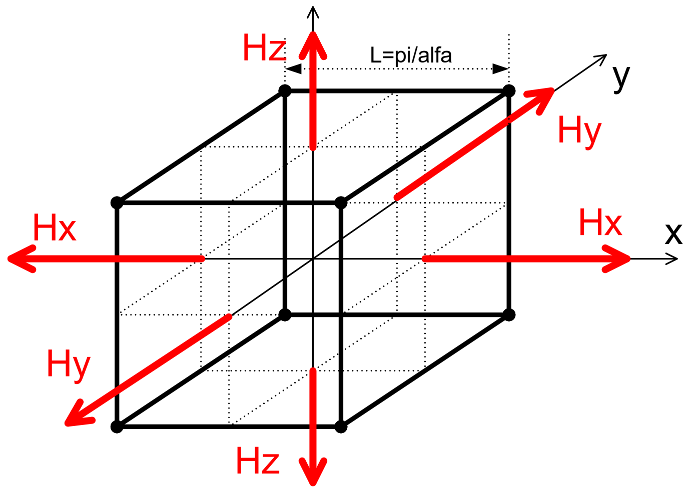

Fig. 3.

5.2. Vacuum structure

Let us now consider the set of WAP. The cubic shape of WAP suggests that many WAP form a continuous volume - see fig. 4. Various combinations of WAP are possible.

There may be a space filled with WAP, creating only magnetic strengths on the edges or only electrical strengths on the edges.

There may be a space filled with only symmetrical WAPs or only asymmetrical WAPs. In the latter case, a direction should arise in space in which there is no tension in any direction. Such a vacuum must somehow exhibit anisotropic properties.

It can be assumed that nature uses all options and there are heterogeneous spaces.

Thus, each WAP remains autonomous, but together they form a continuous volume of vacuum.

It can be assumed that all WAP have the same volume and then there is a single vacuum frequency. It can also be assumed that there are different regions of space with different (but common for a given region) volume of WAP. Then these areas should have different vacuum frequencies.

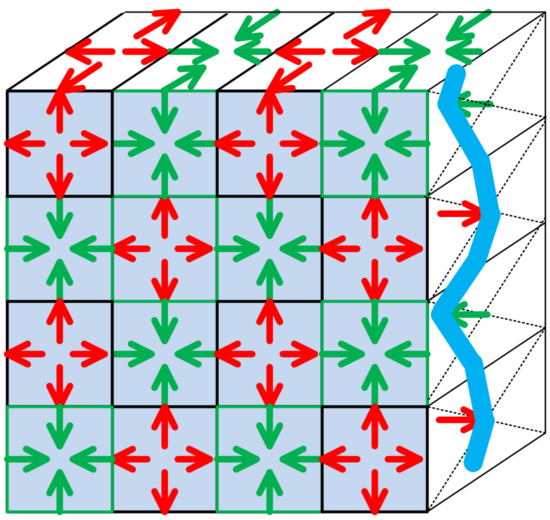
Fig. 4.

Any facet of WAP may end up on the border of an empty region of space. Then tension will arise on the border of this area - the tension that is present on the specified border of WAP. This tension is the given tension that forms a standing wave. Thus, the tension on the edge of some WAP generates a standing wave in the empty space and thereby creates a new WAP. In this way, WAP multiplies, filling the entire vacuum. It can be assumed that the Universe arose from one WAP.

5.3. Casimir effect

Let us consider the right side surface of the vacuum fragment in Fig. 3. Assume that this surface is the boundary of the WAP region. On the open surfaces of WAP in their center the vectors of tensions entering and leaving these surfaces are shown. The thick line going around the ends of these vectors conventionally depicts a wave of tension on open surfaces. These tensions vary sinusoidally in time. Thus, there is a standing wave of tensions on the surface of the WAP domain border.

But, most importantly, there is constant pressure on exposed WAP surfaces. If some body is adjacent to these surfaces, then it must experience this pressure. Thus, the body, located in a vacuum filled with WAP, experiences vacuum pressure from all sides. Each WAP area also puts pressure on the neighboring area. Consequently, WAP seeks to fill internal voids. One can argue, following Torricelli, that “a vacuum does not tolerate a emptiness.”

In more detail, the book proves that what has been said is nothing more than a proposed explanation of the Casimir effect - two parallel mirror surfaces located at short distances in a vacuum attract each other.

In the existing vacuum model, the cause of the Casimir effect is considered to be “energy fluctuations*physical vacuumdue to constant birth and disappearance in itvirtual particles*…. *This occurs due to the fact that only standing waves can exist in the space between the plates, the amplitude of which on the plates is zero. As a result, the pressure of virtual photons from the inside on the two surfaces turns out to be less than the pressure on them from the outside, where the birth of photons is not limited in any way.*“In addition, when explaining this effect, the existence of negative energy is recognized. These references are provided to highlight the apparent contradiction between the proposed and existing theories (PT and ET).

In PT it is proved that there is a volumetric standing wave with certain intensities at the nodes, and in ST it is stated that the amplitude of the intensities at the nodes (on the plates) is equal to zero (it can be proven that the law of conservation of energy is not satisfied in this case).

In PT it is proved that real particles fill the vacuum, and in ET the existence of virtual particles is assumed, the birth of which is not limited by anything, and the disappearance of which is inexplicable.

In PT it is proven that there is a constant vacuum pressure on bodies, and in ET it is assumed that such pressure is created by waves of virtual particles that constantly appear and disappear.

The ET proves the existence of negative energy, while the PT maintains respect for the law of conservation of energy.

The reader is invited to choose what he likes best.

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