QUANTUM GRAVITY
Collection of articles

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Abstract

In the Collection ”Quantum Gravity” the first article presents a new method for constructing quantum gravity, based on the equations of Einstein’s general theory of relativity. It is shown that the natural space-time boundary is the Planck length. A new uncertainty relation between the gravitational radius of a particle and its position has been found. The basic equation of quantum gravity has been established. The inevitable nature of the three-dimensionality of space is shown. A hypothesis has been put forward about the nature of the singularities of black holes and the Metagalaxy. The second article establishes Bohr’s general principle of complementarity, its extension to other areas of reality and its philosophical significance. The last article builds a visual model of special relativity and shows its role in scientific knowledge.

Contents

Introduction

The search for a consistent and testable theory of quantum gravity is one of the most important open problems in fundamental physics.

The general theory of relativity is what is called classical, that is, non-quantum theory. The current theories for the other interactions are all quantum theories, or, moreover, it is these interactions that are described within the framework of quantum theory, which uses concepts radically different from classical physics.

Quantum theory is usually applied in the field of microphysics. This is the world of molecules, atoms, nuclei and elementary particles. Thus, quantum theory underlies not only physics, but also chemistry and biology. The smallest scales explored experimentally so far are those explored by particle accelerators such as the Large Hadron Collider. These smallest studied scales are on the order of 10^{-18} m.

All fields of the Standard Model carry energy and thus generate a gravitational field. Since these are quantum fields, they cannot be inserted directly into Einstein's classical field equations. Only a consistent unification of gravity with quantum theory can describe the interaction of all fields at a fundamental level.

We call quantum gravity any theory (or approach) that applies the principle of superposition to a gravitational field.

Einstein's theory itself is incomplete. It is possible to prove singularity theorems, which state that, under certain assumptions, there are regions of spacetime where the theory fails. Specific examples include regions inside black holes and the origin of our universe. There is another type of singularity. Quantum field theories fail due to discrepancies that arise when studying space-time on arbitrarily small scales.

The physical scale where we definitely expect quantum effects of gravity to become relevant is the Planck level. The three constants G, h (and, accordingly, h/2) and c provide the corresponding scales of quantum gravity, since from them it is possible to construct (in addition to numerical coefficients) unique expressions for fundamental length, time and mass (or energy). Since Max Planck formulated them back in 1899, they are named Planck units in his honor.

To generate particles with masses on the order of the Planck mass and higher, it is necessary to build an accelerator of galactic dimensions. This is one of the most important problems in the search for quantum gravity: we cannot directly probe the Planck scale by experimental means.

Everything that has been said so far points to the need for a quantum theory of gravity. For more than a hundred years we have not had a complete quantum theory of gravity. But how can one construct such a theory? Let's consider the main approaches along this path.

First, the connection between quantum mechanics (quantum theory with a finite number of degrees of freedom) and gravity is studied using the Schrodinger (or Dirac) equation in a Newtonian gravitational field.

There are also two approaches to constructing quantum gravity: the covariant approach and the canonical approach. Both approaches are aimed at constructing a quantum version of general relativity. The covariant approach gets its name from the fact that the four-dimensional (covariant) formalism is used throughout. In most cases, this formalism uses path integrals (in which four-dimensional spacetimes are summed up according to the principle of superposition). Like the photon in quantum electrodynamics, the particle is identified as a mediator of the quantum gravitational field - the graviton. It is massless, but has spin 2 (whereas a photon has spin 1). The fact that it is truly massless is indirectly confirmed by the detection of gravitational waves - they move at the speed of light c.

It is believed that quantum general relativity is only an effective field theory, that is, this approach, using standard quantum field theory up to the Planck scale theory, is asymptotically safe.

One promising approach is dynamic triangulation, so named because the spacetimes to be summed in the path integral are discretized into tetrahedra.

One of the candidates for the creation of a final quantum field theory of gravity is supergravity.

A candidate for the creation of a final theory of quantum gravity of a completely different nature is superstring theory (or M-theory)

An alternative to covariant quantization is the canonical (or Hamiltonian) approach. The procedure here is similar to the procedure in quantum mechanics, where quantum operators are constructed for positions, momenta and other variables. This also includes a quantum version of energy called the Hamilton operator. In quantum mechanics, the Hamilton operator generates evolution in time according to the formula of the

Schrodinger equation. In quantum gravity the situation is different. Instead of the Schrodinger equation, there are restrictions - the Hamiltonian (and other functions) are forced to vanish. This is due to the disappearance of space-time at a fundamental level. This is due to the fact that classical theory no longer has a fixed background. Background independence is one of the main obstacles to quantum gravity. An alternative formulation uses variables that have some similarities to the gauge fields used in the Standard Model. This approach is known as Loop Quantum Gravity.[43]

In addition to the approaches already mentioned, there are many others. This article proposes another approach to constructing quantum gravity. We call it the integral method.

Chapter 1

Quantum gravity

1.1 General information

The Planck length (denoted ℓ_P) is a fundamental unit of length in Planck System of Units, equal in International System of Units (SI) approximately 1.6^{-35} meters.

The Planck length is a natural unit of length because it only includes fundamental constants: speed of light, Planck's constant, and the gravitational constant.

The Planck length is: : $\ell_P = \sqrt{(G/c^3)\hbar} = 1.616229(38)^{-35}m$, where: $\hbar$ is Dirac constant ($\hbar = h/2\pi$), where h is Planck constant; G - gravitational constant; c is the speed of light in a vacuum.

Dimensional analysis shows that measuring the position of physical objects accurate to the Planck length is problematic.

In a thought experiment, to determine the position of an object, a stream of electromagnetic radiation, that is, photons, is sent to it. The higher the energy of the photons, the shorter their wavelength and the more accurate the measurement will be. It is assumed that if photons had enough energy to measure objects the size of the Planck length, then when interacting with the object they would collapse into a microscopic black hole and it would be impossible to measure. This imposes fundamental limitations on the accuracy of length measurements.[1]

1.2 Qualitative substantiation of photon collapse on the Planck scale

According to general relativity, any form of energy, including photon energy, must generate a gravitational field. And the greater this energy, the more powerful the gravitational field they generate.[2][3] Further: let's introduce the concept of "kinetic energy of photons", which is determined by the formula $E_{kin} = P\,c$, where P is the photon momentum, and c - their speed; this energy is a positive quantity and, with the free movement of photons, is not limited by anything; the total energy of a photon beam also includes the potential energy of interaction of photons with each other and this energy is a negative quantity.[2]

1.2.1 Initial reasoning

For two massive particles each with mass m, the potential energy of interaction depends only on the distance between them. Based on Newton's equation of gravity, the potential energy of interaction, when taking the state of infinite removal of particles as zero, has the form [4]

$E_{pot} = -G\,m^2/r$, where G is the gravitational constant; m is the mass of each particle; r is the distance between particles.

To find the total energy of a system of two bodies with mass m, you need to add up the kinetic energies of both bodies and add here their mutual gravitational potential energy, which together gives a constant: [5]

$$\sum(1/2)m_i v_i^2 - Gm^2/r_{ij} = const;\ \ i = 1, 2 \tag{1.1}$$

Based on the admissible analogy with the potential energy of massive particles, taking into account the fact that photons have no mass, we believe that it is permissible for two photons to substitute the value of the photon momentum divided by the speed of light into this equation instead of the mass m, then there is P/c.[6]

This allows us to introduce the concept of potential energy of interaction of photons with each other and define it as

$$E_{pot} = G\,P^2/c^2 r \tag{1.2}$$

Here r must be compared with the photon wavelength λ.

Then the total energy of interacting photons is equal to the sum of the kinetic (in order of magnitude) and potential energies and has the form

$$E = E_{kin} + E_{pot} \approx 1/2 \left(\frac{2P}{c}\right) c^2 - \frac{G\,P^2}{c^2\,\lambda} = P\,c\left(1 - \frac{G\,P}{c^3\,\lambda}\right) = P\,c\left(1 - \frac{\lambda_g}{\lambda}\right) \tag{1.3}$$

(photon spin is not taken into account here, but for now this is not significant). The quantity $\lambda_g \approx (G/c^3)P$ for a system of gravitationally interacting photons is an analogue of the gravitational radius $r_g \approx (G/c^3)mc$ for a massive particle. To use this equation in quantum theory, we consider these quantities P and λ using

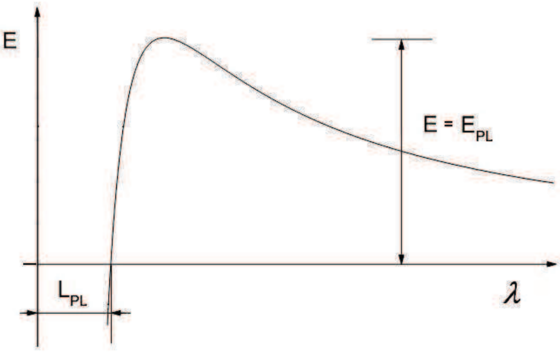

Figure 1.1: The graph of the function $E(\lambda)$

the Heisenberg uncertainty relation as the momentum and position uncertainties. By allowing one to obtain important estimates in a fairly simple way, uncertainty relations turn out to be a useful "working tool" of quantum theory. According to the uncertainty relation, these quantities are related to each other.

Assuming that $P\,\lambda \approx \hbar$, where $\hbar$ is the Dirac constant and using this relation (by substituting $P \approx \hbar/\lambda$), we find the function $E(\lambda)$ from the last equation

$$E(\lambda) = \frac{\hbar c}{\lambda}\left(1 - \frac{\ell_P^2}{\lambda^2}\right) \tag{1.4}$$

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

The graph of the function $E(\lambda)$ constructed on the basis of this equation (Figure 1.1) shows that as the wavelength of photons λ decreases, their total energy increases, since the second term in the last equation at low photon momentum is practically zero. In this case, the maximum total energy $E(\lambda)$ turns out to be approximately equal to the Planck energy E_P, and the photon wavelength λ is almost comparable to the Planck length .

However, if the momentum of photons continues to increase, the total energy of the system of photons will begin to decrease due to an increase in the negative gravitational component of the total energy, which until this moment did not play a significant role. When the photon wavelength λ is equal to the Planck length $\ell_P \approx 10^{-35}$m, the total energy of interaction of photons with each other becomes equal to zero, the photons collapse and turn into microscopic Planck black hole.

Thus, when electromagnetic radiation acquires Planck energy (that is, its wavelength λ becomes equal to the Planck length ℓ_P), the electromagnetic radiation collapses. Therefore, it is no longer possible to use it as a tool for "probing" ultra-small distances. We have discovered the limit, the frontier of scientific research.

A system of two or more gravitationally interacting photons is called a geon.[7]

1.2.2 More rigorous reasoning

If we think more strictly, then we need to proceed from the Hamilton-Jacobi equation [7]

$$g^{ik}\partial^2 S/\partial x^i \partial x^k = (m')^2\,c^2 \tag{1.5}$$

with metric coefficients g^{ik}, taken from the Schwarzschild solution, where S - action, m' is the mass of the particle (we denote the mass of the central body here as m).

This equation is a generalization of the equation between relativistic energy and momentum of a particle in special relativity

$$E^2 - \mathbf{p}^2 c^2 = (m')^2 c^4 \tag{1.6}$$

The generalized equation is covariant (the physical content of the equation does not depend on the choice of coordinate system). In expanded form, the indicated Hamilton-Jacobi equation has the form

$$\left(1-\frac{r_g}{r}\right)^{-1}\left(\frac{\partial S}{c\,\partial t}\right)^2-\left(1-\frac{r_g}{r}\right)\left(\frac{\partial S}{\partial r}\right)^2-\frac{1}{r^2}\left(\frac{\partial S}{\partial \varphi}\right)^2-(m')^2c^2=0 \tag{1.7}$$

It can be rewritten as follows

$$E^2=\left(1-\frac{r_g}{r}\right)^2 P^2c^2+\left(1-\frac{r_g}{r}\right)\frac{N^2c^2}{r^2}+\left(1-\frac{r_g}{r}\right)(m')^2c^4 \tag{1.8}$$

where N - angular momentum of the particle; r_g is the gravitational radius of the central attracting body with mass m.

For the above approximation, it is necessary to put in this equation the mass of particles (photons) m' equal to zero, neglect the angular momentum (spin) of photons N and use the Heisenberg uncertainty relations $P\ ,r\approx\hbar$. Then we obtain an approximate equation for the total energy

$$E\approx\left(1-\frac{r_g}{r}\right)P\,c=\left(1-\frac{2G\,m}{c^2r}\right)P\,c\approx\left(1-\frac{2\ell_P^2}{\lambda^2}\right)\frac{\hbar c}{\lambda} \tag{1.9}$$

where $r=\lambda$ - photon wavelength; $r_g=2G\,m/c^2$ is the gravitational radius of the central body.

In this expression, the gravitational mass m must be replaced by P/c, where P is the momentum of the photons; $P\approx\hbar/\lambda$. The resulting equation, up to a coefficient 2, coincides with the equation established above for the total energy of the photon system.

To take into account the angular momentum of photons in the specified equation, you need to perform the substitution $N^2=\hbar^2 l(l+1)$, where l is the quantum number of the total angular momentum of photons. Taking into account the angular momentum of photons leads to the appearance of a second, internal event horizon in the resulting Planck black hole (point 2 on the graph).

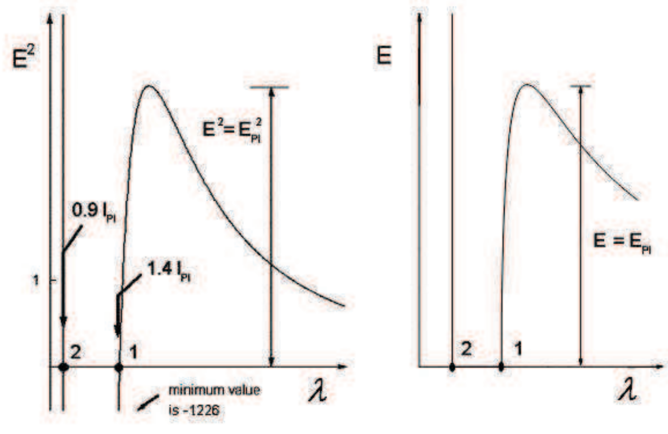

Figure 1.2: The graph of the function $E(\lambda)$ with allowance for the angular momentum $l=1$

For a charged black hole, the metric coefficient g_{00}, according to the Reissner-Nordstrom solution, has the form [8]

$$g_{00}=1-\frac{r_g}{r}+\frac{GQ^2}{c^4r^2} \tag{1.10}$$

where Q is the total charge of the black hole.

Considering that the Planck charge is $Q=\sqrt{\hbar c}$ [9], then at the Planck level

$$\frac{GQ^2}{c^4r^2}=\frac{G\hbar}{c^3\lambda^2}=\frac{\ell_P^2}{\lambda^2} \tag{1.11}$$

Therefore, the metric coefficient g_{00} takes the form

$$g_{00}=1-\frac{r_g}{r}+\frac{GQ^2}{c^4r^2}=1-\frac{2\ell_P^2}{\lambda^2}+\frac{\ell_P^2}{\lambda^2}=1-\frac{\ell_P^2}{\lambda^2} \tag{1.12}$$

That is, the charge has virtually no effect on the overall functional dependence $E(\lambda)$. The general rule is that the metric coefficient g_{ik} cannot be greater than 1.

This thought experiment uses both general relativity and the uncertainty principle of quantum mechanics. Both theories predict that it is impossible to measure with precision that exceeds the Planck length. In any theory of quantum gravity that combines general relativity and quantum mechanics, the traditional concept of space and time does not apply at distances smaller than the Planck length or for periods of time shorter than the Planck time. It follows that at the Planck level all particles are massless and move at the speed of light. This conclusion follows from the very course of reasoning in this article, since the Planck length naturally appears as a result of the interaction of only massless energy quanta.[10]

1.2.3 Planck length and dimension of space

Now, according to the general belief of experts, "true" physics is formed under the Planck parameters $l \sim \ell_P$, $t \sim t_P$, $M \sim M_P$. Understanding the ongoing processes in this area will lead to the construction of a unified field theory, a quantum theory of gravity, the creation of a theory of the origin of the Metagalaxy and a quantitative representation of physical geometry.[11] The same applies to the dimension of space.

Analysis of the Hamilton-Jacobi equation for photons in spaces of different dimensions n indicates the preference (energy advantage) of three-dimensional space for the emergence of Planck black holes, real or virtual (quantum foam). When considering this issue, we will use the results obtained at one time by P. Ehrenfest.[12][13]

Ehrenfest considers "physics" in n-dimensional space U^n. In this case, he derives the law of interaction with a point center (similarly to the three-dimensional case) from the Poisson differential equation in U^n for the potential that determines this interaction. Fundamental physical laws of interactions are given in variational form. The Lagrangian for the simplest case of a scalar massless field $\varphi(t, x^1, x^2, \cdots, x^n)$ has the form

$$L = \left(\frac{\partial \varphi}{\partial t}\right)^2 + \sum_{k=1}^{n} \left(\frac{\partial \varphi}{\partial x^k}\right)^2$$

This Lagrangian leads to the Poisson equation and hence to the point center field $\varphi \sim r^{n-2}(\varphi \sim \ln r \text{ for } n = 2)$. The dimension of space is taken into account here only as a condition on the set of values that the index k can take. In the $(3+1)$-dimensional case $k = 1, 2, 3$. Thus, this Lagrangian allows us to obtain the corresponding part of physics in a space of any dimension. The Poisson equation is just mathematically equivalent to the indicated Lagrangian (with a natural generalization to other fields).

In the spherically symmetric case in U^n, from the Poisson equation or from Gauss's law for the field strength, expressions for the potential energy follow

$$E_{pot}^{(n\geq 3)} \approx -\frac{k\, m^2}{(n-2) r^{n-2}}; \quad n \geq 3 \tag{1.13}$$

$$E_{pot}^{(2)} \approx k\, m^2 \ln r; \quad n = 2 \tag{1.14}$$

$$E_{pot}^{(1)} \approx k\, m^2\, r; \quad n = 1 \tag{1.15}$$

where k is the interaction constant in n-dimensional space. With the usual Newton's constant, it is found through the matching of potentials for 3-dimensional space and the corresponding n-dimensional space.

For the potential energy of interacting photons, these equations take the form (taking into account that $m \to P/c\,; P \approx \hbar/\lambda;\ r = \lambda$)

$$E_{pot}^{(n\geq 3)} \approx -\frac{k\,(P/c)^2}{(n-2) r^{n-2}} = -\frac{k\,(\hbar/\lambda\, c)^2}{(n-2)\lambda^{n-2}}; \quad n \geq 3 \tag{1.16}$$

$$E_{pot}^{(2)} \approx k\,(P/c)^2 \ln r = k\,(\hbar/\lambda\, c)^2 \ln \lambda; \quad n = 2 \tag{1.17}$$

$$E_{pot}^{(1)} \approx k\,(P/c)^2\, r = k\,(\hbar/\lambda\, c)^2\, \lambda; \quad n = 1 \tag{1.18}$$

Then the total energy of interacting photons in spaces of different dimensions is approximately equal to

$$E^{(n)}(\lambda) \approx E_{kin} + E_{pot}^{(n)} \tag{1.19}$$

where the kinetic energy $E_{kin} = P\, c = \hbar\, c/\lambda$ does not depend on the dimension of space. Equations for the total energy $E^{(n)}(\lambda) \approx E_{kin} + E_{pot}^{(n)}$ in spaces U^n will have the form (taking into account that $k = c = \hbar = 1$)

$$E^{(n\geq 3)}(\lambda) \approx E_{kin} + E_{pot}^{(n\geq 3)} = \frac{Pc}{2} - \frac{kP^2}{c^2 (n-2)\lambda^{n-2}} = \left(1 - \frac{2}{(n-2)\lambda^{n-1}}\right)\frac{1}{2\lambda}; \quad n \geq 3 \tag{1.20}$$

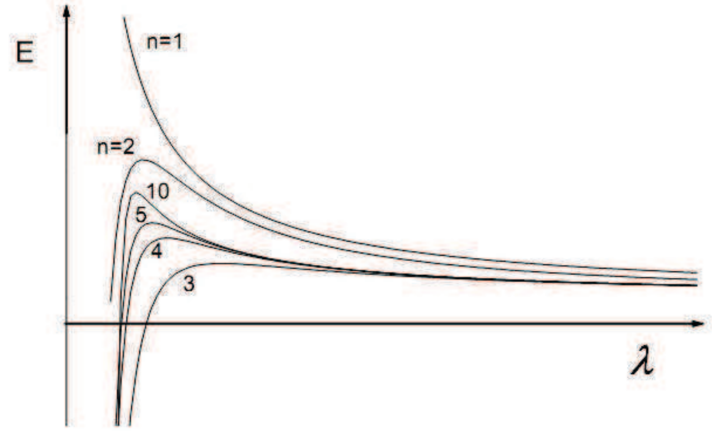

Figure 1.3: The graphs of the functions $E(\lambda)$ in n -dimensional spaces

$$E^{(2)}(\lambda) \approx E_{kin} + E_{pot}^{(2)} = \frac{Pc}{2} + \frac{k}{c^2}P^2 ln\,\lambda = \left(1 + \frac{2ln\,\lambda}{\lambda}\right)\frac{1}{2\lambda}; \quad n = 2 \tag{1.21}$$

$$E^{(1)}(\lambda) \approx E_{kin} + E_{pot}^{(1)} = \frac{Pc}{2} + \frac{k}{c^2}P^2\lambda = \frac{1,5}{\lambda}; \quad n = 1 \tag{1.22}$$

Graphs of the functions $E^{(n)}(\lambda)$ are shown in the Figure 1.3 and indicate that the formation of Planck black holes (real or virtual) is energetically most favorable in 3-dimensional space.[14]

If we assume that on the Planck scale virtual black holes form the so-called space-time quantum foam,[15] which is the basis of the "fabric" of the Universe, then the energetic advantage during the formation of Planck black holes most likely predetermined the 3-dimensionality of the observable space. It is not space that exists and imprints its form on things (in the form of a box filled with material objects according to Newton), but things and the physical laws governing them that define space. This point of view reaches its maximum validity in Einstein's general theory of relativity.[16]

1.2.4 Philosophy of space dimension

The concept of the dimension of space is associated with a specific physical law and is involved in one of the ideological confrontations in the history of physics - the confrontation between the concepts of absoluteness and relativity of space.

The first concept assumes that space is something absolute, given, something like a ready-made stage on which physical phenomena are played out, but which does not depend on these phenomena.

The second concept of the relativity of space means that spatial relations are some relationships between physical bodies.

If space can be likened to a stage, then this scene is created during the performance itself, created by physical phenomena, interactions between bodies. And this scene cannot even be imagined to exist independently of interactions.

The concept of absolute space prevailed in Newtonian mechanics.

The general theory of relativity was won by the concept of the relativity of space, of which Leibniz was a staunch supporter. Kant was also influenced by Leibniz's views. At age 23, he wrote: "Three-dimensionality appears to result from the fact that substances in the existing world act on each other in such a way that the force of action is inversely proportional to the square of the distance... It is easy to prove that there would be no space and no extension if substances would not have any power to act externally. Without this force there is no connection - no order, without order there is no space."[17] That is, space is order in the totality of bodies, space is the relationship of bodies. These relationships are manifested in the forces acting between bodies.[18]

Kant talks about a force inversely proportional to the square of the distance, which simply physically substantiates the three-dimensionality of the observed space.

We are considering general patterns in multidimensional spaces, once established by Ehrenfest, but in relation to massless energy quanta, the existence of which is characteristic of the Planck scale. Here it is natural to assume that interactions between massless energy quanta create a system of relations that is energetically the most favorable. On the Planck scale, interactions between massless energy quanta (photons, gravitons, etc.), as a result of which Planck black holes, real and virtual, are formed (quantum "foam", the basis of the fabric of the Universe), are energetically most favorable in the system of relations that form space of dimension three.

We come to the conclusion that the three-dimensionality of space is associated with the fundamental properties of the material world at the Planck level.

1.3 Towards quantum gravity

1.3.1 Uncertainty relations on the Planck scale

A particle of mass m has a reduced Compton wavelength

$$\bar{\lambda}_C = \frac{\lambda_C}{2\pi} = \frac{\hbar}{mc} \tag{1.23}$$

On the other hand, the Schwarzschild radius of the same particle is equal to

$$r_g = \frac{2Gm}{c^2} = 2\,\frac{G}{c^3}\,mc \tag{1.24}$$

The product of these quantities is always constant and equal

$$r_g \bar{\lambda}_C = 2\,\frac{G}{c^3}\,\hbar = 2\ell_P^2 \tag{1.25}$$

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

$$\Delta r_g \Delta\bar{\lambda}_C \geq \frac{G}{c^3}\,\hbar = \ell_P^2 \tag{1.26}$$

which is another form of the Heisenberg uncertainty relation on the Planck scale. Indeed, substituting here the expression for the Schwarzschild radius, we obtain

$$\Delta\left(2\,\frac{G}{c^3}\,mc\right)\Delta\bar{\lambda}_C \geq \frac{G}{c^3}\,\hbar \tag{1.27}$$

By canceling identical constants, we arrive at the Heisenberg uncertainty relation [19]

$$\Delta\,(mc)\,\Delta\bar{\lambda}_C \geq \frac{\hbar}{2} \tag{1.28}$$

1.3.2 Uncertainty relations and Einstein's equation

The uncertainty relation between the gravitational radius and the Compton wavelength of a particle is a special case of the general Heisenberg uncertainty relation on the Planck scale

$$\Delta R_\mu \Delta x_\mu \geq \ell_P^2 \tag{1.29}$$

where R_μ is a component of the radius of curvature of a small region of spacetime; x_μ is the conjugate coordinate of the small region.

In fact, the indicated uncertainty relations can be obtained based on Einstein's equations

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \tag{1.30}$$

where $G_{\mu\nu} = R_{\mu\nu} - \frac{R}{2} g_{\mu\nu}$ is the Einstein tensor, which combines the Ricci tensor, scalar curvature and metric tensor, $R_{\mu\nu}$ - Ricci tensor, obtained from the spacetime curvature tensor R_{abcd} by convolving it over a pair of indices, R is the scalar curvature, that is, the convoluted Ricci tensor, $g_{\mu\nu}$ is the metric tensor, Λ is the cosmological constant, and $T_{\mu\nu}$ is the energy-momentum tensor of matter, π is pi, c is speed of light in vacuum, G is Newton's gravitational constant.

In this form, the essence of the right side of Einstein's equations (1.30) is greatly obscured. It is advisable to rewrite these equations by grouping the constants into separate factors that have a specific meaning

$$\left(\frac{1}{4\,\pi}\right)(G_{\mu\nu} + \Lambda g_{\mu\nu}) = 2\left(\frac{G}{c^3}\right)\left(\frac{1}{c}\,T_{\mu\nu}\right) \tag{1.31}$$

A simple rearrangement of the factors allows us to gain deeper insight into the physical nature of the phenomenon. It is known that the factor $(1/c)\,T_{\mu\nu}$ is associated with the density and flow of energy-momentum of matter,[20] and with the help of the factor (G/c^3) you can make the transition to the Planck scale, since the same factor is present in the expression for the Planck length $\ell_P = \sqrt{(G/c^3)\,\hbar}$.

When deriving his equations, Einstein assumed that physical space-time is Riemannian, that is, curved. A small region of Riemannian space is close to flat space.

Example: if you cut out a small enough area from a sphere, the geometry will be imitated by Euclidean geometry. A similar technique—isolating the simplest from a more complex geometry (in this case, Euclidean geometry) by isolating a small part of the total space (here a sphere)—is a very common technique. Using the example of a sphere, it becomes clear that with a decrease in curvature or an increase in size, the surface locally approaches Euclidean space. Locally - in the small - the sphere can be approximated by part of the plane; globally - as a whole - impossible. This approximation is also realized in a more general case, when all curvature components decrease.[11]

For any tensor field $N_{\mu\nu\ldots}$ the value $N_{\mu\nu\ldots}\sqrt{-g}$ can be called the tensor density, where g is the determinant of the metric tensor $g_{\mu\nu}$. When the region of integration is small, $\int N_{\mu\nu\ldots}\sqrt{-g}\,d^4x$ is a tensor. If the region of integration is not small, then this integral will not be a tensor, since it represents the sum of tensors given at different points and, therefore, is not transformed according to any simple law when transforming coordinates.[21] Only small areas are considered here. The above is also true when integrating over the three-dimensional hypersurface S^ν.

Thus, Einstein's equations for a small region of pseudo-Riemannian spacetime can be integrated over the three-dimensional hypersurface S^ν.

$$\frac{1}{4\pi}\int (G_{\mu\nu} + \Lambda g_{\mu\nu})\sqrt{-g}\,dS^\nu = 2\left(\frac{G}{c^3}\right)\frac{1}{c}\int T_{\mu\nu}\sqrt{-g}\,dS^\nu \tag{1.32}$$

Since the integrable region of spacetime is small, that is, it is practically flat, from (1.30) we obtain the tensor equation

$$R_\mu = \frac{2G}{c^3}P_\mu \tag{1.33}$$

where $P_\mu = \frac{1}{c}\int T_{\mu\nu}\sqrt{-g}\,dS^\nu$ is the 4-pulse component matter; $R_\mu = \frac{1}{4\pi}\int (G_{\mu\nu} + \Lambda g_{\mu\nu})\sqrt{-g}\,dS^\nu$ is a component of the radius of curvature of a small region of space-time.

The resulting tensor equation (1.33) can be rewritten in another form. Since $P_\mu = mc\,U_\mu$ then

$$R_\mu = \frac{2G}{c^3}\,P_\mu = \frac{2G}{c^3}mc\,U_\mu = r_g\,U_\mu \tag{1.34}$$

where r_g is the Schwarzschild radius (invariant of the radius of curvature), U_μ is the 4-speed, m is the gravitational mass. This entry reveals the physical meaning of the quantity R_μ, as the μ-component of the Schwarzschild radius. Note that here $R_\mu R^\mu = r_g^2$ (compare, for example, with $dx_\mu dx^\mu = dS^2$).

Here the expression for the gravitational radius $r_g = 2\,(G/c^3)mc$ is a more convenient form of notation than the form $r_g = 2\,(G/c^2)m$. In this case, continuity is visible between the resulting tensor equation (1.33) and the expression for the gravitational radius of a massive body or a similar expression for interacting massless photons $\lambda_g = 2\,(G/c^3)P$ and their connection with Planck length. This happens due to the presence of the (G/c^3) multiplier.

For a static spherically symmetric field and a static matter distribution we have $U_0 = 1, U_i = 0\,(i = 1, 2, 3)$. In this case we get

$$R_0 = \frac{2G}{c^3}mc\,U_0 = \frac{2G}{c^3}\,mc = r_g \tag{1.35}$$

In a small region, space-time is practically flat and the tensor equation (1.33) can be written in operator form

$$\hat{R}_\mu = \frac{2G}{c^3}\hat{P}_\mu = \frac{2G}{c^3}(-i\hbar)\frac{\partial}{\partial x^\mu} = -2i\,\ell_P^2\frac{\partial}{\partial x^\mu} \tag{1.36}$$

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

$$[\hat{R}_\mu, \hat{x}_\mu] = -2i\ell_P^2 \tag{1.37}$$

This implies the above uncertainty relations

$$\Delta R_\mu \Delta x_\mu \geq \ell_P^2 \tag{1.38}$$

Substituting into (1.38) the values $R_\mu = \frac{2G}{c^3}P_\mu$ and $\ell_P^2 = \frac{\hbar\,G}{c^3}$ and canceling the same constants on the right and left, we arrive at the Heisenberg uncertainty relations.

$$\Delta P_\mu \Delta x_\mu \geq \frac{\hbar}{2} \tag{1.39}$$

Note that now, according to the equation $R_\mu = (2G/c^3)P_\mu$, along with the expressions for energy-momentum quanta $P_\mu = \hbar\, k_\mu$ the expressions for the quantity $R_\mu = 2\ell_P^2\, k_\mu$ are valid (but not spacetime quanta), where k_μ is the wave 4-vector. That is, the quantity R_μ (component of the Schwarzschild radius) is quantized, but the quantization step is extremely small. This could serve as the basis for constructing a quantum theory of gravity.

In the static case, the relation must be valid

$$R_0^{(n)} = r_g^{(n)} = 2\ell_P^2\, k_0(n + 1/2); \quad n = 0, 1, 2, ... \tag{1.40}$$

that is, at the Planck level, the gravitational radius of black holes is quantized. Such Planck black holes can be called space quanta, if a space quantum is defined as a minimal volume that is further indivisible. In vacuum ($n = 0$) the gravitational radius of virtual Planck black holes will be $R_0^{(0)} = r_g^{(0)} = \ell_P^2\, k_0$.

For a static spherically symmetric field and a static distribution of matter, the found uncertainty relation takes the form

$$\Delta R_0 \Delta x_0 = \Delta r_g \Delta r \geq \ell_P^2 \tag{1.41}$$

where r_g is the Schwarzschild radius, r is the radial coordinate. Here $R_0 = r_g$, and $x_0 = c\,t = r$, since at the Planck level matter moves at the speed of light.

For vacuum at the Planck level, the last uncertainty relation $\Delta r_g \Delta r \geq \ell_P^2$ will be characteristic, since a state of motion or a velocity vector cannot be assigned to vacuum. In Minkowski space, due to its high symmetry, vacuum is the same state for all inertial frames of reference; in any frame of reference it will appear to be at rest (static). Therefore, the Planck vacuum, according to the specified uncertainty relation, will generate wormholes and tiny virtual black holes (quantum foam).

1.3.3 Basic equation of Quantum Gravity

From equations (1.33) and (1.36) it is clear that the basic equation of the quantum theory of gravity (Klimets equation)[22] should have the following form (similar to the Schrodinger equation)[23]

$$-2i\ell_P^2 \frac{\partial}{\partial x^\mu} |\Psi(x_\mu)\rangle = \hat{R}_\mu |\Psi(x_\mu)\rangle \tag{1.42}$$

In equation (1.42), spatial and temporal coordinates are equal. The $\hat{R}_\mu$ operator acts as a generator of infinitesimal displacements of quantum states. Its form depends on the specific situation.

1.3.4 Estimation of the equations of general relativity at the Planck level

The last uncertainty relation (1.41) allows us to perform some estimates of the equations of general relativity in relation to the Planck scale. For example, the expression for the invariant interval dS in the Schwarzschild solution has the form

$$dS^2 = \left(1 - \frac{r_g}{r}\right) c^2 dt^2 - \frac{dr^2}{1 - r_g/r} - r^2(d\Omega^2 + \sin^2 \Omega d\varphi^2) \tag{1.43}$$

Substituting here, according to the uncertainty relations, instead of r_g the value $r_g \approx \ell_P^2/r$ we get

$$dS^2 \approx \left(1 - \frac{\ell_P^2}{r^2}\right) c^2 dt^2 - \frac{dr^2}{1 - \ell_P^2/r^2} - r^2(d\Omega^2 + \sin^2 \Omega d\varphi^2) \tag{1.44}$$

It can be seen that at the Planck level $r = \ell_P$ the invariant interval dS is limited from below by the Planck length; at this scale, division by zero appears, which means the formation of real and virtual Planck black holes.

Similar estimates can be made for other general relativity equations. In macroscopic physics, when encountering a heavy body, we must first of all estimate the ratio of the gravitational radius to the distance to the center of gravity $\zeta = r_g/r$ and we will already know a lot about the magnitude of the effects associated with general theory of relativity. For example, the ζ parameter determines the scale of change in the clock rate. For the Sun, the ζ parameter is approximately $4 \cdot 10^{-6}$ or 1.76 arcsec, that is, a ray of light passing near the edge of the solar disk, it will deviate by an amount of the order of $4 \cdot 10^{-6}$ radians. For Mercury, this parameter will be 10^{-7}, which in one hundred Earth years gives the displacement of Mercury's perihelion 43 arcsec. The ζ parameter is included in all other estimates. But, as we found out above, the parameter $\zeta = r_g/r$ at the Planck level has the form $\sim \ell_P^2/r^2$, so in order to , in order to estimate any relation obtained within the framework of the general theory of relativity in relation to the Planck scale, it is necessary to replace the relation r_g/r with the expression $\zeta \sim \ell_P^2/r^2$. Indeed, we saw above that the parameter ζ determines at the Planck level the collapse of photons, the dimension of space, the non-Euclidean nature of spacetime, and fluctuations of the spacetime metric.

1.3.5 Shimmering space-time geometry and virtual black holes

The gravitational field makes zero oscillations, and the geometry associated with it also oscillates. The ratio of the circumference to the radius fluctuates around the Euclidean value: the smaller the scale, the greater the deviations from Euclidean geometry become.

Let us estimate the order of the wavelength of zero gravitational oscillations, at which the geometry becomes completely different from Euclidean.[24] The degree of deviation of the ζ geometry from the Euclidean one in the gravitational field is determined by the ratio of the gravitational potential φ and the square of the speed of light $c : \zeta = \varphi/c^2$. When $\zeta \ll 1$, the geometry is close to Euclidean; at $\zeta \sim 1$ all similarity disappears. The oscillation energy of the scale L is equal to $E = \hbar\nu \sim \hbar c/L$ (c/L is the order of the oscillation frequency). The gravitational potential created by the mass m at such a length is $\varphi = Gm/L$, where G is the constant of universal gravity. Instead of m you should substitute the mass, which, according to Einstein's formula, corresponds to the energy E $\left(m = E/c^2\right)$. We get $\varphi = GE/L\,c^2 = G\hbar/L^2c$. Dividing this expression by c^2, we obtain the deviation value $\zeta = G\hbar/c^3L^2 = \ell_P^2/L^2$. Equating $\zeta = 1$, we find the length at which the Euclidean geometry is completely distorted. It is equal to the Planck length $\ell_P = \sqrt{G\hbar/c^3} \approx 10^{-35}$ m. This is where quantum foam comes in.

The spacetime metric $g_{00} \approx 1-\Delta g = 1-\ell_P^2/(\Delta r)^2$ fluctuates, generating the so-called spacetime quantum foam, consisting of virtual Planck black holes and wormholes.[15] But these fluctuations $\Delta g \sim \ell_P^2/(\Delta r)^2$ in the macroworld and in the world of atoms are very small compared to 1 and become noticeable only on the Planck scale. Fluctuations Δg must be taken into account when using the special relativity metric $(+1, -1, -1, -1)$ in very small regions of space and at large momenta. Therefore, the expression for the invariant interval dS in spherical coordinates must always be written in the form

$$dS^2 = \left(1 - \frac{\ell_P^2}{(\Delta r)^2}\right) c^2dt^2 - \frac{dr^2}{1 - \ell_P^2/(\Delta r)^2} - r^2(d\Omega^2 + \sin^2\Omega d\varphi^2) \tag{1.45}$$

However, due to the smallness of $\ell_P^2/(\Delta r)^2$, the expression for the invariant interval is usually written in Galilean form $(+1, -1, -1, -1)$, which is incorrect. The correct expression must take into account fluctuations of the spacetime metric and the gravitational collapse of matter at the Planck distance scale. It can be seen that on the Planck scale Lorentz invariance is violated.

In physical work, a certain small parameter is usually determined, which can be neglected under clearly defined conditions. As a rule, the approximation is expressed in the form of an inequality when the dimensionless quantity defining the approximation becomes small compared to unity. For example, classical Newtonian mechanics is true if two conditions are met: $v/c \ll 1; \hbar/S \ll 1$ (c is the speed of light, v is the speed of the body, $\hbar$ is Planck's constant, S is an action).[11] In our case, special and general relativity are true when $\ell_P^2/L^2 \ll 1$ (ℓ_P is the Planck length, L is the macroscopic length). When $\ell_P^2/L^2 \sim 1$ the laws of quantum gravity apply. Approximations reign in physics.

It is known that the coordinate speed of light c_k in some place with gravitational potential $\varphi = -Gm/r$ is equal to $c_k = c\,(1 + 2\,\varphi/c^2) = c\,(1 - r_g/r)$, where c is the physical speed of light.[25] Then on the Planck scale, due to quantum fluctuations of the potential, the expression for the coordinate speed of light will take the form $c_k = c\,(1-\ell_p^2/(\Delta\lambda)^2)$. Here λ is the wavelength of light emitted by the source. The greater the distance from the source the light travels and the shorter its wavelength, the more noticeable the dispersion of the rays will be due to accumulated distortions. In this case, the photon velocity inhomogeneities $\Delta c = c\,\ell_p^2/(\Delta\lambda)^2$ are determined not by the Planck length, but by its square, so that these inhomogeneities are immeasurably small (of the order of $10^{-56}\,c$ for $\lambda = 10^{-5}$ cm) and images of distant sources will be sharp even at metagalactic distances.[26]

As noted in [27], for a region of spacetime with dimensions L, the uncertainty of the Christoffel symbols should be of order ℓ_P^2/L^3, and the uncertainty of the metric tensor should be of order ℓ_P^2/L^2. If L is a macroscopic length, then quantum limitations are fantastically small and can be neglected even at atomic scales. If the value of L is comparable to ℓ_P, then maintaining the previous (ordinary) concept of space becomes more and more difficult and the influence of microcurvature becomes obvious.

The expression for metric fluctuations is consistent with the Bohr-Rosenfeld uncertainty relation $\Delta g\,(\Delta L)^2 \geq 2\ell_P^2$.[9]

From this point of view, other expressions for fluctuations of the metric tensor, namely $\Delta g \sim \ell_P/L$ and its first derivatives (Christoffel symbols) $\Delta\Gamma \sim \ell_P/L^2$, set to 1 by analogy with electrodynamics,[28] do not correspond to reality, since gravity (geometrodynamics) is fundamentally different from electrodynamics.[29] Observations of the degree of blurring of distant stellar objects did not confirm these expressions.[30] The correct expression is $\Delta g \sim \ell_P^2/L^2$.

As emphasized in[28], these small-scale fluctuations indicate that everywhere in space something similar to gravitational collapse is happening all the time, that gravitational collapse is essentially constantly occurring, but the reverse process is also constantly occurring, that in addition to the gravitational collapse of the Universe and stars, it is also necessary to consider a third and the most important level of gravitational collapse at the Planck distance scale.

The uncertainty relations written above are valid for any gravitational fields, since in a sufficiently small 4-region of any gravitational field space-time is practically flat.

Note that according to Markov M.A.,[31] real Planck black holes with a mass of 10^{-5} g may not "evaporate", but be stable formations. The fact is that the entire mass of a black hole can "evaporate", with the exception of that part of it that is associated with the energy of zero-point, quantum oscillations of the black hole's matter. Such vibrations do not increase the temperature of the object and their energy cannot be radiated. On the other hand, the quantum laws of conservation of baryon and lepton charges should also prevent the complete "evaporation" of a black hole. The residual mass is 10^{-5} g. Planck black holes have an extremely small interaction cross section $10^{-66} cm^2$. This leads to the fact that stars and planets are almost completely transparent to them - the mean free path of a Planck black hole in matter of nuclear density is comparable to the radius of the visible part of the Universe, and therefore they are very difficult to detect. Therefore, Planck black holes, which arose as a result of the collapse of radiation in the first fractions of a second of the Big Bang (for example, during the collision of energetic photons), could hypothetically serve as a source of mysterious dark matter. As is known, dark matter does not manifest itself in any way, except for the gravitational effect on the visible part of matter.[15]

On the other hand, the uncertainty relation $\Delta r_g \Delta r \geq \ell_P^2$ indicates that on the Planck scale there is a vacuum consisting of virtual Planck black holes. The energy density of such a vacuum does not change as the Universe expands, which creates negative vacuum pressure. This vacuum can serve as a source of dark energy.

From the uncertainty relation $\Delta r_g \Delta r \geq \ell_P^2$ it follows that a decrease in Δr will lead to an increase in Δr_g and vice versa. When $r \ll \ell_P$ the Schwarzschild radius r_g exceeds both r and the Planck length ℓ_P. Therefore, any attempt to probe length scales $r \ll \ell_P$ will require localizing the energy within a radius that is much smaller than the corresponding Schwarzschild radius, $r_g \gg \ell_P$. Thus, the corresponding act of measurement will result in the formation of a macroscopic classical black hole long before we have a chance to measure the distance $r \ll \ell_P$.[1]

It can be seen that the Planck length is the limit of distance, less than which the very concepts of space and length cease to exist. Any attempt to explore the existence of shorter distances (less than 1.66^{-35}m) by carrying out collisions at higher energies would inevitably end in the birth of a black hole. Collisions at high energies, instead of breaking matter into smaller pieces, will lead to the birth of black holes of ever larger sizes.[32] Decreasing the Compton wavelength of the particle will lead to an increase in the Schwarschild radius of the black hole. The uncertainty relation between the Schwarzschild radius and the Compton wavelength gives rise to virtual black holes on the Planck scale.[33]

Virtual Planck black holes are also important for the theory of elementary particles. The fact is that when carrying out calculations in modern quantum theory and, in particular, when calculating the intrinsic energy of particles, the contribution of intermediate states with arbitrarily high energy is usually taken into account, which leads to the appearance of known divergences. Taking into account the gravitational interaction of the corresponding virtual particles and the possibility of the emergence of virtual (short-lived) black holes in the intermediate state should lead to the elimination of these divergences.[15]

It can be seen that at the Planck level, matter is in a black hole state, and Planck black holes are characterized by different quantum numbers. It is assumed that the basis (nuclei) of quarks and leptons are Planck black holes[34] and this may be an alternative to string theory. Significant matter can be built from Planck black holes.[35][36] In a free state, Planck black holes, as noted above, can act as so-called dark matter.

The problem of singularities in Planck black holes is resolved if we assume that the singularities are multidimensional and therefore have unlimited capacity and finite density of matter.[2] It is assumed that the additional dimensions of space in the singularity are compactified (folded into rings). Thus, the three-dimensionality of the external, observable space is due to the energetic advantage in the formation of virtual Planck black holes, and the multidimensional nature of the singularities hidden under the event horizon in black holes solves the problem of the infinite density of collapsing matter.

1.3.6 Space quantization and Planck length

In the 1960s, the hypothesis of the quantization of spacetime[37] along the path of unifying quantum mechanics and general relativity led to the assumption that there are cells of spacetime with the minimum possible length equal to the fundamental length.[38] According to this hypothesis, the degree of influence of space quantization on transmitted light depends on the size of the cell. Research requires intense radiation that travels as far as possible. From the picture of space-time foam presented by Wheeler,[39] it follows that for photons with a wavelength λ propagating in the foam, the travel time T from the source to the detector must be indefinite in accordance with the law , which can only depend on the distance traveled x, the wavelength of the particle λ and the Planck scale ℓ_P with a shape of type $\delta T \sim x^n \ell_P^{1+m-n}/\lambda^m$, where m and n are model-dependent powers, and $1 + m - n > 0$. The phenomenology of quantum gravity currently focuses mainly on effects suppressed at the first power of the Planck scale, since stronger suppression leads to even weaker effects.[40] Therefore, the picture that experimenters are now focusing on corresponds to the following choice: $n = m = 1$, that is,

$\delta T \sim x\,\ell_P/\lambda$.

Currently, a group of scientists has used data from the gamma-ray burst GRB 041219A, taken from the European space telescope Integral. The gamma-ray burst GRB 041219A was included in the one percent of the brightest gamma-ray bursts over the entire observation period, and its source is at least 300 million light years away. The Integral observation made it possible to estimate the cell size several orders of magnitude more accurately than all previous experiments of this kind.

Analysis of the data showed that if the granularity of space exists at all, then it should be at a level of 10^{-48} meters or less.[26] The theory of spacetime quantization is discredited by this. There are two options available to explain this fact. The first option assumes that at the micro level—on the Planck scale—space and time vary simultaneously with each other, so that the speed of photon propagation does not change. The second explanation assumes that photon velocity inhomogeneities are determined not by the Planck length, but by its square (of the order of $10^{-66}cm^2$), so that these inhomogeneities become immeasurably small.[41] Indeed, in a gravitational field, the coordinate speed of light changes, as a result of which light rays are bent. If we denote by c the physical speed of light at the origin, then the coordinate speed of light c_k at some place with a gravitational potential φ will be equal to $c_k \approx c(1+\varphi/c^2)$.[25] But then, as was shown above, on the Planck scale $c_k \approx c(1-\ell_P^2/l^2)$. That is, fluctuations in the speed of light $\Delta c \approx c\ell_P^2/l^2$ are determined not by the Planck length, but by the square of the Planck length and therefore are immeasurably small. In fact, if the wavelength of visible light is $\lambda \approx 10^{-5}$cm, then in this case the ratio $\ell_P^2/\lambda^2 = 10^{-66}/10^{-10} = 10^{-56}$ is less than the ratio $\ell_P/\lambda = 10^{-33}/10^{-5} = 10^{-28}$ by 28 orders of magnitude.

From a modern point of view, the hypothesis[37] of the quantization of spacetime is unsatisfactory. In fact, from Einstein's equations, as has been shown, the quantization of the curvature of spacetime (quantization of the Schwarzschild radius) follows. In accordance with this, the dispersion of light rays from distant galaxies is determined not by the Planck length, but by its square, $n = 1; m = 2$ and $\delta T \sim x\,\ell_P^2/\lambda^2$, therefore, fluctuations in the speed of light will be immeasurably small and images of distant sources will be sharp even at metagalactic distances.[42]

1.4 On the problem of singularities

1.4.1 Introductory Statements

One of the difficulties of the general theory of relativity is the problem of singularities, which actually arose from the moment Friedman obtained non-stationary cosmological solutions to the equations of the general theory of relativity and became even more acute in connection with the problem of gravitational collapse. Singularity denotes a state of infinite density of matter, which indicates the insufficiency of the general theory of relativity. Multidimensionality solves these problems.

1.4.2 How to place the Universe at a "point"

The Universe at a "point" is the author's asserted possibility of placing spaces of any extent in a multidimensional "point" with a given size (that is, in a small region of multidimensional space), including the free placement of our entire Universe in a multidimensional "point" with a diameter of 10^{-33}cm.[44]

For a book, as an example of a 3-dimensional object, the amount of information in the form of letters takes up V volume in the book.

If the same amount of information is placed in 2-dimensional space, that is, on a plane, then in the form of lines the information will occupy an area S with a square side $a(2)$, and $a(2) > a(3)$, where $a(3)$ is the side of a 3-dimensional cube representing a book.

The same amount of information, placed in a one-dimensional space, in the form of a string will stretch in length by the value $a(1)$, and

$$a(1) > a(2) > a(3) \tag{1.46}$$

Accordingly, as the number of dimensions of space increases, to accommodate the same amount of information (in the form of letters), we will need an n-dimensional cube with an ever smaller side $a(n)$ of the corresponding n-dimensional cube, that is

$$a(1) > a(2) > \cdots > a(k) > \cdots > a(n) \tag{1.47}$$

It is easy to show that $a(n)$ and $a(k)$ are related by the following relation

$$a(n) = a(k)^{k/n} \tag{1.48}$$

Indeed, (1.48) follows from the equality of volumes of information (or matter) in one or another n-dimensional space

$$V(1) = V(2) = \cdots = V(k) = \cdots = V(n) \tag{1.49}$$

where $V(n)$ are "volumes" of n-dimensional spaces containing the same (equal) number of units of information (or units of matter - atoms), located at the nodes of n-dimensional cubic lattices with a step of d in one or another n-dimensional space. One can imagine that the distance d between particles (atoms) becomes smaller and smaller. Chains of particles in the direction of each coordinate axis transform into what we call continuum. And our rows of atoms turn into solid lines $V(1)$, planes $V(2)$, volumes $V(3)$, etc. to $V(n)$.

And since

$$V(1) = a(1)^1; V(2) = a(2)^2; \cdots ; V(k) = a(k)^k; \cdots ; V(n) = a(n)^n \tag{1.50}$$

then (1.48) follows from here. Here, for example, $a(1) = d \cdot t$, where t is the number of lattice steps.

For a 3-dimensional space from (1.48) we obtain the following relation

$$a(n) = a(3)^{3/n} \tag{1.51}$$

An interesting conclusion follows from the relation (1.51). Suppose we need to place the entire observable Universe together with matter in an elementary n-dimensional "cube" with side $a(n)$ equal to $10 \cdot 10^{-33} cm = 10 \cdot \ell_P$ (then there are ten units of Planck length), where $\ell_P = 10^{-33} cm$ is one unit of Planck length. How many dimensions of space do we need for this?

The size of the observable Universe is 10^{28} cm or, in Planck length units, $10^{61} \ell_P$ Planck length units. From the relation (1.51) we have

$$10^1 \ell_P = (10^{61} \ell_P)^{3/n} \tag{1.52}$$

Hence $n = 183$. From (1.52) it is clear that already with 183 dimensions of space, the entire observable Universe can be placed in a 183-dimensional "cube" with a side $10\ell_P$, that is, in fact, in a "point" (183-dimensional).

The density of matter in such a "cube" remains equal to the density of matter located in the 3-dimensional space of the observable Universe. Indeed, the density of matter in n-dimensional space is determined as follows: $\rho(n) = M/V(n)$, where M is the mass of matter of the observable Universe, $V(n)$ is the volume n-dimensional space, $\rho(n)$ is the density of matter in n-dimensional space. And since, by condition, $V(3) = V(183)$, then $\rho(3) = \rho(183)$.

An illustrative example: folding a one-dimensional thread of length r_1 into a flat two-dimensional "mat" in the form of a spiral with a diameter of r_2 or into a three-dimensional ball with a diameter of r_3. It is clear that $r_1 > r_2 > r_3$, that is, the compactness of the placement of the thread increases with increasing dimension of space, but the density of placement of the substance of the thread remains the same (the atoms of the substance of the thread will still be located at a distance of d from each other in the direction of each nth coordinate axis.

Based on the above, we claim that any finite-dimensional space can be placed in an infinite-dimensional "point".

It can be assumed that the singular "point" (that is, a very small region of space), from which, according to the general theory of relativity, our Universe arose, was multidimensional.

It can also be assumed that during the collapse of black holes, when the matter of the black hole reaches a certain (for example, Planck?) density, the collapsing matter in the center of the black hole (in the singularity) is squeezed out into other dimensions of space, which can be folded (compactified) into rings with a diameter on the order of the Planck density length.

1.4.3 Development

Based on the calculations of Klimets A.P.[44] Trofimenko A.P.[45], the idea was put forward that terrestrial black holes represent topological features in the structure of near-Earth space-time.

According to Trofimenko A.P., this means the multidimensionality of space and time of earthly objects, the presence of bridges (tunnels) to parallel worlds right on Earth.

Taking into account the possibility of compactification using higher dimensions of terrestrial bodies (up to Planck dimensions) while maintaining their usual density, A. P. Trofimenko concludes about the possibility of penetration of man and his technical devices (the density of the substance of objects during multidimensional compactification may not change) through multidimensional terrestrial black holes to other worlds (metagalaxies), "launching" directly from Earth. In relation to the problem of space civilizations, this means the possibility of replacing the spatial expansion of civilization in three-dimensional space with the emergence of a supercivilization into the higher dimensions of the Universe.

Chapter 2

General principle of complementarity

The General or Generalized Complementarity Principle is a generalization of the complementarity principle proposed by Niels Bohr in 1927 as a “defense” against conceptual contradictions of quantum mechanics such as Wave-Particle Duality and the Uncertainty Principle, and later the abstract mathematical General Uncertainty Principle.[46]

2.1 General information

Initially, even Bohr himself pointed to areas of knowledge other than the mathematical formalisms of quantum theory as being subject to the principle of complementarity. With the course of history, it turns out that, completely independent of the subject of quantum theory, the principle of complementarity extends to all systems, the properties of which are partly knowable in their entirety, but partly only associated with such properties, the essence of which does not tolerate abstract study. Dividing the universe of concepts into two halves of duality or dichotomy turns out to be useful, at least in classical systems subject to observer effects. The principle of complementarity turns out to be necessary both in models of various areas of reality, and in abstract models of perception, thinking and feedback control.

Implicitly begun by Bohr himself, the generalization of the principle of complementarity as a task of philosophy was made explicit by a publication in the American Journal of Philosophy in 1957 Journal of Philosophy[47] following John Archibald Wheeler’s essay in Scientific American.[48].

In 2004, Alexander Pavlovich Klimets, the author of this book, proposed his interpretation in the article “Science and Irrationalism.” [49][50][51], later the thesis was developed in the dissertation “The relationship of the irrational and rational in mystical experience” [52], in which the principle is stated as follows: “the rational side of reality and its knowledge and the associated irrational side of reality and its knowledge are complementary to each other.”

2.2 Introduction

The principle of complementarity was discovered by Bohr (1885-1962) in 1927 and is an important principle of quantum mechanics.

The essence of Bohr’s principle of complementarity in physics is that in any experiment with micro-objects the observer receives information not about the properties of the objects themselves, but about the properties of the objects in connection with a specific situation, including, in particular, measuring instruments. Information about an object obtained under certain specific conditions should be considered as additional to information obtained under other conditions. Moreover, information obtained under different conditions cannot be simply added, summarized, or combined into a single picture; they reflect different (complementary) aspects of a single reality that correspond to the object under study. The principle of complementarity finds its direct expression, in particular, in the idea of wave-particle duality and uncertainty relations.

After the initial formulation of the principle of complementarity in physics, Niels Bohr worked hard to explore the application of the concept of complementarity in other fields of knowledge. He considered this task no less important than purely physical research. He makes the case that the two approaches—biological and physicochemical—are complementary. According to Bohr, the fundamental difference between biological and physical research makes it impossible to establish firm boundaries for the application of physical ideas to the solution of biological problems, boundaries that would correspond in quantum mechanics to the difference between a causal mechanistic description and a description of quantum phenomena proper. [53]

Bohr did not believe that biological laws can be reduced to physical and chemical processes. In his opinion, the laws of living matter, although determined by the laws of physics and chemistry, are not reducible to them.

Bohr justified the idea that the two approaches—biological and physicochemical—are complementary. Biological and physical research are not comparable, since both have their own limited areas of reality. In any experiment on a living organism there is some uncertainty in the physical conditions, and therefore the idea arises that the minimum freedom available to the organism is just sufficient to allow it to hide its last secrets from researchers. From this point of view, the very existence of life, according to Bohr, should be considered in biology as an elementary fact, just as in atomic physics the existence of a quantum of action should be taken as a basic fact that cannot be deduced from ordinary mechanical physics.

According to Bohr, the fundamental difference between biological and physical research makes it impossible to establish firm boundaries for the application of physical ideas to the solution of biological problems, boundaries that would correspond in quantum mechanics to the distinction between a causal mechanistic description and a description of quantum phenomena proper. Bohr believes that biological laws are additional to the laws that inanimate nature obeys.

At one time, Niels Bohr was influenced by his father's interests. His father, Christian Bohr, is a famous physiologist, author of classic works on the physical and chemical processes of respiration. Despite his interest in the physics and chemistry of living things, he adhered to finalist views, believing that biological laws should be perceived from the point of view of expediency, and not as the result of physicochemical laws. His works gave rise to lively discussions on one of the main topics of the time - vitalism and mechanism. Vitalism (from the Latin vitalis - "vital") is the doctrine of the presence in living organisms of an immaterial supernatural force that controls vital phenomena - "vital force" ("souls", "entelechies", "archaea", etc.). The theory of vitalism postulates that processes in biological organisms depend on this force, and cannot be explained in terms of physics, chemistry or biochemistry. Subsequently, this led Niels Bohr to the idea that a correct understanding of living things is possible only on the basis of the idea of complementarity of physico-chemical causality and biological purposefulness.

Bohr thought a lot about the application of the concept of complementarity in psychology. He said: "We all remember the old saying that when we try to analyze our experiences, we stop experiencing them. In this sense, we discover that between psychological experiences for which it is adequate to use words such as "thoughts" and "feelings," there is a relation of complementarity, which exists between data on the behavior of atoms.'" [53] Bohr suggests that in this areas there are mutual relationships that are due to the unified nature of consciousness and are strikingly reminiscent of the physical consequences of the existence of the quantum of action, since the continuity of thinking and the preservation of the individuality of the individual in relationships between people are similar to the wave description of material particles while maintaining their individuality in the process of interaction. Trying to critically comprehend any strong feelings, say, love or pious tenderness, we immediately destroy these very feelings. But if, on the other hand, you succumb to a feeling, then you can hardly think it through at that moment.

Bohr compares the process of measurement in a quantum system with the influence of a purposeful will, one's own or another's, on human consciousness. According to Bohr, "finding the verbal equivalent of a thought is analogous to the action of measurement on a quantum object".

According to Bohr, the physical picture of a phenomenon and its mathematical description are complementary. Creating a physical picture of the world requires neglecting details and leads away from mathematical precision. Conversely, attempting to accurately describe a phenomenon mathematically makes it difficult to understand clearly. Indeed, the mathematical description is based on logic, while the physical picture of the world is built on guesses, intuition, and images. To the question "What is additional to the concept of truth?" Bohr replied, "Clarity." [54]

From his student days, Bohr was interested (under the influence of Paul Moller's book "The Adventures of the Danish Studious") by the problem of free will and determinism. Bohr was also strongly influenced by the Danish philosopher Soren Kierkegaard. According to Kierkegaard, the highest quantitative certainty explains the leap just as little as the lowest. New things appear in leaps and bounds. He denies the element of continuity that persists during the transition to the new. A new quality appears with the suddenness of the mysterious. The leap is illogical, inaccessible to rational understanding, does not follow with logical necessity from the previous state, and is irrational.

Bohr also believed that free will and a sense of responsibility, as well as mercy and justice, are in complementary relationships to each other. Bohr sees the common goal of all cultures in the closest combination of justice and mercy that can be achieved; nevertheless, it must be recognized that in every case where the law must be strictly applied, there is no room for the exercise of mercy, and, conversely, benevolence and compassion may come into conflict with the very principles of justice. The human community realizes the complementarity of justice and mercy in conjunction with the institution of state judicial bodies, guided in their activities by the letter of rational laws and jury trials, more susceptible to the influence of irrational feelings.

The additional pairs established by Niels Bohr can be grouped as:

- Corpuscular and wave properties of particles;
- Physico-chemical processes and biological processes;

- Mechanism and vitalism;
- Physico-chemical causation and biological purposefulness;
- Thoughts and feelings;
- Mathematical description of the phenomenon and physical picture of the phenomenon;
- Truth and clarity;
- Determinism and free will;
- Justice and mercy;
- Quantity and quality;
- Logic and intuition;

In the paired relationships established above, a general pattern can be traced: the rational side of reality and its knowledge is displayed on the left, and the irrational side on the right. Thus, Bohr's general principle of complementarity can be formulated as follows: ***the rational side of reality and its knowledge and the associated irrational side of reality and its knowledge are complementary to each other***.

Regarding the first pair, we note that the wave properties of a single microobject are irrationalism, since from the point of view of rational thinking, a single microobject cannot simultaneously pass through two spatially separated slits and interfere with itself. However, these are precisely the phenomena that occur in the microcosm. As the famous physicist Richard Feynman put it: "I can safely say that no one understands quantum mechanics... No one knows how to dig deeper here. Even nature itself does not know which way the electron will fly."[55] De Broglie waves have nothing in common with classical waves. Einstein called them "ghost" waves. They do not carry energy and propagate in multidimensional configuration space. This is due to the fact that the probabilistic laws of nature do not follow the rule of addition of probabilities, but require the addition of probability amplitudes. There are two interference phenomena in nature: classical interference caused by the addition of waves, and quantum mechanical interference caused by the addition of probability amplitudes (or so-called wave functions). The probability amplitude is a certain complex number, the square of the modulus of which is equal to the probability of the micro-object transitioning from the initial to the final state. In essence, the probability amplitude (state vector) is an irrational quantity that has no analogue in classical physics.

Erwin Schrodinger was the first to find an explicit equation for waves in wave mechanics and based on it to construct a rigorous method for considering quantization problems in 1926. This equation, obtained by transforming classical equations in the Hamiltonian representation, has the peculiarity that not all of its coefficients are real numbers ; it also includes imaginary numbers. In classical physics, the wave propagation equations contain only real numbers, and if sometimes real functions are replaced by imaginary functions (or, more precisely, complex ones), then we are talking only about a method of calculation. Meanwhile, in the Schrodinger wave function (probability amplitude), imaginary coefficients are fundamentally irremovable and therefore seem to be inherent in the very phenomenon that they describe. In other words, if in classical physics waves correspond to vibrations of a really existing medium (for example, air during sound waves), then a wave in wave mechanics cannot be considered as a physical reality corresponding to vibrations of some medium. A wave such as a wave conjugate with a particle that does not carry energy and propagates in a multidimensional configuration space cannot be attributed to physical existence; it is a "fictitious wave," as Louis de Broglie called it, or a "ghost wave," as Einstein dubbed it. This wave is an "irrational" wave.

Historically, classical physics first encountered the irrational side of reality at the end of the 19th - beginning of the 20th centuries when studying black body radiation, when explaining the phenomenon of the photoelectric effect, when explaining the laws of spectral lines in atoms (Planck, Einstein, Bohr, de Broglie, Heisenberg, Pauli, Schrodinger , Dirac, Born, etc.). The apparatus of quantum mechanics created, which did not contain any internal contradictions, was successfully applied to the solution of specific problems, but its physical interpretation remained unclear for a long time. To this day, there is a kind of psychological barrier that everyone who begins to study quantum mechanics faces to one degree or another. And this is not a matter of mathematical complexity. The fact is that it is difficult to abandon familiar concepts, it is difficult to rebuild the "thinking style" developed on the basis of everyday experience. This is the price one has to pay for coming into contact with irrational reality.

The remaining complementary pairs listed also follow the "rational" - "irrational" rule. It is important to emphasize here that even in the most rational science - physics, at the micro level we are faced with irrationality.

2.3 General definition of rational and irrational

Rational is a logically sound, theoretically conscious, systematized universal knowledge of a subject. This is in epistemological terms. In ontological terms, it is an object, a phenomenon, an action, the basis of whose existence lies law, formation, rule, order, and expediency. A rational phenomenon is transparent, permeable, and therefore it can be expressed by rational means, that is, conceptually, verbally, it has a communicative nature, can be transmitted to another, can be perceived by all subjects.

Irrational has two meanings. In the first sense, the irrational is such that it can be rationalized. In practice, this is an object of knowledge, which initially appears as the sought-after, unknown, unknown. In the process of cognition, the subject transforms it into logically expressed, universal knowledge. More correctly, such irrational things should be designated as "not yet rational." The interdependence of the rational and the irrational as the not-yet-rational is quite clear. The subject of cognition faces a problem that is initially hidden from him under the veil of the irrational. Using the means of cognition available in his arsenal, he masters the unknown, turning it into the known. The not-yet-rational becomes rational, that is, an abstract, logically and conceptually expressed, in short, a cognized object.

The second meaning of the irrational is that this irrational is recognized in its absolute meaning - irrational-in-itself: something that, in principle, is not knowable by anyone and never. Irrationalism believes that there are areas of understanding of the world inaccessible to reason and accessible only through such qualities as intuition, feeling, instinct, revelation, faith, etc. In irrationalism, reason, which gives rational knowledge about the phenomenal world, is recognized as useless, helpless for knowing the world of things themselves. to yourself. Rational knowledge is possible only in relation to the world of phenomena; the thing itself is inaccessible to it. From the point of view of irrationalism, rational knowledge does not and, in principle, is unable to provide knowledge of the essence of an object as a whole; it glides on the surface and serves exclusively for the purpose of orienting a person in the environment. [56]

In the "general principle of complementarity" formulated above, the second meaning of the irrational is implied.

2.4 The principle of complementarity in other areas of knowledge

The general principle of complementarity allows us to search for phenomena of duality in various areas, grouping them according to rational and irrational criteria. Continuing the series further, it can be argued that the following relations have a complementarity relationship with each other:

- Discreteness and continuity;
- Finitude and actual infinity. Regarding the irremovable contradictions in the foundations of modern (rational) mathematics, which does not take into account the complementarity of the rational and irrational, we recommend the book of the American mathematician M. Klein "Mathematics. Loss of certainty";[57] One of the author's conclusions: logic, mathematical reasoning complements intuition, and in the substantiation of mathematical truths the main role is played by intuition (irrational), and evidence, logic (rational) is given only an auxiliary role . A proof is the testing of ideas suggested by intuition.
- Locality and non-locality;
- Multiplicity and unity, integrity (one, as an expression of the ultimate indecomposability of reality into sets); [58]
- Determinism and indeterminism;
- Spatio-temporal picture of the world (statics) and impulse-energy picture of the world (movement, process, formation);
- Real particles and virtual particles; Virtual particles take their energy from nowhere and, after existing for a short time in accordance with the Heisenberg uncertainty relation, disappear into nowhere. This is their irrationality.
- Mixture of states and quantum superposition of states;
- Science and art; The core of science is logic and experience. The basis of art is intuition and insight. Close to this are thoughts and feelings: thoughts can be rationally conveyed in words, but feelings are irrational and cannot be conveyed in words.
- Reflection on the world and dissolution in the world, merging with it;

- Universality, universality and uniqueness, individuality;
- Appearance (thing for us) and essence (Kantian “thing-in-itself”);
- Phenomena and noumena;
- Consciousness and subconsciousness; [59]
- The starry sky above your head and the moral law in the soul (Immanuel Kant);
- entropy and negentropy
- Mechanical unity (a part cannot be a whole) and organic unity (a part is a whole);
- Reductionism and holism. In their research, physicists can do two things: firstly, isolate a phenomenon from the surrounding world in order to study it separately, and, secondly, try to consider the phenomenon in its connection with nature. Those who share the first point of view are faced with the danger of “killing” the phenomenon under study, severing its life-giving connections with the outside world. They try to understand how a system works by studying an isolated part of it. Representatives of this trend are called reductionists (from the Latin reducere - ”to reduce the complex to a simpler one”). Another approach—systemic—is based on the study of a phenomenon or physical object as a whole. Followers of this method are usually called holistics (from the Greek “holos” - “whole”, “whole”). Reductionism was the leitmotif of the development of physics in the twentieth century. Scientists tried to find the “material point” of physics, its primary object, the dimensions of which could be neglected (atoms, nuclei, elementary particles, quarks and leptons, Planck black holes...). Scientists hoped that such a fundamental object could be described by a simple and convenient apparatus of linear physics. However, when they reached Planck scales, physicists discovered that the most fundamental objects today—Planck black holes—have extension. This is where the movement into depth ends, since on the Planck scale any measuring instruments (accelerated electrons, protons, energetic photons, etc.) inevitably themselves turn into the same Planck black holes. Deeper space has nothing to verify or measure. This portends another crisis in physics. Nonlinear methods should become the germ of a new direction that can lead it out of the deadlock. Nonlinearity and irrationalism, inevitably inherent in the holistic approach, is a new dimension and direction in the development of physics with truly boundless prospects. Probably, the physical science of the 21st century will be completely different from all previous physics; [60]
- Tonal and nagual (dualistic concept of reality according to Carlos Castaneda [61] Castaneda reveals to us two aspects of the tonal: this is the space in which an ordinary person exists throughout life, and the organizing principle that gives meaning and meaning to everything which has to do with awareness. The tonal includes everything that a person is, everything that he thinks and does, everything that we can think and talk about at all. Reason, thinking and the ordinary description of reality are the stronghold of the tonal, they include the entire spectrum of the known. For an ordinary person, there is only the known, and therefore conscious experience is limited for him by the limits of the tonal - the acquisition of this experience begins with the moment of birth and ends with death. Accordingly, the nagual can be defined as everything that remains outside the tonal. This is what which is impossible to conceive.Castaneda describes the tonal as an island on which all daily life takes place.No one knows what lies beyond the island. The nagual in this case will be a space of unimaginable secrets surrounding the island. The tonal and the nagual are true opposites, although in essence they are one. The tonal is what is called order, space, samsara, the earthly world. Nagual - lack of order, chaos, nirvana, the heavenly world. The tonal and the nagual are in everything or everything is them. A person’s personality is formed in the tonal. Physiologically, personality is connected to the left hemisphere of the brain, and essence is connected to the right. At the beginning of life, both hemispheres of the brain have right-sided functions. After the separation of the functions of the hemispheres of the brain, a struggle between feelings and mind, the nagual and the tonal, the devil and the guardian angel flares up in a person. Often this guardian turns into a guard - a despot who suppresses everything that does not correspond to his ideas about morality. The right hemisphere of the brain is connected to the left side of the body, which is considered to perceive the world of the nagual. The left hemisphere of the brain is connected to the right side of the body—the tonal side. This division is known in many mythological and religious systems. The human nagual is responsible for intuition, feelings, dreams, and will. The tonal contains a map of the world, that is, a list of everything known, things, concepts, etc., which have their own verbal designation. The nagual is our individuality. He is responsible for creativity (for the tonal is only patterns and stereotypes of learned actions), for strength and unusual abilities. The nagual can do incredible things: the spirit of a person, his will. When the nagual comes out, the tonal contracts. For example, at the moment of a flash of intuition, the internal dialogue, an attribute of the tonal, subsides. At the moment of strong emotional experiences, the logical mind of the tonal recedes into the background. The perception of the tonal is limited to the

world of the tonal and a person cannot perceive the nagual. To perceive the nagual, one must move away from the ordinary perception of the tonal. Also, in order to dream, you need to fall asleep and disconnect from the physical world. The splitting of the tonal and nagual is carried out by separating the right and left hemispheres of the brain, for which a variety of methods are used (for example, a method of such splitting can be whispering in both ears). The mysterious power that lies within a woman is the gift of the nagual. A woman is more perfect in understanding the nagual. Entering the nagual is known in India as samadhi, but the impressions of this exit are not always easy to transfer into the tonal;

- Evolutionism and creationism. The long-standing dispute between evolutionists and creationists finds its resolution in the generalized principle of complementarity. Both are right. The observable world develops evolutionarily (rationally), but the basis of matter, life and mind is creation (irrational). And any act of creativity is an irrational phenomenon. Creativity is a creative process, a process of becoming. It is always an increase, an addition, the creation of something new that was not in the world - nothing becomes something, non-existence becomes being (compare: in quantum mechanics, measurement reduces the irrational, the indefinite - to the rational, concrete). Creativity determines the eternal process of creation; it is immanent to freedom, since it realizes the existential process. Freedom is the result of the creative process as being. Freedom is understandable only mystically; it is inexpressible, irrational, and incommensurable with any of our categories. Beyond this point, the rational mind is powerless, as it is unable to express the inexpressible. Only mystical insights remain, which are the basis of creativity. That is why modern computers, built on cells with Aristotelian rational logic "yes" or "no", are only able to calculate, but not create. Computers are programmed, but they are not free.

- Between "Something" and "Nothing", in the spirit of the famous Russian philosopher S. N. Bulgakov, when God, from the point of view of human mental capabilities, is inexpressible in any definitions and concepts. Therefore, God turns out to be "Nothing" as the negation of any definitions of God. "Nothing" has producing potentials that have existential possibilities and ultimately transform it into "Something", that is, a certain existence. It is impossible to define God himself, that is, to endow him with certain qualities—humanity does not have such tools of cognition. One can only study God's creation, since God reveals himself precisely in creation. Only through the endless process of creation, the transformation of "Nothing" into "Something," the design of being as a result of the realization of existential potentials can one approach God, try to comprehend and describe his transcendental, irrational essence.

- Nominalism and Realism. The world is divided into quantum objects and devices. Quantum objects are described by quantum physics, devices by classical physics. The properties of quantum objects are not characterized by any fixed numbers. To describe this situation, there is the concept of relativity to means of observation, illustrating the "emergence" of numerically determined properties during measurement. For example, in the special theory of relativity, the length of an object and the duration of a process characterize not the attributes of the object itself, but the "relationship" of the observed object to another object associated with the observer. Without indicating a frame of reference, length and duration are something indefinite. In quantum physics, a quantum object "in itself" is described by operators, and not by numbers, as in classical physics, so that this object "objectively" represents a set of observable operators. The number "emerges" when measured. This "objective uncertainty" means that uncertainty is not associated with our ignorance, but is a property of the object itself. Heisenberg said that quantum physics is close to platonism (the objective existence of general concepts), if we talk about quantum reality as "in itself." [62] Description in the language of operators is interpreted as the existence of "coordinates in general", "momentum in general", the principle of particle identity - as the existence of "particles in general", etc. This is the philosophy of medieval realism , who argued with nominalism on the question of the existence of general concepts. For example, does "man in general" exist, and not just specific people. Then the dispute was resolved in favor of nominalism (as in classical physics in favor of individual, specific objects). But in quantum mechanics, the principle of particle identity says that, for example, if there is a system of electrons, due to their identity, they cannot be given separate names - first, second, etc. We can only say how many electrons there are. All this provides grounds for a more serious attitude to realism and, accordingly, to platonism, which follows from it.[63] Nominalism and realism are complementary as the rational and the irrational;

Obviously, the series written out above can be continued, placing on the left the rational aspects of reality and their knowledge, on the right - the associated irrational aspects of reality and their knowledge. As Bohr wrote: "Every truly profound phenomenon of nature cannot be defined unambiguously using the words of our language and requires for its definition at least two mutually exclusive additional concepts."[54]

Due to the general principle of complementarity between the rational and irrational aspects of reality established above, they never come into conflict with each other, since the more one aspect of reality is specified, the more uncertain the second aspect of reality associated with it becomes. By creating more and more certainty in the rational aspect of any phenomenon, nature reduces certainty in the additional, irrational aspect of the phenomenon associated with it and vice versa.

Using the principle of complementarity of the rational and irrational aspects of nature, for example, Zeno's aporias are resolved. Indeed, Zeno's aporias are insoluble only within the framework of rational thinking. Consider, for example, the Arrow aporia. It is as follows: if we assume that space, time and the process of movement consist of some "indivisible" elements, then during one such "indivisible" the body cannot move (because otherwise the "indivisible" would be divided), and since the sum If rest cannot give movement, then movement is generally impossible, although we observe it at every step.

But breaking down into "indivisible" elements is a rational action. According to the general principle of complementarity, it is also necessary to take into account the irrational aspect of movement. The irrational aspect is not visually representable (that's why it is irrational), but it is precisely it that is responsible for the transition of a body (arrow) from one indivisible element to another indivisible element or for the process of its "becoming", when the arrow is simultaneously on a given segment of the path and not on it (both "yes" and "no" at the same time or a superposition of "yes" and "no"). Thus, the state of relative rest (characterized in physics by a coordinate) provides the rational aspect of the phenomenon, and the state of motion (characterized in physics by momentum) provides the irrational aspect of the phenomenon.

Analyzing the dialectical nature of movement revealed in the 5th century. BC the ancient Greek philosopher Zeno, the German scientist G. Hegel wrote: "When we generally talk about motion, we say: the body is in one place and then moves to another place. While it is moving, it is no longer in the first place, but also not in the second. To move means to be in this place and at the same time not to be in it; This is the continuity of space and time, and it is precisely this that makes movement possible." [64]

In movement we discover not only moments of stability (rational moments) - "yes" or "no", but also moments of variability (irrational moments) - that is, "yes" and "no" at the same time. With the help of the interference of alternatives "yes" and "no", problems of movement and development are solved. Rest (rational) is only a moment of movement (the moment of the irrational), due to the relative constancy of a particular phenomenon. Rest is essential for moving matter; without rational (relative rest) it is impossible to cognize the irrational (movement, formation, development). The possibility of relative rest of bodies is an essential condition for the differentiation of matter and thereby an essential condition for life. Rest and movement complement each other, but rest is only a relative moment of movement, while movement is absolute and eternal.

The irrational underlies the existence of matter, the rational is a particular moment of the irrational, its degenerate case, the result of the process of decoherence, state reduction (decoherence is the process of loss of coherence of quantum superpositions as a result of the interaction of the system with the environment).

Based on the above, we can generalize the Heisenberg uncertainty relation as follows:

$$\Delta R \Delta I \geq C$$

where R is the rational aspect of reality, I is the associated irrational aspect of reality, C is a certain constant, which can be conventionally taken as a unit. Accordingly, the commutation relationship between R and I will have the form:

$$RI - IR \geq iC$$

that is, the result of the sequence of rational and associated irrational aspects of reality when performing some actions depends on the order in which they occur, and the sequence RI is not identical to the sequence IR. For example, if a person performs some action guided first by the rational mind and then by irrational feelings, then the result will be different from the case when the action first occurs under the influence of irrational feelings and then by the rational mind. Let us pay attention to the fact that on the right side of the commutation relation between R and I there is an imaginary unit i, which indicates the nontrivial (irrational) nature of this commutation relation. At the same time, the imaginary unit i on the right side of the commutation relation indicates that it is impossible to "predict" the difference in the result in advance.

Thus, due to the general relationship of uncertainties between the rational and irrational aspects of reality found above, they never come into conflict with each other, since the more one aspect of reality is specified, the more uncertain the second aspect of reality associated with it becomes. By creating more and more certainty in the rational aspect of any phenomenon, nature reduces certainty in the additional, irrational aspect of the phenomenon associated with it and vice versa. Examples include the scientific and mystical picture of the world, reason and feelings, thinking and intuition, etc., etc.[65] The original development of the above ideas is also in the article by B. Galenin. [66] “”The creation of quantum physics at the beginning of the 20th century, in which the central concept turned out to be not matter, but immaterial, fundamentally unobservable, that is, a purely spiritual given, noumenon, psi-function that describes the probability of the existence of a substance, the discovery by biologists of the mechanism of protein synthesis on ribosomes under the control of nucleic acids, which showed that life is not a chemical laboratory, but a publishing house where texts are continuously printed and edited, their translation from one language to another and distribution to different authorities, and in mathematics - the theorems of Godel, Tarski and Paris-Harrington, which showed that mathematics is based not on logic, but on intuition, on the extra-mathematical idea of actual infinity, greatly undermined rational character of the exact sciences." But, as the author claims, the humanities, including history, were practically not affected.

German theoretical physicist and Nobel Prize winner W. Heisenberg (1901–1976), author of the uncertainty principle, defended the idea that complementarity is universal. And in the context of the development of physics, he believed, this idea awakens hopes that "in the final state, different cultural traditions, new and old, will coexist, that very heterogeneous human aspirations can be united in order to form a new equilibrium between thoughts and action, between contemplation and activity."≫[62] German theoretical physicist and Nobel Prize winner M. Born (1982–1970) believed that the idea of complementarity has universal significance because there are many areas of human activity where the same fact can be viewed in different but complementary aspects. He agreed with Bohr that the idea of complementarity can be applied to other areas of knowledge, in particular in biology, psychology, philosophy, politics, and stated that we should not refuse such an enrichment of our thinking. "Thus," concludes Max Born, "physics leads to the need to abandon the representation of all aspects of a phenomenon through the same kind of observation and the same system of concepts. There are always at least two aspects of the process, and in each individual case it is necessary to choose which one to give preference." [67]

'I believe," M. Born further wrote, "that complementarity is an important concept, because it clarifies much beyond the boundaries of physics. This applies to such pairs of concepts as "'matter"' and "life"', "'body"' and "'soul"', "'necessity"' and "' Liberty"'. There has been a philosophical and theological debate around them for centuries due to the desire to bring everything into one system. If it now turns out that even in the most rigorous and simplest science - physics, this is impossible to do, that even there various aspects need to be considered from the standpoint of complementarity, then it is clear that the same thing should be expected everywhere.""[68]

Austro-Swiss theoretical physicist and Nobel laureate W. Pauli (1900–1958) believed that the idea of complementarity goes beyond the scope of physics. Its philosophical significance lies in the fact that it, opposing one-sidedness, "'could be the first step towards progress towards a single general picture of the world, in which the natural sciences form only a part of it.'"[69]

Wolfang Pauli was absorbed by the ideas of C. G. Jung (1875–1961) about the deep connections between physical and psychological phenomena. ""I personally believe that in the science of the future, reality will no longer be "mental" or "physical," but both or neither." This leads to W. Pauli's central idea about psychology. He suggested that the connection between the conscious and unconscious satisfies the principle of complementarity in the sense used by Niels Bohr. Pauli hoped that in this way the unified picture of the world, which existed in the 17th century and has since split into two branches - rational and mystical-religious, would be restored through overcoming their antitheses. He sees a correspondence between psychological and quantum-mechanical concepts, calling the unconscious "a "secret laboratory"," and characterized the connection between mysticism and rationalism: ""In my opinion, this is the narrow path to truth that runs between the Scylla of the blue mist mysticism and Charybdis of sterile rationalism. This path will always be full of traps, and you can plunge into the abyss, going astray in both directions."[70]

But this is the purpose and essence of the general principle of complementarity between the rational and irrational aspects of nature - the construction of a single general picture of the world.

2.5 The principle of complementarity and mysticism

Fridtjof Capra's book "The Tao of Physics" says: "Science and mysticism are two complementary sides of human knowledge: rational and intuitive.

A modern physicist is a follower of an extremely rationalistic direction, and a mystic is an extremely intuitive one. These two approaches differ from each other in the most fundamental way, and not only in matters of interpretation of the meaning of the phenomena of the material world. Moreover, they are characterized by, as they say in physics, complementarity. One approach cannot be replaced by another; each of them has a unique value, and their combination gives rise to a new, more adequate worldview. To paraphrase an ancient Chinese saying, one can say that mystics understand the roots of the Tao, but not its branches, and scientists understand the branches of the Tao, but not its roots. Science does not need mysticism, mysticism does not need science, but people need both. Mystical perception allows us to achieve a deep understanding of the essence of things; science is indispensable in modern life. Thus, what would be best for us would be a combination of mystical intuition and scientific rationality, and not a dynamic alternation of them."

The foundation, the roots of the rational, objective, divided macroworld is the microworld with its quantum irrationalism: 1. virtual particles that receive their energy from non-existence; 2. tunnel passages; 3. quantum indivisibility and integrity; 4. the principle of uncertainty, etc. and so on.

It is from the principle of complementarity that all the unusual features of quantum theory follow, in particular, its probabilistic nature. Now let's compare. One of the scientific objections to mysticism is this.

Science, unlike mysticism, is based on experiments that a scientist can reproduce anywhere at any time an unlimited number of times. Mystics, on the other hand, operate with facts that are not reproducible in the same sense. But it is not difficult to understand that due to the probabilistic nature of the principle of complementarity, we should not demand rationality from mystical phenomena, which science so insists on, and their reproducibility is not at all necessary, since in mysticism, as in quantum mechanics, the observer plays an essential role and his psychological state.

The probabilistic description of the classical world in quantum mechanics arises not because we do not know something about the system, but because it does not have any specific characteristics before measurement. There is a superposition of possible states in the system, only one of which appears in experiment. The same superposition of possible states exists in mysticism. Therefore, each mystical experience is individual, unique, unrepeatable.

Note that the Einstein, Podolsky, Rosen paradox (EPR) [71] means a rejection of common sense and the recognition of non-physical connections between physical phenomena similar to otherworldly ones. We are talking here about so-called quantum correlations. Niels Bohr, in his response to the EPR, did not refute or analyze the common sense that guided the EPR, but from the very beginning transferred the whole problem to the other world. He said that a quantum system can only be considered in relation to an observer as a single whole, and it is pointless to raise questions about the processes within the system that lead to the results of observing the system as a whole. These processes are unknowable. In other words, a quantum system is a thing in itself and its internal processes are an otherworldly world for us. Common sense was developed within the framework of a local approximation, within the framework of a discrete approach. But remaining within the local approximation, it is impossible in principle to reconcile quantum correlations with common sense. Common sense is based on discrete, Aristotelian logic. The creation of quantum mechanics showed the insufficiency of the local approximation to the description of the microscopic world and the need to develop the so-called "continuous logic" [72]. The nature of quantum correlation is unknown. Its existence indicates the presence in nature of a connection between objects that cannot be explained by known physical factors3. Clarifying the nature of quantum correlation is a problem of the "otherworldly", irrational world.

2.6 Einstein's tragedy

Einstein's tragedy

In quantum mechanics, the principle of superposition is fulfilled - the wave function A consists of the wave functions of mutually exclusive events (alternatives). Let there be a screen with two holes between the electron beam and the photographic plate. Close one of the holes with a flap. Then the electron necessarily goes through the other, and the shutter does not affect its wave function. Let us denote this function by A_1. Let's move the shutter to another hole and denote the new wave function A_2. If both holes are open, the wave function $A = A_1 + A_2$. The probability of finding an electron at any point on the photographic plate will be $P = (A)^2 = (A_1 + A_2)^2 = A_1A_1^* + A_2A_2^* + (A_1A_2^* + A_1^*A_2)$. If at any point A_1 and A_2 are equal, then we get the probability $P = 4(A_1)^2 = 4P_1$, and if they differ in sign, then $P = 0$ - electrons do not fall into these places. If the holes are opened alternately, the probabilities will add up, not the wave functions. The corresponding probability will be $P = A_1A_1^* + A_2A_2^* = P_1 + P_2$. The interference will disappear, the values of P_1 and P_2 are positive and do not cancel each other out. Thus, attempting to refine a particle's trajectory by selecting cases in which it passes through a single hole eliminates interference. This is how the complementarity of the space-time description of the particle and its wave properties is manifested.

The terms $A_1A_1^*$ and A_2A_2* characterize the discreteness or rational (classical) side of reality, and the terms in brackets $(A_1A_2^* + A_1^*A_2)$ characterize the continuity (integrity) or irrational side of reality.

Further. At one time, Einstein (1909) derived a formula for radiation energy fluctuations $< e^2 >$, where $< e^2 >$ is the root mean square value of energy fluctuations [71,p.174]. If we consider a small part of the volume of the cavity v filled with thermal radiation with temperature T, limited on all sides by a wall that blocks radiation of all frequencies except the frequencies of the interval dv, we can write this formula as follows $< e^2 >= [hvr + (c^3/8\pi v^2)r^2]vdv$ (provided that the spectral function r is given by the well-known Planck law). Einstein obtained a similar relation in 1925 for a gas of massive particles [71,p.496]. The expression in square brackets consists of two parts-corpuscular and wave. The corpuscular term hvr characterizes the discrete, rational component of radiation (particles), while the wave term $(c^3/8\pi v^2)r^2$ characterizes the continuous, irrational component of radiation (particles)

The tragedy of the outstanding physicist Albert Einstein was that he was never able to accept the dichotomy of the world, its division into rational and irrational aspects. For him, there was only the rational side of reality with its unambiguous cause-and-effect relationships. Einstein rejected the irrational side of reality ("God does not play dice"). This was especially clearly manifested in the work of Einstein, Podolsky, Rosen (EPR) "Can the quantum mechanical description of physical reality be considered complete?" (1935) [71, p.604].

Statement of the fact that the world has not only a rational, but also an irrational component obliges physicists to admit that there is another, spiritual reality that lies beyond the boundaries of the material, objective world, additional to it and therefore not amenable to reasonable, rational comprehension. A good example of where a person comes into contact with this reality is our intuitive, creative (but not logical, Aristotelian) thinking, manifested in e.g. in the form of “insights” [72]. And in any other area, as shown above, we can find the phenomena of duality. In light of the above, well-known studies of the phenomenon of life after life (but in a different, irrational reality), conducted by Dr. R. Moody [73], do not look so fantastic. Therefore, physicists must put aside inappropriate snobbery towards mysticism and religion and recognize their equal right to their truth. Only a synthesis of rational and non-rational forms of knowledge of the world can provide a complete reflection of reality. Both of these sources of knowledge must be organically combined and complement each other.

2.7 Man and his mental structure

In the recently emerging (70s - 80s of the last century) new science about man, socionics (see [75], we also find a division of human socionic functions into rational and irrational. From the author’s point of view, such socionic characteristics of a person, How extroversion - introversion, logic - ethics, intuition - sensory, rationality - irrationality should be grouped as follows:

1. Extroversion - introversion
2. Logic - ethics
3. Sensory - intuition
4. Rationality - irrationality

Here, on the left side are the rational functions of man, and on the right side are the irrational functions of man. Here we somewhat disagree with K.G. Jung, who considered ethics to be rational function, and sensory to irrational function. The fact is that the functions of logic, like sensory functions, are specific, discrete, countable, that is, rational, which cannot be said about ethics and intuition, which can rather be classified as continuous, holistic, i.e. irrational functions. For example, the ethical attitude “good - bad” is subjective, i.e. irrational (“What is good for a Russian is death for a German”).

The pairwise functions listed above are antagonistic functions in the sense that the actualization and dominance of one of them in the personality structure suppresses the manifestations of the other. (Compare with the Heisenberg uncertainty relation - exact knowledge of the coordinate of a particle leads to a loss of knowledge of its momentum and vice versa). These functions are complementary to each other in the sense of Bohr’s principle of complementarity. For example, the pair logic - ethics reflects the classic alternative ”sober reason, mathematics - sizzling passion, love.” The pair intuition - sensory characterizes the alternative ”penetration into the inner essence of people and phenomena, a sense of time or impact, suppression, expansion, sensation here and now.” Further, extroverts are turned to the external, objective, rational world. The consciousness of introverts, on the contrary, is turned to their inner, irrational world; for them, their feelings and experiences are more important than any external, rational events. Finally, rational types are distinguished by rationalism, thoughtfulness, ready-made opinions, and logic. Irrational types react to outside influences creatively, adapting to the situation on the fly. Logic (rational) and creativity (irrational) are two complementary types of human behavior. Let us note that any act of creativity is an irrational phenomenon.

Thus, we see that the complementarity of the rational and irrational aspects of nature is clearly manifested in the human psyche and determines its division into 16 psychological types, discovered at one time by the outstanding psychologist K.G. Jung (see [75]).

The complementarity of the rational and the irrational is clearly manifested in the structure of the human brain. The brain consists of two hemispheres, left and right, which are cross-connected with the right and left halves of the body. Neural connections between the hemispheres pass through the corpus callosum and commissures. In neurosurgical practice, a method of treating, in particular, severe epileptic seizures, is known, which consists of dissecting the corpus callosum and commissures, which interrupts direct connections between the hemispheres. After such an operation, patients experience an unusual picture of “two consciousnesses.” According to the laconic formulation of the American neuropsychologist K. Pribram, the results of a study of such patients, as well as patients with various lesions of the left and right hemispheres, can be summarized as follows: “In right-handed people, the left hemisphere processes information in many ways like a digital computer, while the right hemisphere functions more quickly on the principles of optical and holographic data processing systems.” In particular, the left hemisphere contains genetically determined mechanisms for the acquisition of natural language and, more generally, symbolism, logic, and “rationality”; the right, silent hemisphere is in charge of images, holistic perception, intuition. The normal functioning of human consciousness constantly reveals this combination of two components, one of which may manifest itself more noticeably than the other, and the discovery of their physiological carriers sheds light on the nature and typology of mathematical intellects and even schools in the problem of the foundations of mathematics.

2.8 Complementarity of the rational and irrational in the history of philosophy

If we turn to the history of Europe, to the history of philosophy, we can find that the rational and irrational stages in its development alternated with each other. The pre-antique (mythological) period belonged to the irrational stage, while the ancient period belonged to the rational stage.[76] The Middle Ages (Christianity) belong to the irrational stage. After the Renaissance, a rational stage in the development of Europe began again, continuing to the present day. In the Western world, rationalism has been taken to its extreme manifestations, which can result in a global environmental disaster. Obviously, a way out can only be found in a combination (complementarity) of rational and irrational (back to nature) moments in the development of human society.

The Age of Enlightenment (late 11th - 11th centuries) became a time of triumph of the rationalistic worldview. In previous history, there are many attempts to give reason a special status, to emphasize its high significance, to indicate the order and even expediency inherent in the world, which evoke the idea of the dominance of reason in the world order itself. Similar reasoning is already found in the ancient philosophers Heraclitus and Anaxagoras. However, these were only individual actions aimed at elevating the ideological and semantic status of the mind. Only in the Age of Enlightenment does the attitude towards reason turn into a kind of cult of it. This is immediately reflected in philosophy, where reason is given a fundamental role in the actions and social actions of people. By analogy with logical connections, the image of the world is formed. It affirms unilinear cause-and-effect relationships between phenomena, and events unfold according to strictly defined and initially defined patterns.

Reason occupies the place of the supreme judge in the ideology of the Enlightenment and acts as the highest authority of critical analysis. Reason itself is beyond criticism, since there is nothing above it that could subject it to critical evaluation. From the point of view of the Enlightenment, reason is united and universal, common to all people, at all times, therefore a culture that should be built on the principles of reason seems to be the only possible rational culture. Everything that existed before it is only lies and delusions, the result of ignorance or deliberate deception.

This version of rationalism found expression in the works of the French enlighteners J. La Mettrie, C. Helvetius and others. It was continued and taken up by scientism (from the Latin scientia - knowledge, science), a trend quite popular in the century before and last. In the eyes of supporters of scientism, natural science turned out to be a true standard of cognitive and practical actions of people.

The first strong blow to Enlightenment rationalism was dealt by Rousseau, who was a very consistent critic of many trends and attitudes of Enlightenment consciousness. Following Rousseau, the outstanding German philosopher I. Kant made a comprehensive critique of the rationalistic ideas of the Enlightenment. From Kant's point of view, reason and morality are opposite to each other. Truth and goodness are compatible only as an exception. Relying only on reason leads to immorality. It is not the arguments of reason, but the dictates of conscience that should guide a person's actions - this is Kant's conclusion. But was it possible in his time to practically overcome the system of social relations, which objectively generated a gap between truth and goodness, reason and morality, and create a fundamentally new one, within the framework of which a person could use his reason without prejudice to another person, where reason would become moral, and morality is reasonable. Theoretically, this is quite possible. However, the real practice of social relations, neither during the life and work of enlightenment philosophers, nor at the present time, has anywhere confirmed this. In the USA today there is a saying: "If you are so smart, then why are you poor," which clearly demonstrates that Kant was right in his historical dispute with the revolutionary ideology of the French enlightenment philosophers.

The rationalistic theory of continuous social progress put forward by the enlighteners received a negative assessment from many representatives of the Russian philosophical tradition. Russian thinkers A.S. Khomyakov. I.V. Kireyevsky. K.S. Aksakov. F.M. Dostoevsky, N.N. Berdyaev, S.N. Bulgakov, N.A. Florensky, S.L. Frank, I.A. Ilyin comprehended the danger of rationalistic claims for an accelerated transformation of social life, and were the first to clearly realize the catastrophic nature of attempts to change humanity and people through the re-creation of the "social environment" on the basis of a preconstructed speculative plan, project. These philosophers strove for integral knowledge and understood the need to supplement rational knowledge with non-rational, super-rational knowledge. They believed that the hidden depths of existence cannot be comprehended only by reducing the world to logical concepts and theoretical schemes. Finding the meaning of life, in their opinion, can rather be achieved in a symbol, an image - through intuition, inner experience, the power of imagination, spiritual enlightenment and mystical insight.

In essence, Russian thinkers raised the question of moral "counterweights" and "limiters" of speculative-rational projects for transforming the world, of overcoming the "predatory-mechanical" aspirations of a growing technogenic civilization. The result of their criticism is a warning about the dangers of unbridled technological activism (industrial violence against nature) and revolutionary social-utopian experiments (political violence against human life and society), which they bequeathed to the world. In particular, the Russian "cosmists," defending the idea of the world as a living whole, prepared the ground for the establishment in science of an extremely promising and fruitful hypothesis about a self-organizing cosmos, acting not as a dead mechanism, but as an integral internally organized system. This is their merit.

It seems that humanity now just needs such a turn in worldview, the forerunner of which was Russian cosmism. The time has come to consider our planet not as a "workshop", but as a single animate organism. Also, society should be viewed not technocratically, as a "mega-machine" controlled from one center, but as an organic integrity, arbitrary external manipulation of which is harmful and destructive. Only with such an approach to peace can we find new horizons of existence and establish new principles of life that provide the necessary conditions for the survival of humanity.

One of the advantages of Russian philosophy is that, developing within the tradition of European rationalism, it reveals its limitations and opens up new ways of philosophizing, new ideological paradigms.

The rationalism of European philosophizing, appealing to scientific knowledge and considering science as the highest form of rationality, increasingly encountered serious obstacles in its development. A whole series of life phenomena did not lend themselves to this kind of rationalization and did not fit into strict rational schemes, models, patterns. The philosophy of rationalism seemed to ignore the non-rational, emotional, and unconscious, did not take into account, considered it insignificant and "frivolous."

Back in the middle of the 19th century. I. Kirievsky and A. Khomyakov conjectured that the truth is holistic, and it can only be revealed to a whole person. Both philosophers knew German classical philosophy well, especially Hegel, but, being connoisseurs of this great system, they also saw its limitations: rationalism is the result of dissecting the single life of the spirit, it removes the intellect from the integral context of consciousness. As a result of this, it becomes obvious that the abstract mind is not able to comprehend the integrity of the comprehended essence, because the essence as a whole is not subject to purely rationalistic tools. The new rationalism presented in Russian philosophy is a synthesis of sensory experience, rational thinking, aesthetic contemplation, moral comprehension and religious "revelation", designed to comprehend the true existence of the world. About 150 years have passed since then, and the intellectual world, having experienced during this time the intoxication of faith in the limitless possibilities of science, today is forced to agree that, along with the rationality of science, the rationality of myth, religion, morality, art and others exists as equal spiritual phenomena types of rationality. Truth - truth is comprehended by the "heart". Cognition is not only a person's reflection on the world, but also his dissolution in this world, merging with it. Cognition in Russian philosophy is the experience of being as one's personal destiny. The "heart" contains the motive of knowledge, the "heart" is the second mind, which is deeper than the primary mind. To stimulate cognition and research, it is necessary first of all to awaken one or another motive, arouse appropriate interest, and feel something deep, hidden from a person by everyday life.

Russian philosopher V.S. Soloviev (1853-1900) believed that true knowledge is the result of a synthesis of empirical, rational and mystical knowledge in their interrelation, where the rational form, without losing its capabilities, is enriched by the introduction of a "life principle". The new philosophy must combine Eastern understanding and Western knowledge. It must carry out a synthesis of philosophy, science and religion and provide meaning to human life.

Clearing the way to a future "integral worldview," the Russian thinker P.A. Florensky (1882-1937) believed that it should synthesize faith and reason, intuition and reason, theology and philosophy, art and science.

Already in the twentieth century. rationalism became the cause of a new intellectual metamorphosis, the result of which was technocracy. Technocratism absolutizes the importance in the life of society of not only science, but also technology. He assigns a special role in making social decisions and their implementation to various types of specialists. This direction, which arose on the basis of a broad understanding of rationalism, greatly contributed to the philosophical justification of the new European civilization, which in its internal essence is a technogenic society. Its main goal is to take full conscious control of all social processes - economics, politics, science, law and order, etc. However, this ideal turned out to be unattainable in principle. Moreover, over time it became clear that there was no need to strive for it. The subsequent development of philosophy and science convincingly proved the ability of natural and social systems to self-organize. The optimal management of socio-natural complexes is one that releases the internal reserves of systems and is combined with the laws of their self-organization.

A peculiar reaction to the immense exaltation of the role of reason was irrationalism - a special type of philosophical knowledge, which laid the foundation for the corresponding direction. Irrational views have long been found in philosophical teachings. They have a prominent place in various religious and philosophical doctrines, where they usually appear in the form of mysticism. But social, spiritual and cultural factors that were especially beneficial for the development of irrational views emerged by the middle of the 19th century. It was then that F. Schelling developed his "philosophy of revelation"; it was at that time that the fundamental ideas of the philosophy of life were put forward (F. Nietzsche, W. Dilthey, G. Simmel, A. Bergson)

Speculative reasoning of classical philosophy, the loss of the problem of individual existence of a person from the field of view of rationalism, the inability of its supporters to comprehend and describe the everyday world became the cause of colossal spiritual tension in society, which caused a powerful release of intellectual energy, the products of which formed a whole constellation of views on the nature and content of irrational phenomena.

Philosophers suddenly began to show a keen interest in various non-rational ways of mastering reality: will, feelings, subconscious, intuition. The role and place of reason in people's lives is being reconsidered. The Danish philosopher S. Kierkegaard resolutely rejects the Hegelian way of considering everything that exists through the prism of logical relations. With caustic irony, he notes that Hegel broke off a dry branch from the tree of life along with the nest of God who had decayed on it. Philosophers are making attempts to find the intellectual niche within which science should exist. The German thinker Wilhelm Dilthey (1833-1911) makes a comparative analysis of natural science and humanitarian knowledge. The sciences of the spirit, he emphasizes, set themselves the goal of expressing the individual, unique, inimitable, and not of finding the universal, which is typical for the exact, natural sciences (we also noted this above, speaking about the irreproducibility of mystical events). Although both of these spheres of knowledge use concepts, these concepts differ significantly from each other. The concepts of natural sciences are the result of identifying universal, constantly operating and repeating, mainly cause-and-effect relationships. The concepts of the spiritual sciences only express a certain system of connections, which each time not only turns out to be unique, but is also experienced by the cognizing subject himself. Thus, the concepts of the spiritual sciences are not the result of purely logical operations and do not fix laws, they are an expression of life itself. The concepts of the spiritual sciences are not the result of the activity of the mind; they record the meanings and values that arose as a result of the subject's experience of life itself. The stable meanings and meanings with which the sciences of the spirit operate cannot be explained by the mind using logical operations. They can only be co-experienced, i.e. understood. And here V. Dilthey draws attention to another difference between the two spheres of knowledge. The exact sciences are focused on "explaining" external experience with the help of the constructive activity of the mind, the sciences of the spirit are focused on understanding - on determining meanings and meanings, on intuitive comprehension of life.

Continuing the comparison of these two types of knowledge, the German thinker notes that within the framework of natural science, the cognizing subject tries to distance himself as much as possible from the outside world, from the object of knowledge, in order to obtain objective, reliable information. In humanitarian knowledge, the subject is "immersed" in an object, be it a historical process, a work of art, a philosophical concept, etc. The subject here is the creator of the cognizable object, since it is impossible to draw a boundary between the act of experiencing and what is experienced.

Compare this situation with classical and quantum mechanics. In classical mechanics, the observer has no influence on the observed object. In quantum mechanics, the observer and the object of observation are fundamentally inseparable from each other, they form one whole, and are described by one wave function (state vector).

According to Dilthey, life experience, which the sciences of the spirit strive to comprehend, goes far beyond the boundaries of reason; it is irrational. Life in general cannot be put before the court of reason, since it is changeable, fluid, it is a creative process, a process of becoming. The famous Hegelian dialectic does not help here either.

2.9 Man and technogenic society

Representatives of irrationalism were among the first to notice that a civilization that seeks to subordinate everything to logically verified schemes and does not trust the natural course of history, ignores the feelings, will and natural instincts of people, sooner or later falls into its own trap. There is no doubt that the mind opens up for us a wide exit into the world and creates great opportunities for its development. But he is only a part of our spiritual universe. There are also other, non-rational ways of mastering reality.

Man managed to put the powerful forces of nature at his service - and as a result created a threat to his own life. He penetrated the deepest secrets of the universe in order to give birth to weapons of universal destruction. He created countless material and spiritual riches, but hundreds of millions of people live in poverty and ignorance, and millions of others suffer from the emptiness and meaninglessness of life. He came up with excellent plans for social transformation, but while implementing them, he encountered results that were directly opposite to those for which he was striving... Thus, we now have every reason to assert that the rationalistic system of values, with the formation and development of which the greatest achievements are associated Western European civilization turned out to be exhausted by the end of the twentieth century. It was discovered that the rationalistic approach to reality contains, along with the creative, a destructive, destructive principle. What's the matter? Why did rationalism turn out to be such a contradictory and ambiguous phenomenon? The fact is that rational consciousness is a transformative consciousness. Its goal is not adaptation to the surrounding world, but change, accelerated transformation of objects. At the same time, this consciousness very rarely rises to such a level of development or depth of penetration into the essence of things in order to calculate and foresee all the consequences of its transformative intervention in the natural and social environment. As a result, the process of transformation is often carried out contrary to the nature of objects and the internal logic of their existence. In the practice of social life, rational consciousness turns into coarsening, unification, reduction of complex social processes to abstract entities, the desire to fit people's lives into a certain formula, equation... Rational practice in relation to nature turned into the danger of a global environmental catastrophe, and in relation to social life - a constantly reproducing trend of violence against individuals, the formation of totalitarian regimes. The new direction, humanistic rationality, excludes any attempts to foresee and rationally arrange everything once and for all. Comprehension of reality is understood by her as an endlessly "branching" multivariate and divergent process (compare with quantum mechanics, in particular, with Feynman's path integrals or, for example, with Everett's worlds), characterized by the irreversibility and unpredictability of the consequences of any human choice and action. In this case, rationality (like reason in general) becomes a means of realizing a person's initial responsibility for his actions; do rationality and responsibility seem to change places? Responsibility becomes primary in relation to rationality. This means an attempt to establish the limits of human intervention in the natural dynamics of nature, society, culture, along with the questions "how?" and why?" teleological question "why?" Now, at the beginning of the 21st century, humanity is faced with a task of enormous scale - to form a holistic worldview, the foundation of which will be based on both rational-scientific and non-rational (including figurative) perception in reality, to develop integral knowledge, where the "world", "space", "man" would be perceived as an organic living integrity. Therefore, humanistic rationality will only correspond to modern needs if it can absorb other, non-rational forms of exploration of the world , recognize their diversity and equality, move from a rational to a rational-imaginative picture of the world. In our time, only a synthesis of "philosophy of mind" and "philosophy of the heart" can give a worthy reflection of the world in his consciousness, become a reliable basis for behavior. For developed people, the rational and non-logical perception of reality are in a certain balance, and in human knowledge as a whole, both of these sources of knowledge must be organically combined and complement each other.

It should be emphasized that some prerequisites for the formation of technogenic civilization also took place in the cultural achievements of antiquity and the Middle Ages. But the actual "semantic code" of technogenic civilization was formed precisely during the Renaissance. In this era, egoistic anthropocentrism begins to make its way in the understanding of the surrounding reality, placing man at the center of the universe, declaring him "the king of nature," "the crown of creation," "the conqueror of the universe."

The slogan, popular in the USSR in the 1930s, that we cannot expect favors from nature, but must take its riches, is a direct result of the direction of human thought and society, the socio-psychological and philosophical attitude towards the world around us, which began its rapid march across Europe during the Renaissance. Only in the second half of the twentieth century did we truly realize how dangerous a person's growing conceit, his rational pride, is. And this conceit, admiration for reason does not decrease, but grows as the power of machines grows.

Take, for example, textbooks on natural sciences, including physics. What pathos determines their style, and partly the method of presenting material in them? Basically - admiration for the mind of a person who managed to penetrate the secrets of nature and conquer it. But there is absolutely no admiration for the harmony and beauty of nature, against the background of which the achievements of the human mind are insignificant, i.e. From an early age a person is brought up in the consciousness of his power and exclusivity. It is not surprising that environmental problems are most often viewed from the point of view of a threat to our existence, rather than from the point of view of our relationship to wildlife.

What about social problems? A number of features of totalitarian regimes, including the one that arose in the USSR, owe their origin to the idea of the possibility and necessity of rational management of social processes, the desire to rationally restructure social life, to subordinate the movement of society to a predetermined "reasonable" goal. In this regard, let us also recall genetic engineering, cloning of living things, including humans. What awaits us in this case?

The experience of history shows that all large-scale attempts at a strong-willed "reasonable", "rational" transformation of the social world ended tragically: the results achieved were always the opposite of the goals.

Today in modern Western philosophy there is a movement away from rationalism. The Enlightenment slogan of the victory of reason over the inertia of nature and the imperfection of society is being questioned everywhere. The almost undivided dominance in classical philosophy of rationalistic ideas is replaced by the recognition of an equal right to their truth in an artistic image, a mythological description, and a religious symbol. Abstract thinking loses its former attractiveness. The old values seem too far from everyday worries and lifeless. Philosophy turns to the specific problems of human existence. The truths of reason are not denied, but they are given a more modest place. The problems of science and technology appear in a completely different light. These phenomena are now considered not in isolation, as something self-sufficient for understanding the world and its arrangement, but in the context of multifaceted human activity. The view according to which natural science knowledge is an indisputable standard for comprehending reality is questioned.

An analysis of modern Western philosophy allows us to conclude that there has been a significant change in its basic ideas and to highlight its most characteristic features:

1) a decisive turn to the problem of man and his values;

2) active research into non-rational forms of spiritual exploration of the world.

Now certain restrictions on certain types of human activity, potentially containing the danger of catastrophic consequences, are becoming necessary and inevitable. We also need a new consciousness, the purpose of which will be to timely connect the will and mind to the spontaneous organic process of the development of the world, without breaking this process, helping it remove obstacles in its path, preventing the destructive aspirations of individuals and groups, etc. .

With such consciousness, each new decision will be determined by the real situation, or rather by what can be learned from this situation for a person - for his survival, health and happiness. Only taking into account these most important values should the search for ideological guidelines be carried out.

Today, when humanity has come close to the possibility of various kinds of catastrophes (anthropological, demographic, environmental, etc.), when all the terrible consequences of utopian claims for totalitarian control of social processes are extremely clear, the fate of the humanistic ideal is connected with the rejection of the idea of mastery, suppression and domination.

The humanistic dimension today corresponds not to the ideal of anthropocentrism (man is the king of nature, the crown of creation, etc.) and sociocentrism (an attitude towards the separation of society from the cosmos, towards the destruction of the integrity of being, the belittlement and mortification of nature), but the awareness that man is an ally nature, her interlocutor, co-creator.

This ideal represents the joint evolution of man and his natural and social environment, the establishment of equal partnerships with what is outside of man: with natural and social processes, with another person, with the values of another culture, etc.

2.10 Conclusion

The general principle of complementarity formulated above is:

- The law of nature, the formula of the world, a general philosophical epistemological principle]], along with other philosophical principles.

- Proof of the presence of an irrational, unobservable side of reality, existing alongside and in inextricable unity with the visible, rational, material world, which constitutes only part of a more general picture.

The general principle of complementarity harmonizes scientific and irrational approaches to understanding reality. The rational and the irrational in their interdependence and confrontation not only do not exclude each other, but also necessarily complement each other. These are categories that are equally important and significant for the philosophical study of the foundations of being and consciousness.

From the point of view of the general principle of complementarity, both paths - rational and irrational - should not be opposed. On the contrary, these two ways of understanding the world lead to the fullness of truth. The unity of truth is the main postulate of the human mind, expressed in the principle of complementarity of rational and irrational aspects in the knowledge of nature.

Any system, ideally, should combine rational and irrational principles in the form of an organic unity. Spiritual integrity presupposes harmony and universalism. Without a rational organization of existence, a person is doomed to an unworthy, wretched existence. Without irrational values, his life loses meaning. The history of states and nations that deny the rational foundations of economics, politics and law is full of dramatic events. But, at the same time, general, total rationalization ultimately leads to immorality, cultural degradation, spiritual poverty, in a word, to degeneration. The future of humanity largely depends on how far these extremes will be overcome and how, in the future, it will be possible to form an organic unity of rationalism and irrationalism.

2.11 Afterword

In the last few years, there has been a revolution in the understanding of quantum theory. The semi-classical Copenhagen interpretation of quantum mechanics, implying the obligatory presence of a classical observer (measuring device), gave way to a purely quantum approach, in which there was no longer any place for this classical "relict." As a result, the quantum approach to the surrounding reality has become a self-sufficient coherent theory, built from unified general principles, logically including classical physics as a special case of the quantum description.

Quantum theory in the broad sense is no longer a theory of "specific quantum mechanical objects" such as microparticles, to which it supposedly should only be applied. This is the most general theory for any objects, this is a new conceptual approach to explaining reality, qualitatively different from the "local objective theory" of the past... This becomes possible because the physical characteristics of objects are not the initial concepts of quantum mechanics. It is built on a completely different principle, and the main initial concept in it becomes the concept of the state of an object. This approach can be applied both to physical objects and to those objects that are considered non-physical in the generally accepted sense of the word. The formalism of the theory remains the same, which makes it possible to combine within the framework of a single approach the eternally opposing concepts of “material” and “ideal” and to establish the basic laws connecting them, that is, the laws of their mutual transformation.

Our world is fundamentally non-local (irrational), and cannot be described by theories based on locality and determinism. This is exactly what tens, if not hundreds of experiments, aimed at testing the famous Bell inequalities, which make it possible to distinguish the predictions of quantum mechanics from the predictions of a “local objective theory,” speak about. Paradoxes of quantum mechanics, paranormal and supernatural phenomena, magical techniques, etc. have their source precisely in the nonlocality (irrationality) of the surrounding world.

In this regard, it is necessary to consider the complementarity of the rational and the irrational from a slightly different point of view and recognize that ultimately the basis of the observable rational world is its irrationality (quantumity, non-locality, entanglement, non-separability, integrity, etc., etc.) . The rationality of the world, thus, is a consequence of its fundamental irrational basis, the result of the process of decoherence (decoherence is the process of loss of coherence of quantum superpositions as a result of the interaction of the system with the environment). Historically, such a basis is usually called “God” or, in modern physical language, a single quantum source of observable reality. All objects of this world, including you and me, stones, stars, etc. originated from this source, and are essentially this source. We may not be aware of this only because we localize ourselves in layers of existence with a low degree of entanglement.

Chapter 3

About special relativity

In the third chapter I will briefly outline my view of special relativity. So much has already been written about this theory, but I will still make my contribution. I will build a simple and visual model of special relativity and I believe that it will help to better understand the essence of this theory.

3.1 The model of special relativity

The model of special relativity (SRT) is a system of two observers and two rods (two reference systems) (Fig.3.1a) and uses a coordinate-free approach.

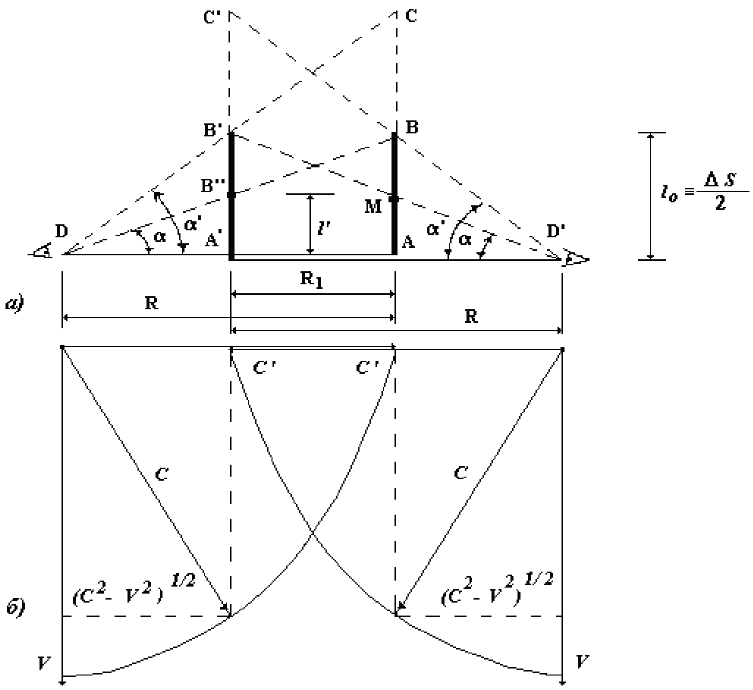

Figure 3.1: The model of special relativity

Here:

- AB and $A'B'$ are rods of length l_0, which can be called unit scales.
- observers are located at points D and D'.
- R is a constant distance, R_1 is a variable distance.

Each of the observers is associated with a corresponding rod (its own frame of reference).
From Fig.1a it is easy to obtain equations that are valid for both observers

$$l' = l_0 \left(1 - \frac{R_1}{R}\right) \tag{3.1}$$

$$tan\,\alpha' = \frac{tan\,\alpha}{(1 - R_1/R)} \tag{3.2}$$

$$R\,tan\,\alpha = tan\,\alpha'(R - R_1) = l_0 = invariant \tag{3.3}$$

Equation (3.1) characterizes the apparent decrease in the length of one rod relative to another rod depending on the distance R_1.

Equations (3.2) and (3.3) characterize the invariance of the extensions of both rods when the distance R_1 changes, that is, the extensions of the rods represent an invariant of transformations.

In (3.1), the decrease in length l' is not the result of the action of some internal molecular forces in the rods. This is similar to SRT where, according to Einstein, the “compression” of the rods is an inevitable consequence of kinematics, and not the result of a change in the balance of forces between the molecules of a solid body during movement, according to Lorentz and Poincare.

If in the indicated model (Fig.3.1a) we consider the movement of a light signal from point A to point B and back to point A, then it is easy to show that for the light signal the formulas ¡(3.1), (3.2), (3.3) take the form

$$l' = l_0\sqrt{1 - \frac{v^2}{c^2}} \tag{3.4}$$

$$\Delta t' = \Delta t_0/\sqrt{1 - \frac{v^2}{c^2}} \tag{3.5}$$

$$c\Delta t_0 = c'\Delta t' = \sqrt{c^2 - v^2}\,\Delta t' = (c^2\Delta t'^2 - \Delta x'^2)^{1/2} = \Delta S = invariant \tag{3.6}$$

Here:

- l' represents the distance that the light signal travels in time $\Delta t_0/2$ in relation to the rod $A'B'$ and is the projection of the light beam onto this system;
- $\Delta t_0 = 2\,tan\,\alpha\,(R/c)$ and $\Delta t' = 2\,tan\,\alpha'\,(R/c)$ are the total times of movement of the light signal back and forth with respect to the proper and improper reference frames;
- c is the speed of light;
- v is a quantity with the dimension of speed (the so-called spatial component of the speed of light (see Fig.3.1b);
- $c' = \sqrt{c^2 - v^2}$ is the so-called “transverse” time component of the speed of light;
- $\Delta S = 2\,l_0$ is an invariant quantity characterizing the constant length of the rods and expressed through the spatio-temporal characteristics of the light signal that travels the length l_0 of the rod twice, from A to B and back to A.

Formulas (3.4), (3.5), (3/6) are similar to the formulas obtained in SRT.

In Fig. 3.1 you can clearly show the value of the speed v.

Since $c' = \sqrt{c^2 - v^2}$ or $c^2 = c'^2 + v^2$ which is the equation of a circle, we get Fig. 3.1b.

Fig. 3.1a and Fig. 31b are interconnected.

It can be seen that for $v \ll c$ we get $l'/l_0 \approx 1$ and $\Delta t'/\Delta t_0 \approx 1$, which is transition from Lorentz transformations to Galilean transformations.

When $v > c$ the SRT model loses its meaning.

The constancy of the speed of light c in the model is reflected by the constancy of the radius of the circles in Fig. 3.1b, regardless of the value of the speed v (that is, regardless of the relative position of the two reference systems).

The form for the speed $c' = \sqrt{c^2 - v^2}$ is due to the fact that the speed of signal transmission has a limit and the highest speed of signal transmission is the speed of light in a vacuum.

The model can also define the so-called “event space”. It is a half-plane over the line DD', where each point can be characterized by time and place. Let’s consider how the model displays the problem of the simultaneity of two events. Let light signals be emitted from point M, lying in the middle between points A and B, to points A and B. An observer at point D will find that these signals arrive at points A and B simultaneously. However, from the point of view of an observer in D, these signals will not arrive at points A' and B' simultaneously. Thus, the concept of simultaneity becomes relative depending on in relation to which frame of reference this process is considered. The observer at point D' will come to similar conclusions.

It is also clear from the SRT model that the “shortening” of the length of the rod l' is closely related to the concept of the simultaneous arrival of light signals at the ends of the rods. Indeed, if light signals are sent from point M (Fig. 3.1), located in the middle of the rod AB, to points A and B, then the observer in

D will find that, according to his watch, these signals will arrive at points A and B simultaneously. In relation to the rod $A'B'$, light signals will arrive simultaneously at points A' and B''. But the distance $A'B''$ is the "shortened" length l'. Thus, in relation to the rod $A'B'$, the SRT model adequately reflects the "shortening" of the original length, which also takes place in the SRT. Moreover, as in SRT, in the SRT model (Fig. 3.1) the indicated "reduction" is also associated with the concept of simultaneity.

Note that the length of the rod can also be determined in such a way that the positions of the ends of the rod $A'B'$, simultaneous in an improper reference frame, are measured. That is, here light signals must be sent from the middle of the rod $A'B'$ to points A' and B'. In this case, the Lorentz transformations will not result in a "reduction", but an "increase" in the length of the rod. In the SRT model in Fig. 3.1, this will be reflected in the fact that in relation to the rod AB from the point of view of an observer in D, light signals will arrive simultaneously at points A and C, and the initial length of the rod $A'B'$ will appear "increased" and equal to AC. In this case, instead of the previous relation, we obtain the equation

$$l' = \frac{l_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{3.7}$$

However, relativistic physics prescribes, when measuring length, to make simultaneous readings in the system in which the measurement is made, and thereby eliminates the ambiguity of the results. The considered example of the relativity of length clearly indicates that the length of an object is not some absolute property associated with the very existence of the object, but, on the contrary, the numerical value associated with the length depends on the conditions of the measurement.

What does decreasing the length of a ruler mean? First of all, it is clear that no compression of theruler can occur. This follows from the basic principle underlying SRT - the principle of equality of all inertial frames of reference (IFR). In all IFRs, the physical state of the ruler is the same. Therefore, there can be no question of the occurrence of any stresses leading to deformation of the ruler. The shortening of the ruler occurs solely due to the different ways of measuring length in the two reference systems. On the other hand, the observed relativity of the length of the ruler is not an illusion of the observer. This result is obtained by any reasonable method of measuring the length of a moving body. Moreover, when considering physical phenomena in a given frame of reference, it is necessary to take the length l' as the length of the body, and not the length l_0.[76]

As W. Pauli noted: "Lorentz contraction is not a property of one scale, but is a fundamentally observable mutual property of two scales moving relative to each other." And further: "It is satisfactory to consider relative motion as the cause of Lorentz contraction, since this latter is not a property of one scale, but a relationship between two scales".[77] The above remark of W. Pauli is reflected in our model in Fig. 3.1 by the presence of two rods AB , and $A'B'$. In SRT, the speed of light is determined from the expression $\Delta S = 2l_0 = 0$. How

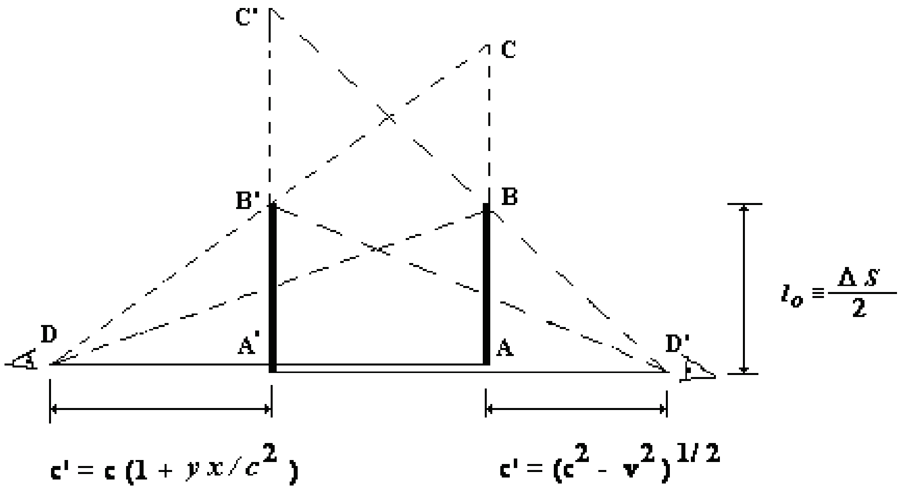

Figure 3.2: The model of special relativity

this situation is reflected in the model. In this case, for an observer in D, the extension of the rod AB is equal to 0, i.e., its own frame of reference no longer exists. All that remains is the light signal and there is nothing to correlate it with. That is, the light signal cannot be a reference system. Light does not have its own reference system. If you count the light itself as a clock, then this clock does not go, it stands. The counting of the time process (the movement of the light ray) can occur only in relation to the rods AB or $A'B'$, but not in relation to itself.

It is clear from the model that the invariant interval ΔS reflects the unchangeable extent of the moving body l_0, which the light signal travels twice (back and forth). This interval is expressed through the spatial r and temporal $c\Delta t'$ characteristics of the light signal.

The model can display a situation where one of the reference systems moves uniformly and accelerated (Fig. 3.2).

In this case, the value c' (in Fig. 3.2 on the left) will have the form

$$c' = c(1 + \gamma x/c^2) \qquad (3.8)$$

where γ is uniform acceleration. On the right, as before, the quantity c' has the form $c' = \sqrt{c^2 - v^2}$. As can be seen from Fig. 3.2, the symmetry of the two reference systems (their equality) is already lost. A change in the speed c' under the influence of acceleration naturally changes the speed of other time processes in the accelerated reference frame. This change in speed c' in the accelerated frame of reference solves the so-called "twin paradox". In the general case, $c' = \sqrt{g_{ik}v^i v^k}$, where $v^i = dx^i/dt$.

Thus, the constructed model quite adequately reflects the spacetime relations in SRT and, by studying the model, one can better understand the essence of special relativity.

3.2 Philosophy of special relativity

Physics is unthinkable without mathematics and mathematical concepts, but it cannot be reduced to them. Indeed, in the SRT model, the formulas (3.1), (3.2), ¡(3.3) can be interpreted in two ways if you do not have Fig. 3.1 and Fig. 3.2 at hand. Either assume that the compression of the rods is the result of a change in the balance of forces between the molecules of a solid body when the distance R_1 changes, or assume that the reduction in the length of the rods is a consequence of a change in the magnitude of their projections onto one or another reference system. Figure 3.1 clearly shows that we are talking about changing the size of the projections of the rods. Lorentz and Poincare accepted the first interpretation of the STR formulas, Einstein proved the second interpretation of these formulas. Thus, we see that the main thing in physics is not formulas, but their interpretation - understanding. This is what feeds intuition. Physics develops not with the help of mathematical logic, but with the help of physical intuition. This statement is difficult for a mathematical physicist to accept, who views physics as a branch of applied mathematics. And he wonders: "Why do you attribute the main credit for creating the theory of relativity to Einstein, while the Lorentz transformations were obtained earlier?" or "Why do you attribute the main role in understanding quantum mechanics to Bohr, while the basic equation of this theory was obtained by Schrodinger (or in matrix form by Heisenberg)?"[78]

In confirmation of all of the above, we point to the article by the famous physicist and close friend of Einstein, Nobel Prize winner Max Born, "Physical Reality,"[79] in which he emphasizes that the essence of the special theory of relativity lies in the logical distinction that a frequently measured quantity is not a property of an object, but the property of its relationship to other objects and indicated examples of this. As an example, he gives a figure made of a cardboard circle and the shadows that it casts from a distant lamp on a flat wall. By rotating this cardboard figure, you can get any value for the axis length of the elliptical shadows from zero to maximum. This is an exact analogy with the behavior of length in the theory of relativity, which in different states of motion can have any value between zero and maximum. Born gives a similar example regarding the behavior of mass in the theory of relativity.

Born points out that "most measurements in physics refer not to the things that interest us, but to some kind of "projections" of them in the broad sense of the word. "Projection" is defined relative to a reference frame. In general, there are many equivalent frames of reference. In any physical theory, a rule is given that connects with each other the "projections" of the same object onto different reference systems. This rule is called the law of transformations (in the special theory of relativity this is the Lorentz transformation); all these transformations have the property that they form a group, that is, the result of two subsequent transformations is a transformation of the same kind. Invariants are quantities that have the same meaning for any frame of reference and therefore are independent of transformations. And now the main progress in the structure of concepts in physics consists in the discovery that a certain quantity, which was considered as a property of an object, is in fact only a property of "projection". And it turns out that in the relativistic theory the maximum length (length l_0) and minimum mass (rest mass m) are relativistic invariants. The idea of invariants is the key to the rational concept of reality.

Some physicists believe (Born included the famous physicist Paul Dirac among them) that there is no need to be interested in the question of whether there is anything behind the "projections". Max Born claims that behind the "projections" there is a physical reality, which is displayed through the "projections". We observe only "projections", which are changeable and also depend on the devices (reference systems). But their combination makes it possible to find the properties of reality itself, no longer dependent on instruments. These paths of transition from "projections" to reality itself are developed by the theory of invariants. At the same time, "projections" cannot be denied reality simply because they are not invariant. "Projection" is the result of the actual interaction of an object with a reference frame. Example: the thermal effect of the solar disk

(”projection” of the Sun) on the observer depends on the distance between the observer and the Sun. But the physical reality is only the Sun itself, and not its ”projections”.

Let us quote another author, confirming this point of view: “Spatio-temporal relations and properties of bodies do not depend on the reference system, but only manifest themselves differently in different systems. In general, physical quantities that depend on the reference system and, in this sense, are relative, are a kind of “projections” of more general quantities that no longer depend on the reference system. In accordance with this, Minkowski gave a four-dimensional formulation of the laws of relativistic mechanics and electrodynamics... Nevertheless, Minkowski’s view of the theory of relativity was not accepted by physicists in all its depth. The point of view of relativity, which takes every phenomenon in relation to one or another frame of reference, was more familiar, firstly, because this is the real position of the experimenter, the observer, and secondly, because the theorist also considers phenomena using one or another coordinate system. But there was also a third point - positivist philosophy, which fundamentally attaches the meaning of reality only to what is given in direct observation; everything else that is contained in the theories of physics is interpreted by it not as an image of reality, but as a construction that only links observational data. From this point of view, Minkowski’s four-dimensional world is nothing more than a diagram that does not reflect any reality beyond that already expressed in the original presentation of the theory of relativity. Thus, two different approaches to the theory of relativity were identified. The first is Minkowski’s approach, which is based on the idea of space-time as a real absolute form of existence of the material world. The second is a purely relativistic approach; the main thing in it is one or another frame of reference. It is clear that the first approach is materialistic in nature and corresponds to the natural logic of the subject: “its form determines its relative manifestations.” The second approach... turns out to be positivist, denying that the relative is only a facet of the manifestation of the absolute.”[80]

For those who do not like formulas, as a “close” visual example, we will give an airplane flying high in the sky. Its apparent size appears reduced and its speed of movement (a temporal process) appears slower. For airplane passengers, the same phenomena on the earth’s surface (for example, moving cars) look similar. Anyone who has flown on an airplane probably remembers that feeling of unreality when looking from a great height at the ribbon of a highway, where cars moving at high speed seem almost frozen in one place. Time seemed to stand still for them. Here, between an observer on the earth’s surface and an observer in an airplane, there is equality, symmetry of phenomena (mutual “shortening” of lengths and mutual “slowing down” of time processes - speeds of movement), similar to how this happens in the special theory of relativity. The only difference is that in our model the variable is the ’relative distance’ between two observers (geometric relativity), while in the special theory of relativity the variable is the ’relative velocity’ between two reference systems (kinematic relativity).

Let us note that the motive for constructing the SRT model was the philosophical analysis of the special theory of relativity, set out in the book of Doctor of Philosophy Valery Nikitich Demin]] (1942-2006)] “The Basic Principle of Materialism”.[81] In particular, we present the following fragment from this chapter: “In the case of Galilean transformations, a direct (immediate) correlation of integral inertial systems occurs. In the case of Lorentz transformations, such a correlation occurs with the help of a material intermediary - the process of light propagation, the speed of which is a universal physical constant. Thus, in the first case there is a two-term relation, and in the second - a three-term one. Meanwhile, there is a universal pattern, which in general form can be formulated as follows: the relationship (result of comparison) of two material elements (systems) is not identical to the relationship of three or more elements (systems) and vice versa. To explain this, we will use the following elementary example. The eye is smaller than the Sun, and no matter what distance from the Sun the observer is, the objective binary relationship between the eye and the Sun remains exactly this (we are, of course, talking about an objective relationship, and not about subjective perception, when the distant Sun appears as a small luminous point). But then the observer brings his palm to his eye and obscures the Sun. Thus, the third element is included in the relation (this three-member relation is objective, because in the place of the eye there can be any object equal in size to it, for example a coin, and it will also be covered by the shadow of the palm). It is absolutely clear that two-term relations are not identical to three-term ones. The laws of both can be expressed mathematically, without losing sight of their concreteness and materiality; otherwise, misinterpretation of mathematical relationships will lead to the conclusion that the palm becomes larger than the Sun as it approaches the eye."" . (In our model, the three-term relations are the observer and the separated rods AB and $A'B'$. The two-term relations are the observer and the combined rods AB and $A'B'$).

In conclusion, let us note that the SRT model describes the spatiotemporal characteristics of the light signal, and not space and time “in general.” This may indicate that the basis of space-time processes and material formations are massless energy quanta.

Chapter 4

Conclusion

In the book, we outlined the path to the construction of quantum gravity, which is a kind of holy grail of all modern physics. Bohr's principle of complementarity also received an unexpected development in the book, unambiguously substantiating the connection between the rational and irrational aspects of nature, between science and religion, science and mysticism. We also analyzed the theory of relativity from a new angle. As a result, we came to certain and somewhat unusual conclusions in each of these areas. In light of this, an interesting problem facing modern physics was solved - the search for an answer to the question why space has three dimensions? It is clear in advance that justifying this distinction by purely mathematical means is completely futile. We have shown that three-dimensionality is associated with fundamental properties of the physical world. An interesting solution in multidimensional spaces was found by the problem of singularity, which arises in cosmology. The riddle of the initial singularity, like a kind of sword of Damocles, has been hanging over relativistic cosmology for over a century. In the light of our consideration, a definite conclusion was made that at the beginning of the expansion the Universe had a different dimension of space from the existing one, and the very emergence of the Universe (Metagalaxy) meant a qualitative leap associated with a change in the dimension of space. In doing so, we used some philosophical considerations. Thus, we have shown how philosophy can actually be used in its concrete application to physics. Philosophy is necessary for science in order to overcome the contradiction between the limitations of facts and the universality of theory. Philosophical ideas are often used by scientists in a semi-intuitive manner. Becoming mature, science overcomes them, but they, like a phoenix, are reborn again, since it is discovered that without philosophical justification it is impossible to understand the achievements of science. Necessity philosophy is due to the fact that science is in constant motion. The abolition of philosophy would be the abolition of science itself, for science is conceivable only as a purposeful process of cognition.

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