Three classes of localized spherical solutions and three classes of cylindrical solutions.

Abstraction. Some solutions of the wave equation in gukuum, possibly creating the whole variety of matter.

Alexander Dubinyansky and Pavel Churlyaev.

So, again, the uniform formula of the universe:

A single formula of all matter, all Particles, all Fields and all Quantums of our Universe:

$$\frac{\partial^2 \mathbf{W}}{\partial t^2} - c^2 \Delta \mathbf{W} = 0;$$

$\overline{\mathbf{W}}$ - displacement vector elastic space

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(1-1)

Here W – displacement vector of the elastic cosmic gukuum element. c is the speed of light or the speed of transverse waves, determined by the mechanical parameters gukuum. Longitudinal waves are not considered.

We start from absolutely reliable results: solutions of the wave equation for displacement, and also physical formulas for an elastic body. The same equation (1-1) expressed in the Cartesian coordinates of the projections of the displacement vector W :

A single formula of all matter, all Particles, All Fields and all Quantums of our Universe in the projections of the displacement vector $\overline{W}$:

$$\frac{\partial^2 W_i}{\partial t^2} - c^2 \Delta W_i = 0;$$

W_i – projections of the displacement vector elastic space. i =1,2,3;

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(1-1)

VARIOUS TYPES OF SOLUTIONS equation (1-1) correspond to different types of oscillatory processes. In particular, a) waves propagating to infinity at the speed of light, b) waves localized, standing, vortex. And these kinds of solutions are not exhausted. It is very likely that some types of localized solutions can also propagate to infinity at the speed of light. And it is very likely that many waves propagating to infinity have a localized structure. All these kinds of oscillations really exist in the universe, creating a visible variety of material objects.

More later. There is an assumption that all material objects existing in our perception are localized. Including radio waves.

Definition. One of the solutions of equation (1-1) is a localized wave. This is a vortex-shaped wave object localized in space - the stress field in gukuum. The basic solution of the wave equation, which is used in gukuum theory to describe localized waves, is the sinusoidal spherical standing waves.

We work in spherical coordinates:

$$x = r\cdot sin\theta\cdot cos\varphi, \quad y = r\cdot sin\theta\cdot sin\varphi, \quad z = r\cdot cos\varphi \,;$$

A particular solution of the wave equation, spherical standing waves:

A particular solution of the wave equation: spherical standing waves.

$$W_i(r,\theta,\varphi,t) = \frac{C^i_{j,m}}{\sqrt{r}} \bullet J_{j+\frac{1}{2}}(kr) \bullet Y_{j,m}(\theta,\varphi) \bullet \cos(\omega t + \delta)$$

i=1,2,3 **(Cartesian)** ; j =0,1,2,...; m=0,1,...,j; c **- Speed of light ;**

ω **- frequency ;** λ **- wavelength ;** $\lambda\bullet\omega=c$; k = 1/λ ;

$C^i_{j,m}$ **- constants ;** $J_{j+1/2}$ **- Spherical Bessel function ;**

$Y_j(\theta,\varphi)$ **- spherical surface harmonics ;**

$Y_j(\theta,\varphi)=\Phi_m(\varphi)\bullet P_j^m(cos\theta)$;

$\Phi_m(\varphi)=(const_1 cos(m\varphi)+const_2 sin(m\varphi))$;

P_j^m **- An associated function of order** m **and rank** j ;

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(1-2)

Where $J_j+1/2$ - spherical Bessel function (simply) or, equivalently, a cylindrical Bessel function of the first kind:

$J_{j+1/2}$ **- spherical Bessel function or,**

what is the same, cylindrical Bessel function of the first kind .

$$J_{j+\frac{1}{2}}(z) = \sqrt{\frac{2}{\pi}\bullet z}^{\,j+\frac{1}{2}}\left(-\frac{1}{z}\frac{d}{dz}\right)^j\left(\frac{\sin z}{z}\right)$$

j=0,1,2,...;

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$Y_j(\theta,\varphi)$ - spherical surface harmonics;

$Y_j(\theta,\varphi)=\Phi_m(\varphi)P_{jm}(cos\theta)$;

$Y_j(\theta,\varphi)= P_{jm}(cos\theta)\ \Phi_m(\varphi)= P_{jm}(cos\theta)(a_m cosm\varphi+b_m sinm\varphi)$;

P_{jm} - The adjoint Legendre function of type 1, of the order m and rank j :

P^m_j - Adjoint order function m and rank j

$$P_j^m(x) = (1 - x^2)^{\frac{m}{2}} \frac{1}{2^j j!} \frac{d^{j+m}}{dx^{j+m}} [(x^2 - 1)^j]$$

i=1,2,3 (cartesian); j=0,1,2,...; m=0,1,...,j;

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(1-3)

$\Phi_m(\varphi)=(const_1 \bullet cosm\varphi + const_2 \bullet sinm\varphi)$;

Further in the formulas, the quantity k , the figures are given in the pictures $k=1/\lambda$. It is related only to the actual mass (energy) of the particle, and it is determined by it. There is no theoretical meaning in it. It is nothing more than a link between ω in the vibrational part of the solution and the radial coordinate in the Bessel function: $\omega=k*c$, c - speed of light. The physics is such that in each particle (in each solution), due to physical reasons, the frequency of the wave traveling along the circle and its particle size are set. Physical causes are determined by the form of the solution, and the way the solution is wound up on itself, and how the whole system stabilizes to a stable state. Also, particles have excited states. It is not yet possible to investigate this. This can only be observed. Thus, all further solutions and formulas are only an illustration of the state in which all the wave vortices are located = loks = elementary particles.

On subsequent pages it will be shown that this value for different particles is different and equal to:

Wave numbers k of loks (j,m)

(elementary particles $\mu_{j,m}$):

$$k_{j,m} = \frac{\mu_{j,m} \bullet c \bullet K^E_{j,m}}{\pi \bullet M_{j,m} \bullet K^M_{j,m}}$$

$K^E{}_{j,m}$, $K^M{}_{j,m}$ - coefficients obtained after solving equations. $M_{j,m}$ - angular momentum.

k - Wave number. j=0,1,2,3,...; m=0,1,2,...,j;

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It is suggested that the velocity of motion of a perturbation in a localized wave is equal to the velocity of transverse waves in gukuum or the speed of light.

In localized oscillations corresponding to the solution (1-2) at first glance, there is not only a circular oscillation, there is no transfer of energy at all. These are truly standing, vibrating vibrations in one place. But that's the situation in fact.

CLASS 1. Allegedly localized "radiation sources" (traditional). The simplest case: j = 0 . Since equation (1-2) is linear, any linear combination of solutions (1-2) will also be a solution of (1-1). From (1-2), taking into account the fact that j = 0,±1, ±2,... it is possible to construct such a linear combination of solutions:

$$W_{0,0}(r,\theta,\varphi,t) = \sqrt{\frac{2k}{\pi}} \bullet \{\frac{\sin kr}{kr} \bullet \cos(\omega t) - \frac{\cos kr}{kr} \bullet \sin(\omega t)\}$$

k - Wave number. i=1,2,3 (cartesian);

$\omega = c \bullet k$; c - Speed of light.

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(1-4)

Откуда получается для j = 0 here is such a localized (!) spherical wave:

For $j=0$ it turns out this localized (!) spherical wave:

$$W_{0,0}(r,\theta,\varphi,t) = \sqrt{\frac{2k}{\pi}} \bullet \frac{\sin(kr - \omega t)}{kr}$$

k - Wave number. i=1,2,3 (cartesian);

$\omega = c \bullet k$; c - Speed of light.

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(1-5)

It is difficult not to recognize in this solution the radiation of a point source. Physicists know that the flow of energy is there! Here is a mathematical trick.

A similar linear combination for j = 1 we also obtain the dipole radiation known in physics:

For j=1 it turns out the known In physics, the radiation of a dipole:

$$W_i(r,\theta,\varphi,t) = A \bullet \left[\frac{1}{kr^2} \bullet \cos(\omega t - kr) - \frac{1}{r} \bullet \sin(\omega t - kr) \right] \bullet \cos\theta$$

k - Wave number. i=1,2,3 (cartesian);

j,m - integer; A - Arbitrary;

$\omega = c \bullet k$; c - Speed of light.

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And there are probably a lot of such combinations. For other j, the transformations are more cumbersome, and multilobal waves are likely to result. What objects correspond to these waves is a separate topic.

As will be shown below, this class of solutions actually determines localized wave objects moving at light speed. And specifically: photons and neutrinos. And other, not yet known in science education, moving with the speed of light.

The general formula for objects moving at the speed of light (photons, neutrinos and others):

The displacement formula for objects moving with speed of light (photons, neutrinos, etc.):

$$W_i(r,\theta,\varphi,t) = \frac{C^i_{j,m}}{\sqrt{r}} \bullet J_{j+\frac{1}{2}}(kr \pm \omega t) \bullet Y_{j,m}(\theta,\varphi)$$

k - Wave number. i=1,2,3 (cartesian); j,m - 0,1,2,...;

$C_{j,m}$ - Arbitrary; $\omega = c \bullet k$; c - Speed of light.

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(1-6)

True, a preliminary check shows that formally the energy integral over the given formula does not converge. But as we have seen before, you can not simply formally integrate. Necessarily somewhere there will be "winding", which must be taken into account. Maybe this test should be done better. The following reasoning may apply. The fact is that photons - they are here, are formed before our very eyes, in the present tense and massively. Therefore, at the time of formation, their shape is very far from the formula described above. Further, during the flight, they gradually relax to a normal form and all this occurs at a light speed. That is, the photon is already in the process of flying gradually grows this "divergent as an integral tail." This tail, despite the fundamental infinity of its energy in infinite time, remains at any finite time not too large in percentage to the energy of the photon center. But they always remain with the finite, initially given energy. By the way, is this the cause of the cosmic "red shift"?!

CLASS 2. You can try to apply the focus described above not to the variable r, but to the variable φ. For example, the solution (1-1) can be the following linear combination of solutions (1-2):

$$W(r,\theta,\varphi,t) = \frac{C_j}{\sqrt{r}} \bullet J_{j+\frac{1}{2}}(kr) \bullet P^m_j(\cos\theta) \bullet$$
$$\bullet [\sin m\varphi \bullet \cos(\omega t) - \cos m\varphi \bullet \sin(\omega t)]$$

k - Wave number. i=1,2,3 (cartesian);

j,m - integer; C_j - Arbitrary;

$\omega = c \bullet k$; c - Speed of light.

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(1-7)

or after an obvious transformation:

Solenoidal solutions. In such a wave
All energy moves around the axis. This
The class of solutions defines elementary
particles: a proton, a neutron, an electron, mesons, etc.

$$W(r,\theta,\varphi,t) = \frac{C_j}{\sqrt{r}} \bullet J_{j+\frac{1}{2}}(kr) \bullet P_j^m(\cos\theta) \bullet$$
$$\bullet \sin(m\varphi - \omega t)$$

k - **Wave number.** i=1,2,3 **(cartesian);**

j, m - **integer;** C_j - **Arbitrary;**

$\omega = c \bullet k$; c - **Speed of light.**

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(1-8)

And this is not the radiation of the point source, but the perturbation running around in a circle.

Even for m = 0, the energy is still moving. The thing is that the gukuum itself does not move, it vibrates on the spot. Like a flickering chain of people on a fire, passing buckets of water to each other. But the energy of this vibration moves, like buckets of water. Sometimes two counterflows of energy create the appearance of neutralization of each other, and then a solution (1-2) is obtained.

We call solutions (1-8) solenoidal. In such localized oscillations, energy moves around a certain axis.

For simple solutions with m = 0, there is also axial symmetry.

As will be shown below, this class of solutions actually defines "inactive" localized wave objects. And specifically: all the elementary particles known to us, the proton, the neutron, the electron, the mesons, and so on. And other elementary particles, not yet known in science.

CLASS 3. But the focus does not end there. Is the variable θ worse? There exist adjoint functions (see solution (1-2), (1-3)), which can be represented as products:

$$P_{j,m} = P^*_{j,m} \cdot \sin\theta \; ; \quad u \quad P_{j,m} = P^{**}_{j,m} \cdot \cos\theta \; ; \qquad (1\text{-}9)$$

eg,

$$P_{2,1} = -3 \sin\theta\cos\theta; \quad P^*_{2,1} = -3 \cos\theta \; ; \quad P^{**}_{2,1} = -3 \sin\theta \; ;$$

To these solutions, you can apply the focus described above, not only to the variable φ, but to the variable θ. Here, the goal is not a complete study of all possible solutions of the wave equation. But experience tells us that it is also possible to draw a similar linear combination of solutions (1 - 2) in the variable θ and get something like:

Toroidal solutions of the wave equation:

$$W(r,\theta,\varphi,t)=\frac{C_j}{\sqrt{r}}\bullet J_{j+\frac{1}{2}}(kr)\bullet$$

$$\bullet(P^*_{j,m}-Q^*_{j,m})\bullet\sin(m\varphi)\bullet\sin(m\theta-\omega t)$$

k - Wave number ; j=0,1,2,...; m=0,1,...,j;

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(1-10)

In such objects, the energy does not rotate around the axis, but around the imaginary toroidal core, with the entrance inward. We call such localized oscillations toroidal. Their research is also a separate issue. It seems that in toroidal coordinates this will be simpler, more beautiful and there will be no singularities.

I remember the ball lightning. Here its field (not purely electromagnetic!), Rolled up with lightning (this process is assumed by us at the formation of ball lightning, see below) as the fingertip from the finger (or according to Lermontov, as the thimble of debauchery) just turns out to be toroidal.

So, here is the hypothetical formula of ball lightning (naturally, in spherical coordinates):

Hypothetical formula for objects like spherical Lightning (in spherical coordinates):

$$W(r,\theta,\varphi,t)=\frac{C_j}{\sqrt{r}}\bullet J_{j+\frac{1}{2}}(kr)\bullet$$

$$\bullet(P^*_{j,m}-Q^*_{j,m})\bullet\sin(m\varphi)\bullet\sin(m\theta-\omega t)$$

Here $\overline{W}$ – displacement vector of the elastic element space gukuum.

k - Wave number. i=1,2,3 (cartesian);

j,m - integer; C_j - Arbitrary;

$\omega=c\bullet k$; c - Speed of light.

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(1-11)

CLASS 4. A similar situation with dotted zippers. Only there the field does not roll down, but remains after the slow decay of lightning. A solenoidal field is obtained, only in cylindrical coordinates. So the mathematical focus gets practical realization. There is

a certainty that there will be many such mathematical tricks.
We work in cylindrical coordinates:

$$x = \rho \cdot cos(\theta), \quad y = \rho \cdot sin(\theta), \quad z = z \,;$$

The main solution having a physical meaning, or Hypothetical formula of objects of the type dotted lightning (in cylindrical coordinates), has the form:

The hypothetical formula for objects of the type lightning (in cylindrical coordinates):

$$W_i(\rho, z, \varphi, t) = c_i e^{\mu ikz} \bullet Z_m(\rho\sqrt{k^2 + K^2}) \bullet$$
$$\bullet (a \cos m\varphi + b \sin m\varphi) \bullet \cos(\omega t + \gamma)$$

This solution should be mathematically a kind of endless garland of sausages along the Z axis.

Here $\overline{W}$ – displacement vector of the elastic element space gukuum. i=1,2,3 (cartesian); m - integer;

c_i, γ, k, K - arbitrary;

$\omega = c \bullet k$; c - Speed of light. Z - Arbitrary Cylindrical Bessel functions of the first kind. These are sinusoidal cylindrical waves.

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(1-12)

Here W_i are the components of the displacement vector of the elastic cosmic gukuum element.

This solution mathematically should be a kind of endless garland of sausages along the Z axis. And if it is physically feasible, then it is very likely that this object will turn out to be a dotted lightning. Some analysis of this decision is made, here it is not given. The energy integrals converge (in terms of one sausage). But we postpone it for the future.

In addition to the cylindrical solution, one can certainly perform work as well as over a spherical solution. That is, similarly to find those three types of solutions, and the corresponding objects that generate the solution of the wave equation in cylindrical coordinates. In a cylindrical solution one can use the variables $(z \pm \omega t)$ and $(\rho \pm \omega t)$:

Hypothetical formula for objects moving along the Z axis:
(in cylindrical coordinates):

$$W(\rho, z, \varphi, t) = ce^{\mu ik(z \pm \omega t)} \bullet Z_m(\rho\sqrt{k^2 + K^2}) \bullet (a\cos m\varphi + b\sin m\varphi)$$

These are sinusoidal waves running along the Z axis.

Here $\overline{W}$ – displacement vector of the elastic element of the space gukuum.

i=1,2,3 (cartesian); m - integer; c_i, γ, k, K - arbitrary;

$\omega = c \bullet k$; c - Speed of light. Z_m - Arbitrary

Cylindrical Bessel functions of the first kind.

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(1-13)

and

The hypothetical formula of cylindrical waves diverging from the Z axis:
(in cylindrical coordinates):

$$W(\rho, z, \varphi, t) = ce^{\mu ikz} \bullet Z_m[(\rho \pm \omega t)\sqrt{k^2 + K^2}] \bullet (a\cos m\varphi + b\sin m\varphi)$$

These are fading cylindrical waves leaving the Z axis.

Here $\overline{W}$ – displacement vector of the elastic element of the space gukuum.

i=1,2,3 (cartesian); m - integer; c_i, γ, k, K - arbitrary;

$\omega = c \bullet k$; c - Speed of light. Z_m - Arbitrary

Cylindrical Bessel functions of the first kind.

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(1-14)

What is the physical meaning of the formulas obtained, so far we will not guess. Where is the photon, where the neutrino, where the radio waves, where other objects moving at the speed of light. This is the future's business.