STUDIES OF PHYSICS

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MMXV

Contents

Introduction

- Model of special relativity is built. The model shows the basic formulas of the special relativity and their physical sense.
- We have built a model of the mass of the photon field, which fully reflects the inertial and gravitational properties of matter. It is shown that the model of mass can not move faster than light.
- We discuss the gravitational collapse of a photon. It is shown that when the photon gets Planck energy, it turns into a black hole (as a result of interaction with the object to be measured). It is shown that three-dimensional space is a consequence of energy advantage in the formation of the Planck black holes. New uncertainty relations established on the basis of Einstein's equations. It is shown that the curvature of space-time is quantized.
- We are considering the possibility of placing the space of any length in the "point" (ie, in a small region of space), including the Universe at the "point" with to the Planck size. The problem is solved in a multidimensional space.
- We show that Bohr's complementarity principle can be generalized to all the phenomena of reality. The generalized principle of complementarity Bohr can be formulated as follows: the rational side of reality and conjugate irrational side of reality are complementary to each other. This raises the question of relations between science and mysticism.

Chapter 1

Special relativity

1.1 Model of special relativity

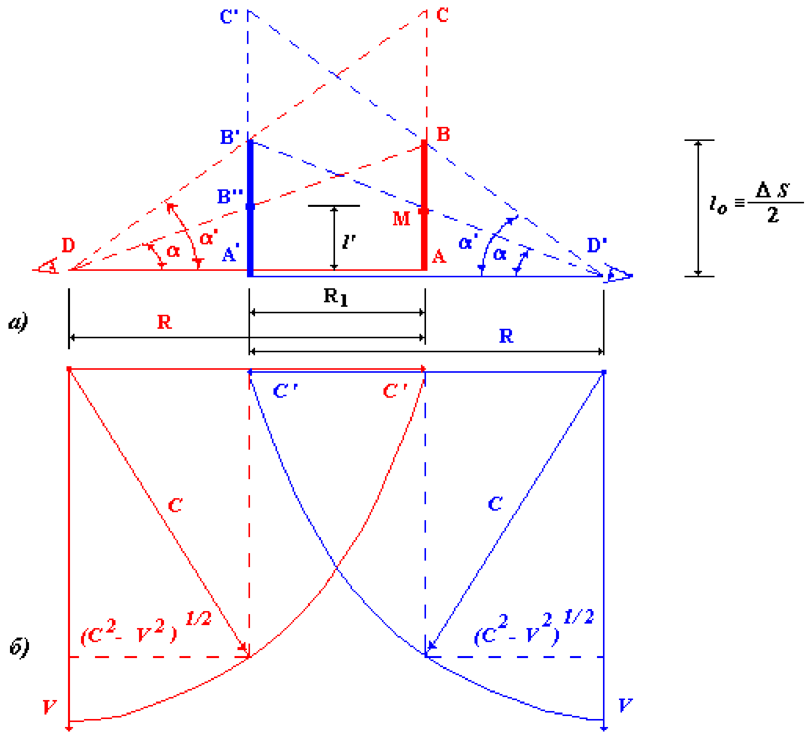

Figure 1.1: Model of special relativity

Create different kinds of models plays an important role in scientific knowledge . Therefore, the construction of a visual model of the special relativity is of great importance for the explanation of the phenomena (length contraction, time dilation processes) inaccessible to direct perception of human senses.

Model of special relativity (analogy model) is a system of two observers and two rods (Fig.1.1a). Here AB and $A'B'$ - rods with a length l_0. At points D and D' are observers. R -

permanent distance, R_1 - variable distance. Thus, each observer associated with a respective rod (own reference system indicated in red or blue). From Figure 1a is easy to obtain equations that are valid with respect to both observers

$$l' = l_0\left(1 - \frac{R_1}{R}\right) \tag{1.1}$$

$$\tan\alpha' = \frac{\tan\alpha}{1 - R_1/R} \tag{1.2}$$

$$R\tan\alpha = \tan\alpha'(R - R_1) = invariant \tag{1.3}$$

Suppose that the light signal travels from point A to point B and returns to the point A. Then the formula (1.1), (1.2), (1.3) will have the form

$$l' = l_0\sqrt{1 - \frac{v^2}{c^2}} \tag{1.4}$$

$$\Delta t' = \frac{\Delta t_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{1.5}$$

$$c\Delta t_0 = c'\Delta t' = \left(c^2 - v^2\right)^{1/2}\Delta t' = \left(c^2\Delta t'^2 - \Delta x'^2\right)^{1/2} = \Delta S \tag{1.6}$$

Here, l' is a projection of the light beam on the rod $A'B'$; $\Delta t_0 = 2\tan\alpha(R/c)$ and $\Delta t' = 2\tan\alpha'(R/c)$ is times of the light signal back and forth; c is speed of light; ΔS is invariant.

Formulas (1.4), (1.5) and (1.6) are similar to the formulas of special relativity. Therefore all the conclusions of special relativity clearly displayed in the model.

An illustrative example: observers in the aircraft and on the ground. The size of the aircraft will be reduced and the speed of his movements is slow and vice versa.

Chapter 2

Inertial and gravitational mass (field model)

2.1 Field model

We consider a thought experiment. Let weightless cylinder is located in the reference frame K' (axis X, Y, Z). The height of the cylinder is equal to h (Fig 4.1). The top cover of the cylinder is denoted by the letter S_2, and the bottom cover is denoted by the letter S_1. S_1 and S_2 are mirrors.

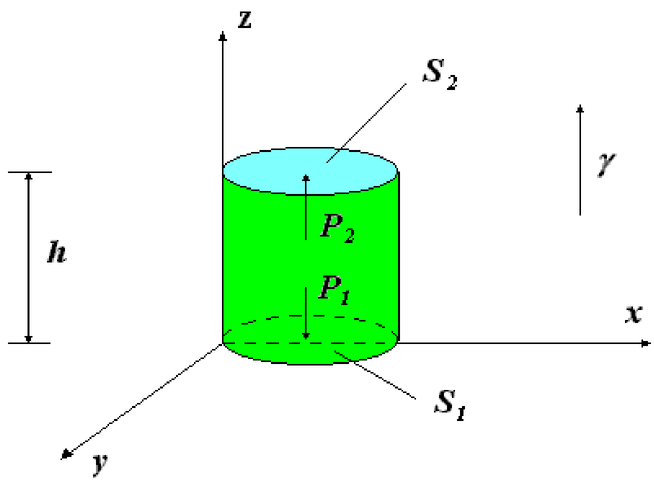

Figure 2.1: Model of mass

Let the system of reference K' (cylinder) is moving with uniform acceleration in the direction of positive values of Z (acceleration γ). Let from S_2 to S_1 emitted quantum of light - a photon with energy E_0. We consider this process in the system K_0, which has no acceleration. Assume that at the moment when the radiation energy E_0 is transferred from S_2 to S_1, K' system has a speed equal to zero (with respect to system K_0). Light quantum will appear in S_1 after time h/c (in first approximation), where c is the velocity of light. At this time, the bottom of the cylinder S_1 has a speed $v = \gamma h/c$. Therefore, according to special relativity, reaching S_1 radiation has an energy E_1, which is equal to

$$E_1 \approx E_0\,(1 + v/c) = E_0\,(1 + \gamma h/c^2) \tag{2.1}$$

Momentum is

$$P_1 = E_1/c = E_0\,(1+\gamma h/c^2)/c \tag{2.2}$$

Let the light quantum with the same energy E_0 is emitted from S_1 in the direction S_2. Then the energy of the radiation reaching the wall S_2 and momentum are of the form

$$E_2 \approx E_0\,(1-v/c) = E_0\,(1-\gamma h/c^2) \tag{2.3}$$

$$P_2 = E_2/c = E_0\,(1-\gamma h/c^2)/c \tag{2.4}$$

If we simultaneously send two light quanta of equal energy - one in the direction of S_1 and the second in the direction S_2, the recoil momenta mutually balanced by, and will play a major role (2.2) and (2.4). Then we get

$$\Delta P = P_1 - P_2 = (2E_0/c^2)(\gamma h/c) = 2\,m\,\Delta v \tag{2.5}$$

where $2\,m = 2E_0/c^2$ is inert mass; coefficient 2 corresponds to two photons.

Weightless cylinder in which there is radiation, as a result of the acceleration behaves as if it has an inertial mass $2\,m$, and the momentum ΔP this inert mass, as is easily seen from Fig.2.1, is directed in the direction opposite the acceleration vector γ. Cylinder with photons within it resists an accelerating force. It is one of the characteristic manifestations of the physical property, which is called "mass".

Model inertial mass indicates that the inertia of the material bodies is their intrinsic property and Mach's principle does not apply to material bodies.

Next. Let weightless cylinder (Fig.2.1) is not accelerating, and is on stand and it is in a weak gravitational field of the Earth. Downstairs field potential is zero, at the height h it equals φ. Taking into account the principle of equivalence can be written $\gamma h = \varphi$. Let from S_2 to S_1 sent a photon of energy E_0. The energy and momentum of the photon will change according to the formulas

$$E_1 \approx E_0\,(1+\varphi/c^2) \tag{2.6}$$

$$P_1 = E_1/c = E_0\,(1+\varphi/c^2)/c \tag{2.7}$$

On the other hand, emitting a photon of energy E_0 from S_1 to S_2 we obtain

$$E_2 \approx E_0\,(1-\varphi/c^2) \tag{2.8}$$

$$P_2 = E_2/c = E_0\,(1-\varphi/c^2)/c \tag{2.9}$$

As a result, the difference of P_1 and P_2 is equal to

$$\Delta P = P_1 - P_2 = (2E_0/c^2)(\Delta\varphi/c) = 2\,m\,(\Delta\varphi/c) \tag{2.10}$$

and directed towards the center of the Earth. Here $2m = 2E_0/c^2$ - a heavy mass. Therefore, the force acting on S_1, is

$$F_z = \Delta P/\Delta t = -2\,m\,(\Delta\varphi/c\,\Delta t) \tag{2.11}$$

For light in the field of the Earth vertically $c\,\Delta t = \Delta z$, then $F_z = -2\,m\,(\Delta\varphi/\Delta z)$ or, more generally

$$F(\vec{r}) = -2\,m\,grad\,\varphi(\vec{r}) \tag{2.12}$$

where $\varphi(\vec{r}) = -G\,M/r$; G - gravitational constant; M - mass of the Earth.

We have received expression for the force of gravity acting on the cylinder, it follows from Newton's theory of gravitation.

The model implies that the free movement of the material structure in the gravitational field is a consequence of the constant redistribution of impulses of massless quanta of energy in relation to the body structure.

Thus, the model adequately reflects the inertial and gravitational properties of massive bodies.

Next. The system of two coupled photons, as we have shown above, has inertial properties and will therefore move with a speed less than the speed of light, or rest. The velocity of light for such a system would be at maximum speed. If the body is made of light, it can not move faster than light.

Thus massless form of matter is primary and fundamental. The massive form of matter is secondary, derivative form.

Chapter 3

To the quantum theory of gravity

3.1 The collapse of the photon and the Planck length

The Planck length ℓ_{P} is defined as $\ell_{\mathrm{P}} = \sqrt{\frac{\hbar G}{c^3}} \approx 1.616\,199(97) \times 10^{-35}$ m, where c is the speed of light in a vacuum, G is the gravitational constant, and $\hbar$ is the reduced Planck constant.

Simple dimensional analysis shows that the measurement of the position of physical objects with precision to the Planck length is problematic. Indeed, we will discuss the following thought experiment. Suppose we want to determine the position of an object using electromagnetic radiation, i.e., photons. The greater the energy of photons, the shorter their wavelength and the more accurate the measurement. If the photon has enough energy to measure objects the size of the Planck length, it would collapse into a black hole and the measurement would be impossible (as a result of interaction with the object to be measured). Thus, the Planck length sets the fundamental limits on the accuracy of length measurement [1].

According to general relativity, any form of energy, including collision energy of a photon with the target, should generate a gravitational field. The higher the energy of the photon, the more powerful gravitational field is generated. We know that the photon has a kinetic energy $E_{kin} = P\,c$, where P is the photon momentum, and c its speed. This energy is positive. But the photon has, according to general relativity, gravitational (potential) energy. This energy is negative. We find its formula from the analogy with the potential energy of massive particles. For a homogeneous sphere of radius r and mass M, its gravitational energy has the form

$$E_{pot} \approx -G\,M^2/r$$

where G is the gravitational constant, M is the mass of the ball, and r its radius. But a photon has no mass M. Therefore M is replaced by the $M \to P/c$, where P is the photon momentum and c is the speed of light in a vacuum. Then the gravitational energy of the photon has the form

$$E_{pot} \approx -G\,P^2/c^2 r$$

where r is necessary to compare with the photon's wavelength λ. The total energy of the interaction of photons with the target is the sum of kinetic and potential energies and has the following form

$$E = E_{kin} + E_{pot} \approx P\,c - \frac{G\,P^2}{c^2\,\lambda} = P\,c\left(1 - \frac{G\,P}{c^3\,\lambda}\right) = P\,c\left(1 - \frac{\lambda_s}{\lambda}\right) \tag{3.1}$$

(here photon spin is not considered, but it is not essential), $\lambda_s = (G/c^3)P$ is an analogue of the gravitational radius for a massive particle $r_s \approx (G/c^3)mc$.

Consider equation (3.1) from the quantum point of view. We assume that $P\,\lambda \approx \hbar$, where $\hbar$ is the Dirac constant. Using this relation (substituting $P \approx \hbar/\lambda$), we find the function $E(\lambda)$

from the equation (3.1)

$$E(\lambda) = \frac{\hbar c}{\lambda}\left(1 - \frac{\ell_P^2}{\lambda^2}\right) \tag{3.2}$$

where $\ell_P = \sqrt{\hbar G/c^3}$ is the fundamental Planck length, which appears here automatically.

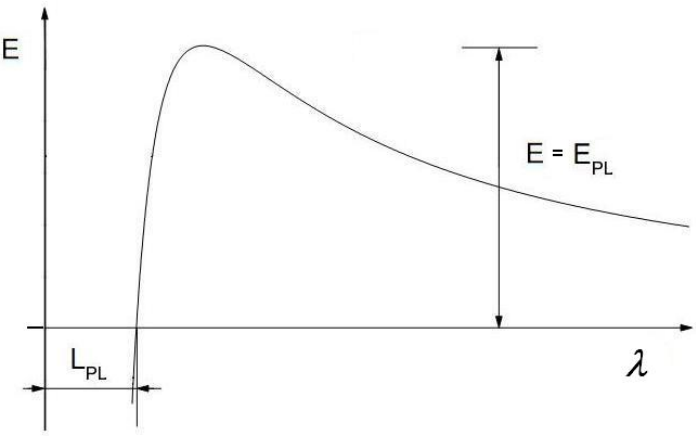

Figure 3.1: Graphs $E(\lambda)$ of the collapse of the photon

When we construct a graph of the function $E(\lambda)$, we can see that as the photon wavelength decreases, its energy increases, see Fig.3.1. The maximum total energy $E(\lambda)$ is approximately equal to the Planck energy, where the photon wavelength is approximately equal to the Planck length. However, if the photon momentum continues to increase, its total energy begins to decrease due to the increase of the gravitational energy of the photon. When the wavelength of the photon is equal to the Planck length, its total energy is zero; The photon collapses and turns into a microscopic black hole, the hypothetical Planck particle (for example, a collision with the target).

To be more accurate, we must proceed from Hamilton-Jacobi equation [2]

$$g^{ik}\partial^2 S/\partial x^i \partial x^k = m^2\, c^2 \tag{3.3}$$

with metric coefficients g^{ik}, taken from Schwarzschild solution, where S is the action and m is the particle mass. It is a generalization of the equation between energy and momentum in special relativity $E^2 - \mathbf{p}^2c^2 = m^2c^4$. Equation (3.3) is generally covariant (physical content of equations does not depend on the choice of coordinate system). This Hamilton-Jacobi equation has the form

$$\left(1 - \frac{r_s}{r}\right)^{-1}\left(\frac{\partial S}{c\partial t}\right)^2 - \left(1 - \frac{r_s}{r}\right)\left(\frac{\partial S}{\partial r}\right)^2 - \frac{1}{r^2}\left(\frac{\partial S}{\partial \varphi}\right)^2 - m^2c^2 = 0 \tag{3.4}$$

It can be rewritten as follows

$$E^2 = \left(1 - \frac{r_s}{r}\right)^2 P^2c^2 + \left(1 - \frac{r_s}{r}\right)\frac{N^2c^2}{r^2} + \left(1 - \frac{r_s}{r}\right)m^2c^4 \tag{3.5}$$

where N is the angular momentum of a particle and r_s is the gravitational radius of the central attracting body.

The following assumptions are necessary for the approach above: 1) the mass of the particle m is zero, 2) angular momentum (spin of the photon) N can be neglected, 3) the Heisenberg uncertainty principle is simplified to $P\,r \approx \hbar$. We then obtain an approximate equation for the total energy

$$E \approx \left(1 - \frac{r_s}{r}\right) P\,c = \left(1 - \frac{2G\,M}{c^2 r}\right) P\,c \approx \left(1 - \frac{2\ell_P^2}{\lambda^2}\right) \frac{\hbar c}{\lambda} \tag{3.6}$$

where $r = \lambda$ is the wavelength of a photon and $r_s = 2G\,M/c^2$ is the gravitational radius. Mass M should be replaced by P/c; $P = P \approx \hbar/\lambda$ is the momentum of a photon. The resulting equation (3.6) agrees with the equation (3.2) for the total energy to within a factor of 2.

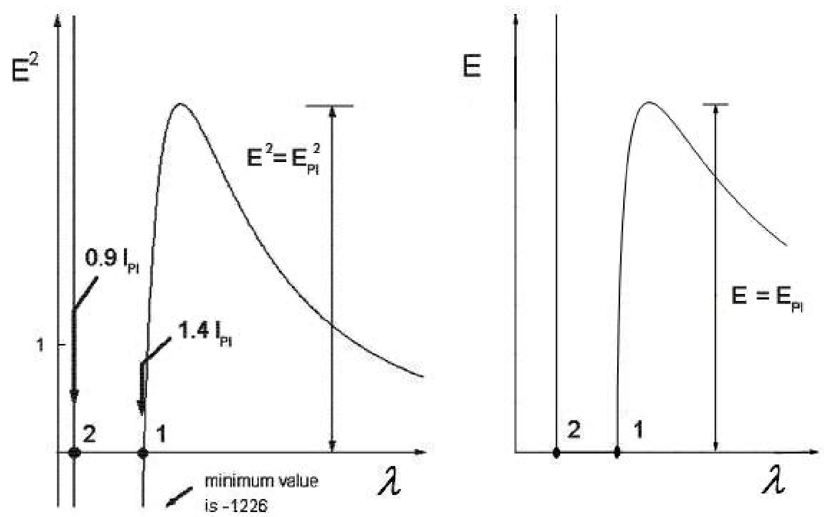

Figure 3.2: Graphs of the collapse of a photon with angular momentum

To account for the angular momentum of the photon in the above equation (3.5) it is necessary to substitute N^2 with $\hbar^2 l(l+1)$, where l is the quantum number of the total angular momentum of the photon (see Fig. 3.2). The angular momentum of a photon leads to the formation of internal event horizon in Planck black hole ($l = 1$, point 2).

Analysis of the Hamilton-Jacobi equation for the photon in spaces of different dimensions n indicates a preference (energy gain) for three-dimensional space for the emergence of the Planck black holes - both real and virtual (quantum foam).

Indeed, according to Ehrenfest [3], expressions for the potential energy in spaces of various dimensions are of the form

$$E_{pot}^{(n\geq 3)} \approx -\frac{k\,M^2}{(n-2)r^{n-2}}; \quad n \geq 3 \tag{3.7}$$

$$E_{pot}^{(2)} \approx k\,M^2 \ln r; \quad n = 2 \tag{3.8}$$

$$E_{pot}^{(1)} \approx k\,M^2\, r; \quad n = 1 \tag{3.9}$$

where k - the interaction constant in n-dimensional space. With the usual Newton's constant it is linked through cross-linking potentials for 3-dimensional space and the corresponding n-dimensional space.

For the potential energy of the photon, equations (3.7), (3.8), (3.9) have the form (given that $M \to P/c$; $P \approx \hbar/\lambda$; $r = \lambda$)

$$E_{pot}^{(n\geq 3)} \approx -\frac{k\,(P/c)^2}{(n-2)r^{n-2}} = -\frac{k\,(\hbar/\lambda\,c)^2}{(n-2)\lambda^{n-2}}; \quad n \geq 3 \tag{3.10}$$

$$E_{pot}^{(2)} \approx k\,(P/c)^2 \ln r = k\,(\hbar/\lambda\, c)^2 \ln \lambda; \quad n = 2 \tag{3.11}$$

$$E_{pot}^{(1)} \approx k\,(P/c)^2\, r = k\,(\hbar/\lambda\, c)^2\, \lambda; \quad n = 1 \tag{3.12}$$

Then the total energy of the photon is approximately equal to

$$E^{(n)}(\lambda) \approx E_{kin} + E_{pot}^{(n)}$$

where $E_{kin} = P\,c = \hbar\, c/\lambda$ on the space dimension is independent.

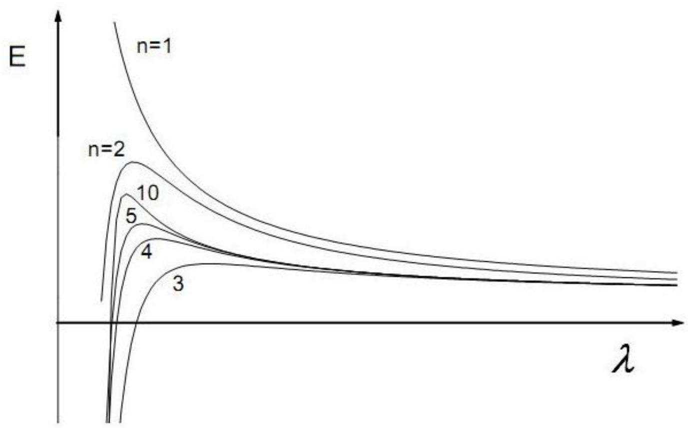

Figure 3.3: Graphs $E^{(n)}(\lambda)$ of the collapse of the photon in the spaces of different dimensions

Graphics functions $E^{(n)}(\lambda)$ are shown in Fig. 3.3 (here $k = \hbar = c = 1$). Thus gain in energy, apparently, predetermined three-dimensionality of the observed space, given that the Planck virtual black holes form the so-called quantum foam, which is the foundation of the "fabric" of the Universe.

3.2 Heisenberg uncertainty principle at the Planck scale.

There is currently no proven physical significance of the Planck length; it is, however, a topic of theoretical research. Physical meaning of the Planck length can be determined as follows:

A particle of mass m has a reduced Compton wavelength

$$\bar{\lambda}_C = \frac{\lambda_C}{2\pi} = \frac{\hbar}{mc}$$

Schwarzschild radius of the particle is

$$r_s = \frac{2G\,m}{c^2} = \frac{2G}{c^3} m\,c$$

The product of these values is always constant and equal to

$$r_s \bar{\lambda}_C = \frac{2G\hbar}{c^3} = 2\ell_P^2$$

Accordingly, the uncertainty relation between the Schwarzschild radius of the particle and Compton wavelength of the particle will have the form

$$\Delta r_s \Delta \bar{\lambda}_C \geq \frac{G\hbar}{c^3} = \ell_P^2$$

which is another form of Heisenberg's uncertainty principle at the Planck scale. Indeed, substituting the expression for the Schwarzschild radius, we obtain

$$\Delta \left(\frac{2Gm}{c^2} \right) \Delta \bar{\lambda}_C \geq \frac{G\hbar}{c^3}$$

Reducing the same characters, we come to the Heisenberg uncertainty relation

$$\Delta \left(mc \right) \Delta \bar{\lambda}_C \geq \frac{\hbar}{2}$$

Uncertainty relation between the gravitational radius and the Compton wavelength of the particle is a special case of the general Heisenberg's uncertainty principle at the Planck scale

$$\Delta R_\mu \Delta x_\mu \geq \ell_P^2 \tag{3.13}$$

where R_μ is the radius of curvature of space-time small domain; x_μ is the coordinate small domain.

Indeed, these uncertainty relations can be obtained on the basis of Einstein's equations

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \tag{3.14}$$

where $G_{\mu\nu} = R_{\mu\nu} - (1/2) g_{\mu\nu} R$ is the Einstein tensor, which combines the Ricci tensor, the scalar curvature and the metric tensor, Λ is the cosmological constant, $T_{\mu\nu}$ is energy-momentum tensor of matter, π is the number, c is the speed of light, G is Newton's gravitational constant.

In the derivation of his equations, Einstein suggested that physical spacetime is Riemannian, ie curved. A small domain of it is approximately flat spacetime.

For any tensor field $N_{\mu\nu\ldots}$ value $N_{\mu\nu\ldots}\sqrt{-g}$ we may call a tensor density, where g is the determinant of the metric tensor $g_{\mu\nu}$. The integral $\int N_{\mu\nu\ldots}\sqrt{-g}\, d^4x$ is a tensor if the domain of integration is small. It is not a tensor if the domain of integration is not small, because it then consists of a sum of tensors located at different points and it does not transform in any simple way under a transformation of coordinates [4]. Here we consider only small domains. This is also true for the integration over the three-dimensional hypersurface S^ν.

Thus, Einstein's equations (3.14) for small spacetime domain can be integrated by the three-dimensional hypersurface S^ν. Have

$$\frac{1}{4\pi} \int \left(G_{\mu\nu} + \Lambda g_{\mu\nu} \right) \sqrt{-g}\, dS^\nu = \frac{2G}{c^4} \int T_{\mu\nu} \sqrt{-g}\, dS^\nu \tag{3.15}$$

Since integrable spacetime "domain" is small, we obtain the tensor equation

$$R_\mu = \frac{2G}{c^3} P_\mu \tag{3.16}$$

where $P_\mu = \frac{1}{c} \int T_{\mu\nu} \sqrt{-g}\, dS^\nu$ is the 4-momentum of matter, $R_\mu = \frac{1}{4\pi} \int \left(G_{\mu\nu} + \Lambda g_{\mu\nu} \right) \sqrt{-g}\, dS^\nu$ is the radius of curvature domain.

The resulting tensor equation can be rewritten in another form. Since $P_\mu = mc\, U_\mu$ then

$$R_\mu = \frac{2G}{c^3} mc\, U_\mu = r_s\, U_\mu \tag{3.17}$$

where r_s is the Schwarzschild radius, U_μ is the 4-speed, m is the gravitational mass. This record reveals the physical meaning of R_μ. There is a similarity between the obtained tensor equation and the expression for the gravitational radius of the body (the Schwarzschild radius). Indeed, for static spherically symmetric field and static distribution of matter have $U_0 = 1, U_i = 0\,(i = 1, 2, 3)$. In this case we obtain

$$R_0 = \frac{2G}{c^3} mc\,U_0 = \frac{2G\,m}{c^2} = r_s \tag{3.18}$$

In a small area of spacetime is almost flat and this equation can be written in the operator form

$$\hat{R}_\mu = \frac{2G}{c^3}\hat{P}_\mu = \frac{2G}{c^3}(-i\hbar)\frac{d}{dx^\mu} = -2i\,\ell_P^2 \frac{d}{dx^\mu} \tag{3.19}$$

where $\hbar$ is the Dirac constant. Then commutator operators $\hat{R}_\mu$ and $\hat{x}_\mu$ is

$$[\hat{R}_\mu, \hat{x}_\mu] = -2i\ell_P^2 \tag{3.20}$$

From here follow the specified uncertainty relations (3.13)

$$\Delta R_\mu \Delta x_\mu \geq \ell_P^2$$

Substituting the values of $R_\mu = \frac{2G}{c^3} m\,c\,U_\mu$ and $\ell_P^2 = \frac{\hbar G}{c^3}$ and cutting right and left of the same symbols, we obtain the Heisenberg uncertainty principle

$$\Delta P_\mu \Delta x_\mu = \Delta(mc\,U_\mu)\Delta x_\mu \geq \frac{\hbar}{2} \tag{3.21}$$

Note that now, according to the equation $R_\mu = (2G/c^3)\,P_\mu$, together with the expressions for the energy-momentum quantum $P_\mu = \hbar\,k_\mu$ valid expressions for the quantum space-time curvature $R_\mu = \ell_P^2\,k_\mu$ (but not quantum space-time), where k_μ - the wave 4-vector. That is, the curvature of space-time is quantized, but the quantization step is extremely small. This can serve as a basis for building a quantum theory of gravity

In the particular case of a static spherically symmetric field and static distribution of matter $U_0 = 1, U_i = 0\,(i = 1, 2, 3)$ and have remained

$$\Delta R_0 \Delta x_0 = \Delta r_s \Delta r \geq \ell_P^2 \tag{3.22}$$

where r_s is the Schwarzschild radius, r is radial coordinate.

Last uncertainty relation (3.22) allows make us some estimates of the equations of general relativity at the Planck scale. For example, the equation for the invariant interval dS in the Schwarzschild solution has the form

$$dS^2 = \left(1 - \frac{r_s}{r}\right) c^2 dt^2 - \frac{dr^2}{1 - r_s/r} - r^2(d\Omega^2 + \sin^2\Omega d\varphi^2) \tag{3.23}$$

Substitute according to the uncertainty relations $r_s \approx \ell_P^2/r$. We obtain

$$dS^2 \approx \left(1 - \frac{\ell_P^2}{r^2}\right) c^2 dt^2 - \frac{dr^2}{1 - \ell_P^2/r^2} - r^2(d\Omega^2 + \sin^2\Omega d\varphi^2) \tag{3.24}$$

It is seen that at the Planck scale $r = \ell_P$ spacetime metric is bounded below by the Planck length, and on this scale, there are real and virtual Planckian black holes [5].

Similar estimates can be made in other equations of general relativity.

It is also seen that the spacetime metric $g_{00} \approx 1 - \ell_P^2/(\Delta r)^2$ is always fluctuates even in the absence of an external gravitational field. This gives rise to the so-called quantum foam, consisting of virtual Planckian black holes. But these fluctuations $\Delta g \approx \ell_P^2/(\Delta r)^2$ in the macrocosm and in the world of atoms are very small compared to 1 and become noticeable only at the Planck scale. Fluctuations need to be considered when using the Minkowski metric of special relativity for very small regions of space and large momenta. For example, fluctuations in the speed of light is equal to the Planck scale $\Delta c = c\Delta g \approx c\,\ell_P^2/(\Delta r)^2$.

This implies that the Planck scale is the limit below which the very notions of space and length cease to exist. Any attempt to investigate the possible existence of shorter distances (less than 10^{-35}m), by performing higher-energy collisions, would inevitably result in black hole production. Higher-energy collisions, rather than splitting matter into finer pieces, would simply produce bigger black holes [6]. Reduction of the Compton wavelength of the particle increases the Schwarzschild radius. The resulting uncertainty relation generates at the Planck scale virtual black holes.

3.3 Summary

The paper shows that:

1. In the microcosm of the Planck length is the limit of distance.
2. Upon reaching the Planck scale appear Planck black holes.
3. At the Planck level vacuum consists of virtual Planckian black holes.
4. Length measurement is meaningless at the Planck scale
5. Three-dimensional space is a consequence of energy advantage in the formation of the Planck black holes at the Planck scale.
6. The curvature of space-time is quantized. Space-time is not quantized.

Chapter 4

Universe at point

4.1 How to place the Universe at the point.

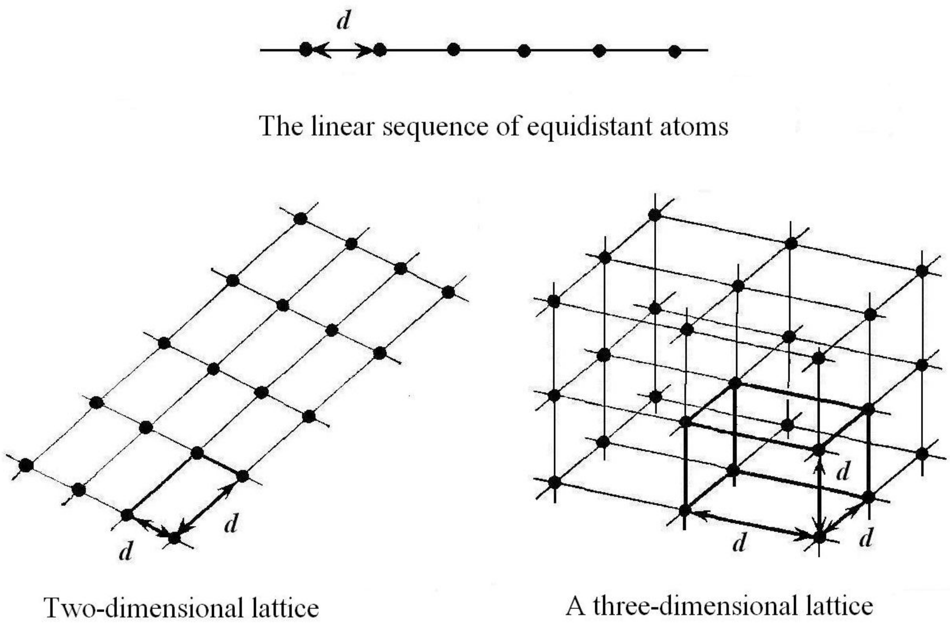

Figure 4.1: Multi-dimensional lattice

One of the difficulties of the general theory of relativity is the problem of singularities, which actually originated with the receipt of the non-stationary Friedman cosmological solutions of the equations of general relativity, and even more aggravated due to the problem of relativistic gravitational collapse. Singularity refers to a state of infinite density of matter, which indicates the failure of the general theory of relativity. These problems are solved in a multidimensional space.

Consider the obvious example. Take an ordinary book, 3-dimensional object. The amount of information in the form of letters in a book occupies a volume V. Let this same amount of information must be placed in the two-dimensional space, i.e. in the plane. In the form of lines of information will occupy an area of a square with the side $a(2)$. It is clear that a $a(2) > (3)$, where $a(3)$ - side three-dimensional cube depicting book.

The same amount of information is located in a one dimensional space in the form of a line with length $a(1)$, and

$$a(1) > a(2) > a(3)$$

Intuitively, it is clear that if we increase the number of dimensions of space to accommodate the same amount of information (in the form of letters), we construct an n-dimensional cube with a smaller side $a(n)$, that is

$$a(1) > a(2) > \cdots > a(k) > \cdots > a(n)$$

It is not difficult to show that $a(n)$ and $a(k)$ are related as follows

$$a(n) = a(k)^{k/n} \tag{4.1}$$

Indeed, (4.1) is a consequence of an equal amount of information (or atoms) in one or other n-dimensional space

$$V(1) = V(2) = V(k) = \cdots = V(n)$$

where $V(n)$ - «volume» n-dimensional spaces, which have an equal number of units of information (or atoms) which are located in nodes n-dimensional cubic lattices with a pitch d in that or another n-dimensional space (see Fig. 4.1)

So how

$$V(1) = a(1)^1; V(2) = a(2)^2; \cdots ; V(k) = a(k)^k; \cdots ; V(n) = a(n)^n;$$

Then we obtain (4.1). Here, for example, $a(1) = d \cdot t$, where t - the number of steps of the lattice.

If the space is three-dimensional, we obtain from (4.1)

$$a(n) = a(3)^{3/n} \tag{4.2}$$

From equation (4.2) should be an interesting conclusion. Suppose that we need to place the observable universe, together with the substance in the elementary n-dimensional "cube" and the side of the cube is equal to $10\,\ell_P$. Here $\ell_P = 10^{-33}$ cm - Planck length. How many dimensions of space is needed?

The size of the observable Universe is 10^{28} cm., or in units of Planck length $10^{61}\ell_P$. From (4.2) we have

$$10^1\ell_P = (10^{61}\ell_P)^{3/n} \tag{4.3}$$

Hence, $n = 183$. Thus the observed Universe can be placed in 183-dimensional "cube". Rib "cube" is $10\ell_P$.

The density of matter in a "183-cube" is equal to the density of a substance in 3-dimensional space of the observable Universe. Indeed, the density of the matter in the n-dimensional space is defined as follows: $\rho(n) = M/V(n)$, where M - mass of the substance of the observable Universe; $V(n)$ - volume of n-dimensional space; $\rho(n)$ - density of material in an n-dimensional space. And since, by hypothesis, $V(3) = V(183)$, then $\rho(3) = \rho(183)$.

An illustrative example. The one-dimensional thread of length r_1 is twisted into a flat spiral with a diameter r_2, or the three-dimensional ball with diameter r_3. It is clear that $r_1 > r_2 > r_3$, but the density of the thread remains the same (atoms substance will still be located at a distance d from each other in the direction of each axis, see Fig. 4.1).

Based on the foregoing, it can be assumed that the singular "point" (ie, a very small region of space), from which emerged our Universe was multidimensional. Perhaps in the center of a black hole the matter is squeezed into other dimensions of space.

Chapter 5

Generalized Bohr's principle of complementarity

5.1 Introduction

Bohr's complementarity principle was opened in 1927 and is an important principle of quantum mechanics. Niels Bohr did a great job on the application of this principle in other areas of knowledge. He considered this a very important task. Niels Bohr discovered complementarity between the following pairs:

- Corpuscular and wave properties of the particles
- Physicochemical processes and biological processes
- Reductionism and vitalism
- Physicochemical causality or biological purposefulness
- Thoughts and feelings
- The mathematical description of the phenomenon and the physical picture of the phenomenon
- Truth and clarity
- Determinism and free will.
- Justice and mercy
- Quantity and quality
- Logic and intuition

In the first pair of de Broglie wave is an irrational wave or "ghost" wave (Einstein). Similarly, in the other pairs. We see a general law in these pairs: the rational side of reality displayed on the left side; the irrational side of reality displayed on the right side. Thus, the generalized principle of complementarity Bohr can be formulated as follows: the rational side of reality and conjugate irrational side of reality are complementary to each other.

Generalized Bohr's principle of complementarity allows you to find the phenomena of complementarity in various fields, grouping them by rational and irrational grounds. We affirm that the complementarity relationships have the following pairs:

- Discrete and continuity.
- Locality and nonlocality
- Plurality and integrity
- The space-time picture of the world (static) and pulse-energy picture of the world (dynamics, becoming).
- Determinism and indeterminism
- The real particles and virtual particles.
- A mixture of state and quantum superposition of states.
- Science and art.
- Phenomenon and essence
- Phenomena and noumena
- Tonal and nagual (Carlos Castaneda)
- Evolutionism and creationism
- Something (World) and nothing (God).
- Nominalism and Realism

And so on.

5.2 Conclusion

Generalized Bohr's complementarity principle is:

- The laws of nature, World formula.
- Evidence of irrational side of unobservable reality.

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