I dedicate to the bright memory of star sister Hanna (21.03.1945 – 04.12.2021), who for 28,018 earthly days filled my world with unearthly sisterly love.

Author

Vasil Tchaban

Electrogravity:

movement in an electric and gravitational field

For those who consider university education to be the first step in learning the Truth

Lviv: "Space M", 2023

UDC 52-336/.337:629.7(=111)
Recommended by the Academic Council of the National University. "Lviv Polytechnic" (protocol No 2 of Juny 20, 2023).

Electrogravity: movement in an electric and gravitational field. (monographic edition) / Author Vasil Tchaban. – Lviv: "Space M", 2023. – 160 p.

The experimental laws of statics – Newton's gravitational interaction and Coulomb's electric interaction in the case of motion of bodies have been adapted, taking into account the finite velocity of propagation of an electric and gravitational fields. As a result, it was found that the force interaction is three-component. The first components are the static forces of Newton and Coulomb. The second components are Lorenz force and gravitomagnetic force, caused by the transverse components of the speed. And the third component (previously unknown) – is due to the longitudinal components of velocity. They play a very important role in the dynamics of motion. On this basis, a unified proto-formula of motion is obtained, with the help of which symmetric information about electric and gravitational energy in the form of the Hamiltonian action of a field functional is prepared. According to the variational principles, similar space-time differential equations of electric and gravitational fields are constructed. The results of the simulation of motion dynamics in both fields of micro-, macro-, and mega world are added

Such important problems as perihelion precession of planets, the capture of celestial bodies by a black hole, interaction of the light beam with gravity, the anomaly of "Pioneer" probes, electromechanical state of Hydrogen and Helium atoms, etc. are simulated.

The expected circle of consumers is a wide range of scientists, teachers, students of natural sciences / V. Tchaban, doctor of sciences, professor, and academician.

Bibl. 46 title. ill. 56.

Reviewers:
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Computer layout – by the author

ISBN 978-617-8055-50-9

As gravity in the hands of God ignites the heavenly stars, so electricity in human hands ignites earthly lamps.

Author.

Introduction

Curious the Reader! Your attention is invited to take part in thinking about those three elephants on which the physical World stands, whose names are Energy, Electricity, Gravity. To be more specific, it is about how to liken the equations of electricity and gravity on the basis of energy approaches. Especially since Newton and Coulomb made such an analogy in the early stages of their study. Experimenting in real life, their laws of force interaction of gravitational masses and electric masses (charges) in a mathematical representation surprisingly repeated each other, and in addition, both of them brought out to global constants, which according to the anthropic principle we owe their existence. This guarantees their truth and steadfastness, but within the limits of the condition under which they were established, and its name is Static (Akinita). And this is so opposed to the all-embracing movement (Panta rhei).

Thus, the idea of the book also came to light – to move from place the interacting masses electric and gravitational – in both the named laws, as so far the only real starting platforms for forward movement. But the movement itself is not only translational (stationary), but also eddy. Fortunately, a part of the vortex component in the electrical movement caught the eye of experimenters Ampere and Faraday, who successfully encoded it under the guise of the laws of magnetism. The theorist Maxwell only had to combine the achievements of his famous predecessors into a coherent theory of electromagnetism – in the form of spatio-temporal differential equations of electric and magnetic vectors, or in a unified representation – in the form of spatio-temporal differential equations of the vector-potential.

But, as our experience has shown, for a complete description of the movement, taking into account the two components of the force, the Coulomb force and the Lorentz force caused by the tangential (transverse) component of the speed of movement, turned out to be insufficient. Here we need to add the lost third component of the electric force interaction, caused by the radial (longitudinal) component of the movement speed. It is this component in our research that will complete the trinity of the full vector of the electric field force, which causes the dynamics of the movement of charged bodies in the field. We draw attention to the fact that in our interpretation the concept of an electric field is broader than the generally accepted one. Because the magnetic field is interpreted as only one of the side effects of movement in the electric field.

Unfortunately, there is still a misconception that in the pre-light (pre-relativistic) range of speeds, sufficient accuracy in the description of motion is provided by Coulomb's law of electrical interaction and the Lorentz force. But this, as we will show, is far from true. It is impossible to fully describe the movement without the third component! This is convincingly confirmed by those claims to the methods of classical physics from the side of the quantum theory of the microcosm, because of which these methods were hastily pushed beyond its limits. But we refuted all these claims. This is important, because it proves the physical unity of the universe at all levels of the micro-, macro- and megaworld. Although this does not deny that each of these worlds may have their own local laws, for example, quantum laws in the microcosm.

Gravity could only envy electricity and rush to catch up. In order to quicken her steps, she nonchalantly called upon unbridled surreality, which for a time dissipated like omnipresent mathematics. Caught in her stiff arms more than a hundred years ago, she still can't free herself from them. Especially since the clasped hands belong to the handsome man of relativism.

The main idea of the book is quite logical - to turn mechanics into the direction of electricity, so that it can use all the assets of its glorious theory. Such a union should be useful for both of them not only in the plane of research of physical processes, but also in epistemology - the theory of knowledge, the relationship of knowledge to reality. Such a union can be served only by the energy inherent in both of them in equal measure, as for electricity and for gravity.

But here another secret of the universe appears - the essence of energy itself. Who disposes of it unconditionally in our ideal material world? Science is still far from understanding energy, but it uses it skillfully. In this regard, it is worth listening to the timeless words of the great thinker H. Poincar?:" Since we cannot give a general definition of energy, the principle of energy conservation simply means that there is something that remains constant. And if so, then no matter how much new information about the world the future experiment gives us, we are sure in advance that something will remain constant, which we can call energy". But, regardless of the limitations of our knowledge, energetic approaches in science remain the most powerful means of learning about the physical world.

In order to achieve the set goal, it was necessary to solve related problems:

1. First of all, adapt the fundamental experimental laws of statics - Newton's gravitational interaction and Coulomb's electrical interaction to the case of the movement of interacting bodies. On this basis, to obtain a unified proto-formula of motion as a triune symbiosis of the laws of Newton, Coulomb and All-encompassing motion from the submission (through the ages) of Heraclitus of Ephesus. It gives a description of the movement on the micro-, macro- and mega-levels of the material world. Not only that, this wonder-formua is filled to the brim with deep philosophical content.

2. On the basis of the received protoformula of motion, ensure all symmetrical

information about the electric and gravitational energy of motion with a view to both components - stationary and vortex. To bring the obtained results to the form of action of the Hamiltonian field functional.

3. Based on the Hamilton-Ostrogradsky variational principle, to construct similar equations of the electric and gravitational fields according to the combined action functional. New results of the theory of gravitation should be dublicated using the methods of classical mechanics if possible.

4. To give epistemological assessments of the obtained results in the first approximation with an orientation to the prospects of further movement forward.

A quite reasonable question may arise: why such a problem and its solution appear so late? – Indeed, this could not have happened if the creators of the so-called of the new physics understood at one time the warning of one of its most active founders, H. Poincar?, regarding the delitant uproar about the failure of Galileo's transformations: "... no physical experience can confirm the truth of some transformations and reject others as inadmissible." Thus, one of the most noble physical theories started with an ignoble act. This fire, as you know, flared up further, as a result of which our flat Euclidean world became cramped and all its creators fell amicably into the crooked Riemanns. And the common people, as usual, sincerely believed all this.

The idea to approximate the equations of electricity and gravity in this way arose recently. This happened in my native village Zahoriv during the coronavirus quarantine. In this regard, I will give two daily entries (short):

19.03.20. *Zahoriv.* I Proved that the second term in my adapted Coulomb law is the net Lorentz force. So, alone, surrounded by the spirits of ancestors, I punched a hole in the biggest rock, through which the pure waters of electricity and mechanics will gushed!

24.03.20. *Lviv.* In the conditions of a total coronavirus pandemic, at 1322 I made a formal assimilation of electricity and mechanics! The solution, surprisingly, turned out to be too simple. First of all, we are talking about the main potential vector **A**, which appeared as a velocity vector, and its first derivatives – as vectors: acceleration (**E**) and angular velocity (**B**). Probably, this is how physics makes its way to our consciousness through the labyrinths of mathematics. And this is already a question of epistomology - knowledge as a form of connection between consciousness and being. Because everything a person deals with is given to him through inner experience.

Vector A has not only the physical dimension of speed (m s^{-1}), but also the philosophical one – the measure of All-Encompassing Motion, "as they say in Greek". It is clear that Heraklitos of Ephesus (Herakleitos ho Ephesios) (535-475 BC) addressed these two miraculous words to us over the centuries for a reason. And so that we understand their greatness. In order to present such voluminous material, it is necessary to immediately write a monograph-blitz! I will call it "Panta Rhei". This will be the Eternal Movement of my tired soul. The wife noticed an interesting fact - pandemic and panta ray are even somewhat consonant.

The book contains five chapters.

The first is didactic in the spirit of Feynman's lectures, focused on mechanics as involved in solving the problem. It reveals the essence of the basic vector characteristics of electromagnetism and the basic laws of statics of electric and gravitational fields.

In the second, the basic laws of statics of the first chapter are adapted to the case of mutual movement of interacting bodies. On their basis, the energy functional of action is prepared for the formal use of variational methods in the construction of the combined equations of electricity and gravity directed in channel of gravity.

The third chapter demonstrates the wide achievements of electricity in the field of variational methods - as a reference point for mastering gravity. At the same time, attention is focused on the basic principles of physics - least action and conservation of energy.

In the fourth, the similar equations of electricity and gravity obtained on the basis of the energy approach are given. A separate place is given to wave processes.

The fifth is assigned the scientific-philosophical role of relieving the tension between all those who gave and are giving all their strength to a noble goal - the search for truth, in the night sky of which the most attractive constellation of gravity and electricity burns.

If we have already asked about the truth, then it is worth listening to the words of the same Henri Poincar? once again: "The harmony that the human mind hopes to discover in nature, does it exist outside the human mind? No doubt, no; an impossible reality that would be completely independent of the mind that grasps it, sees it, feels it. Such an external world, if it even existed, would never be accessible to us. But what we call objective reality is ultimately what thinking beings have in common. This common side can only be harmony expressed by mathematical laws. Therefore, it is precisely this harmony that is the only objective reality, the only truth that we can achieve; and if I add that the universal harmony of the world is the source of all beauty, then it will be clear how we should value those slow and difficult steps forward that little by little reveal it to us."

* * *

And yet, shouldering the solution of such a complex problem as the assimilation of the theoretical foundations of electricity and gravity, human conscience cannot stand aside. Therefore, these first steps taken by us should be considered as one of the possible hypotheses, which has the right to exist next to other possible ones. And even if I am wrong, my mistakes will still accelerate someone's "slow and difficult steps forward".

2021.29.06. Stary Zahoriv

1. 1. BASIC LAWS OF STATICS

1.1. Electric charge

The material world is built from elementary particles that have an electrical charge. These particles are in continuous motion. They are part of atoms and molecules, but they can also be in a free state. The electrical charge of elementary particles is their important physical property along with other physical properties (mass, energy, momentum, etc.) inherent in other forms of matter movement. Thus, mechanical movement can be characterized by resorting to three main quantities - mass, distance, and time. But this is not enough to characterize electrical phenomena. Here it is necessary to resort to the fourth main value - electric charge. The fundamental property of charge is that it can be positive and negative. Entering into interaction, different-named charges are attracted, same-named charges are repelled. The reason for the duality of charges is not exactly known. Modern physics suggests considering positive and negative symmetry as opposite manifestations of the same quality, just as spatial symmetry contains the concepts of left and right, and temporal symmetry contains two directions of the passage of time.

Let's consider two important properties of a charge that relate to its quantity, and therefore, the possibility of its measurement.

The first of them is that in an isolated system, the total electric charge (the sum of positive and negative charges) remains constant. By isolated we mean such a system through the boundaries which no other substance can penetrate. Light can enter and leave the system, because photons do not have a charge, and if a photon with high energy ceases to exist, it gives rise to an electrically neutral pair - an electron and a positron with charge equal in value but opposite in sign. By the way, charged particles can be born only in pairs, because our universe is a completely compensated system of positive and negative charges.

The law of conservation of charge can be considered as a postulate, or an empirical law, confirmed by all experiments without exception. Deviations from this law are incompatible with the modern theory of electricity. In addition, the complete electric charge of an isolated system is a relativistically invariant number. Observers placed in different inertial coordinate systems, measuring the charge, will get the same value.

According to the existing beliefs of relativists (which is difficult to agree with, but more on that later) according to Lorentz transformations, space, mass, effort, and time undergo changes during the transition from one inertial coordinate system to another, and the charge is unchanged. Otherwise, it would not be possible to observe the phenomenon of preservation of a complete charge in the experiments. For example, let's heat an untuned conductor. Since the masses of protons and electrons are different, they acquire different velocities. And if the charge depended on the velocities of the particles that carry it, then the charges of protons and electrons of the heated conductor would not be compensated, and it would be charged. However, no one observed anything similar in the experiment.

Another important property of charge is its quantization. Evidence confirms that all elementary particles have the same charges. For example, consider two elementary particles – a proton and an electron. There is the greatest possible difference between them for elementary particles (at least the fact that a proton is 1836 times heavier than an electron), but their charges are the same in value and opposite in sign. In this lies some incomprehensible secret of nature for us. It is the charges of the proton and electron that are the smallest values of the charge, the further division of which is impossible. Although recently, this shrine has been shaken in connection with the doctrine of quarks.

One of the latest hypotheses states that the electron, as the smallest particle, consists of three quarks. To supplement it, we put forward our own hypothesis - only about the quark distribution of the lattice densities in three active zones of the same volume by radius: -e2/3, -e2/3, +e1/3 with a white hole in the center. This model of the electron cancels at least two important problems of electricity without contradicting its classical laws, the crisis of the electromagnetic mass and the point-likeness of the charge. The crisis of the electron mass was caused by the deficit obtained by the universal formula $m = E/c^2$ and by the pulse of the electromagnetic field. The crisis of the pointiness of the charge consisted in going towards energy and mass when the radius goes to zero. The experimental fact of the collapse of Coulomb's law at distances of 10-16 m tells us about one thing - there is no electric field beyond the sphere of the electric radius of a white hole, and this will be the case only when particles cannot cross it. As you can see, the electron is small, but the scientific discussions about it are big. But this will be discussed in more detail in paragraph 1.5.

The charge of a body is the algebraic sum of all its elementary charges. The number of electrons in one gram of substance is 3.1023. At the macro level, the discreteness of the charge can be neglected, considering that its values can change continuously from zero to admissibly large. We denote the charge by the letter q, measured in coulombs: C = As. In practice, it is necessary to use derived concepts: volume, surface, and linear charges.

1.2. Coulomb's law

Even the ancient Greeks observed that a rubbed piece of amber could lift small pieces of papyrus. But many hundreds of years passed until people found an explanation for this strange phenomenon and established a quantitative law describing it. It is not necessary to state separately that we are talking about the force interaction of two charged bodies and Coulomb's law, which is at the basis of it,

$$\mathbf{F}_{12} = k\frac{q_1 q_2}{r_{12}^2}\mathbf{r}_{12}, \tag{1.1}$$

where $\mathbf{F}_{12}$ is the force vector; q_1, q_2 are interacting charges; r_{12} is the distance between the charges; $\mathbf{r}_{12}$ s ort, directed from the first charge to the second; k is an electrical constant

$$k = \frac{1}{4\pi\varepsilon_0} = 8.987742\cdot 10^9\ \mathrm{N\,m^2\,C^{-2}}.$$

Thus, *stationary electric charges are repelled or attracted with a force proportional to the product of the values of the charges, and inversely proportional to the square of the distance between them*. At the same time, it is assumed that both charges have exact coordinates, occupying areas that are small compared to r_{12}, because otherwise, r_{12} loses its ambiguity. The condition of immobility of charges is necessary in this case to exclude the effects of movement that occur during movement and are known as magnetic forces.

Coulomb's law of the interaction of electric charges is similar to Newton's law of universal gravitation

$$\mathbf{F}_{12} = G\frac{m_1 m_2}{r_{12}^2}\mathbf{r}_{12}, \tag{1.2}$$

where m_1, m_2 are masses of interacting bodies;

$$G = 6{,}674\cdot 10^{-11}\,(\mathrm{m^3kg^{-1}s^{-2}})$$

is gravitational constant.

The main content of both laws is the statement about the inverse dependence of the force on the square of the distance. But, despite the external similarity of both laws, they lead to strikingly different quantitative results, which are a consequence of the ratio $k/G = 1{,}35\cdot 10^{20}$. And the fact that we encounter the force of gravity every day and practically do not feel electrical forces is a consequence of the fact that incredibly large electrical forces are balanced in individual physical bodies. But if the body of our neighbor, who is at arm's length away, had one percent more electrons than protons, then the force of interaction between us would be enough to lift our planet.

A real example of a huge electrical interaction is the atomic bomb. Its energy is the energy of repulsion between protons of two fragments of the nucleus of a heavy element. The protons of the nucleus are held together by intranuclear forces that are greater than electrical repulsive forces, but these are short-range forces. If a slow neutron enters the nucleus of a heavy element, which contains many protons, it will cause individual protons to move away to a distance greater than the distance of close action of nuclear forces of attraction. And here Coulomb's law begins to work without hindrance.

According to modern information, the range of distances of Coulomb's law starts from 10^{-16} m and more. At smaller distances, the application of the laws of electromagnetism is doubtful. Looking ahead, let's say that the entire modern theory of electricity can be built on the basis of Coulomb's law and the invariance of the charge relative to the transformation of coordinates. But such a path is unnecessarily complicated. The simpler one is the one that leads to the concept of a magnetic field.

1.3. Electric field vectors

Let's consider some distribution of electric charges q_1, q_2, ..., q_N. fixed in space. If we are not interested in the forces of interaction of these charges with each other but are interested in their interactions with some other electric charge q with known coordinates x, y, z, then this force can be calculated according to (1.1):

$$\mathbf{F} = \sum_{i=1}^{N} k \frac{qq_i}{r_i^2} \mathbf{r}_i, \tag{1.3}$$

where r_i is the distance from the i-th place to point x, y, z; $\mathbf{r}_i$ is spatial single vector.

If we shift the q out of the sum, we get

$$\mathbf{F} = q\mathbf{E}, \tag{1.4}$$

where

$$\mathbf{E} = \sum_{i=1}^{N} k \frac{q_i}{r_i^2} \mathbf{r}_i = \mathbf{E}(x, y, z). \tag{1.5}$$

The vector value (1.5) is called the electric field intensity vector, measured in volts/meter: V m^{-1}. The function $\mathbf{E}(x,y,z)$ can be calculated at any point in space. Therefore, the question arises: does it characterize a physical substance called an electric field or is it just a convenient coefficient that is sufficient to multiply by the value of the charge to obtain the value of the force. Now they adhere to the first opinion, because the electric field vector at an arbitrary point in space makes it possible to predict the force that will act on an arbitrary device at that point, and this force is capable of doing work.

If in (1.4) we take q = 1 K, then we get **F** = **E**. Therefore, the electric field intensity vector is equal in value to the electric field intensity vector with which it acts on one stationary positive charge in a vacuum.

Much effort was spent on the geometric construction of field paintings, but all of them are imperfect and do not reflect the physical essence. The most correct point of view turned out to be the most abstract - the fields should be considered as mathematical functions of coordinates and time. We owe the study of the field to the English physicist Faraday. This is how he solved the problem of the force of proximity interaction of charges.

You will not surprise us with the Earth's magnetic field. However, we rarely think about the fact that we live between the covers of a giant capacitor. Its negative electrode is the Earth, and its positive electrode is the ionosphere. An atmospheric generator with a capacity of about 700 MW maintains a voltage between the electrodes of 400 kV. The electric field strength near the Earth's surface of such a capacitor is 100 Vm^{-1}. The average daily current of the atmosphere (due to the imperfection of its insulating properties) is 1800 A, reaching a minimum value at 4 o'clock, and a maximum at 7 p.m. GMT. This current is enough to upset the capacitor in half an hour and thereby compensate for the entire negative charge of the Earth. But this does not happen, because the generator from the Earth into the ionosphere in concentrated beams in the form of lightning sends positive charges towards the atmospheric current. About 2,000 thunderstorms occur simultaneously on Earth. Energy equal to the energy of a hydrogen bomb is concentrated in each of them. 100 lightning strikes the ground every second. If we have good weather, somewhere it is raining, if we have cracking frosts, somewhere there is unbearable heat. Unfortunately, we cannot use the energy of the atmospheric generator, because we acquire the potential of the Earth.

All our previous considerations have been about a physical process in a vacuum. The concept of emptiness is relative. In electricity, a vacuum is understood as a space filled only with an electromagnetic field. The real environment determines a certain influence on the intensity of the electric field. This phenomenon was first noticed by Faraday. It is natural that the field in the real environment should be characterized by another vector – the electric induction vector **D**, the dimension of which is C m^{-2}.

The vector **D** can be represented by the sum of two vectors: the vector $\varepsilon_0\mathbf{E}$, which characterizes the field in the void, and the polarization vector **P**, which characterizes the field of coupled charges:

:

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}(\mathbf{E}), \tag{1.6}$$

where $e_0 = 8.854.10^{-12}$, farad/meter (Fm^{-1}) is an electrical constant.

Summarizing (1.6), we write:

$$\mathbf{D} = \mathbf{D}(\mathbf{E}). \tag{1.7}$$

Function (1.7) is the main characteristic of the dielectric. In an isotropic medium, the vectors **D** and **E** are collinear, which is a consequence of the collinearity of the vectors **E** and **P**; in an anisotropic medium, the collinearity of vectors **D** and **E** is violated, since **P** and **E** are non-collinear. In an isotropic linear medium, the expression (1.7) is simplified:

$$\mathbf{D} = \varepsilon \mathbf{E}, \tag{1.8}$$

where e is the dielectric constant of the medium (Fm^{-1}).

If **D** and **E** are known, **P** can be calculated from (1.6).

1.4. Magnetic field vectors

The magnetic field, like the electric field, describes the interaction of charged particles. The magnetic field is determined by the force acting on the moving charges. As it turned out, this force is proportional to the speed of the charge movement and depends on its direction. The formula for determining the strength of the magnetic field was established experimentally

$$\mathbf{F} = q(\mathbf{v} \times \mathbf{B}), \tag{1.9}$$

where **v** is the velocity vector; **B** is the magnetic induction vector ($T = Wb\, m^{-2}$).

Vector **B** is the main characteristic of the magnetic field. It determines its intensity at a given point in space. Thus, if the value and direction of vector **B** are known, then this determines the acceleration that a moving charged particle would receive at this spatiotemporal point. It is only for this reason that the idea of the field as an objective substance is acceptable.

Vector **F** is perpendicular to vectors **B** and **v**. Force perpendicular to the direction of motion cannot do work. According to (1.9), the module $F = qvB \sin(\mathbf{v}\hat{}\mathbf{B})$. If we now take $q = 1$ C, $v = 1$ m s^{-1}, $\mathbf{v}\hat{}\mathbf{B} = 90^0$, then $F = B$. Therefore, *the magnitude of the vector of magnetic induction is equal to the magnitude of the vector of the force with which the magnetic field acts on a unit positive charge, which moves with a unit speed, and in such a direction when this force is maximal* ($\sin(\mathbf{v}\hat{}\mathbf{B}) = 1$).

The magnetic field is our eternal companion. The magnetic field of the Earth near its surface is approximately $0.5.10^{-4}$ T. The field of an ordinary electromagnet reaches 1...2 T, and a superconducting industrial electromagnet reaches 6...8 T. In local areas on the surface of the Sun (sunspots), the magnetic field reaches hundredths of a tesla. Several stars are known whose surface magnetic fields are greater than 0.1 T. The infinite magnetic fields of our Galaxy have a value of about 10^{-9} T. But, despite such a small value, they play a decisive role in its dynamics.

The geometric construction of the picture of the magnetic field is even more difficult than that of the electric field, since it will be different in different coordinate systems, and in the system rigidly connected to the moving object, the magnetic field is completely absent.

Naturally, if electric and magnetic fields exist simultaneously in this coordinate system, then the force must be defined as the result of the combination of (1.4) and (1.9):

$$\mathbf{F} = q\left(\mathbf{E} + \mathbf{v} \times \mathbf{B}\right)). \tag{1.10}$$

This force is often called the Lorentz force.

Magnetic forces are much smaller than the forces of electrical interaction. They would be comparatively imperceptible, if nature had not created two types of charges capable of compensating for the force of electrostatic action in bodies. In intranuclear phenomena, where the full Coulomb force acts in the interaction of elementary particles, magnetic effects take second place after electrical interactions. Magnetic forces are weaker than electric forces precisely by a factor equal to the square ratio of the particle's speed to the speed of light (v^2/c^2). It is precise because the speed of light is limited that magnetic interaction is observed, but if it were unlimited, then the magnetic field could not exist in principle.

As already mentioned, the magnetic field manifests itself due to the force interaction on the moving rods. But it has been established that only moving objects also generate a magnetic field. Static magnetic masses do not exist, in contrast to static electric masses, which are charges. The idea of the unity of electricity and magnetism, which arose after Maxwell's work, suggested that any moving charge must create a magnetic field. But it was incredibly difficult to experimentally confirm this. For the first time, the fact of the emergence of a magnetic field during the movement of an electrostatically charged sheet was established in the last century by H. Rowland. The magnetic field to be measured was approximately 10-5 the value of the Earth's field, measuring such weak fields is a problem even for modern instruments. Thus, ten years before Hertz's discovery of electromagnetic waves, Rowland's experiment provided independent confirmation of Maxwell's theory of the electromagnetic field.

Formula (1.9) is not related to the medium in which we observe the magnetic field. But it is quite reasonable that the real environment should affect the intensity of the magnetic field, because it contains material particles that have an electrical charge and are in continuous motion, and therefore generate their own magnetic field. Therefore, vector **B** makes it possible to judge the intensity of the magnetic field source only in the void, where there are no moving objects. In order to be able to judge the intensity of the source in a real environment, it is necessary to introduce another characteristic of the magnetic field. It is the magnetic field intensity vector H (Am^{-1}).

There are moving parts inside any substance. We imagine this movement as the movement of electrons along orbits inside atoms and as the rotation of electrons around their axes. If these movements are chaotically oriented, then upon macroscopic examination of the phenomenon, the charged particles do not create a magnetic field. However, if, under the influence of an external magnetic field, a somewhat consistent orientation of the motion of the charged particles appears, then they create their own additional magnetic field, which deforms the external field.

The vector **H** can also be represented by the sum of two vectors: the vector $\nu_0\mathbf{B}$, which characterizes the field in a vacuum, and the magnetization vector **M**, which characterizes the field of elementary magnetic moments of the medium

$$\mathbf{H} = \nu_0\mathbf{B} - \mathbf{M(B)}. \qquad (1.11)$$

where $\nu_0 = 0.796\,10^6$ (H^{-1} m) is the magnetic constant.

It is *vector* $\dot{\mathbf{H}}$ *that makes it possible to judge the intensity of the source of the magnetic field.*

Generalizing (1.11), we get

$$\mathbf{H} = \mathbf{H(B)} \qquad (1.12)$$

Function (1.12) is the main characteristic of a magnet. In an isotropic medium, vectors **H** and **B** are collinear, in an anisotropic medium they are non-collinear.

In an isotropic linear medium, the expression (1.12) is simplified:

$$\mathbf{H} = \nu\mathbf{B}, \qquad (1.13)$$

where $\nu = 1/\mu$ is the reluctivity (inverse magnetic permeability) of the medium, μ is the magnetic permeability.

The whole difficulty lies in the fact that it is still not possible to write analytically the functional dependence (1.12) because **H** at any time depends not only on **B** at the same time but also on the entire prehistory of the magnetization of the material. Magnetization and hysteresis loops are different for different substances. The chemical composition of the material, cooking technology, etc. are involved here.

Based on known **B** and **H**, according to (1.11), it is possible to calculate **M**.

Mathematically describing the curve of nonlinear (ferromagnetic) media (1.12) is an urgent need of time. Let's hope that this will be done in the near future.

1.5. The conflict-free model of the electron

Unfortunately, the theory of the electromagnetic field still does not have a problem-free model of its simplest-tuned elementary particle – the electron. The internal contradiction of known constructions boils down to two problems. The first of them is related to the paradox of the self-action of an electron itself. Its essence is that the electromagnetic mass of a moving electron, obtained from the pulse of the electromagnetic field, turns out to be greater than the rest mass. At one time, the brightest minds of the creators of theoretical physics attempted to solve this problem, but all their developments, in one way or another, requiring intervention in the fundamental equations of electromagnetism, and even the complete rejection of electromagnetic mass. Only Poincare, as a temporary way out of the situation, proposed the spontaneous action of the electron on itself - the so-called "Poincare springs". It was the energy of these magical springs that was intended to compensate for the required mass deficit. But years passed, and no one found these springs. The second problem is related to the boundless energy, and at the same time, the mass of a point charge when the radius of the particle is directed to zero.

From the point of view of the significance of these problems for the theory, it can be considered necessary to express one's own opinion, which does not claim to be the final truth but has the right to exist, just like the known ones. Looking ahead, let's say that it by no means enters into a dispute with the modern theory of electricity or with the experiment, but, on the contrary, appears against their background.

1. Poincare springs. An electron is a stable, negatively charged elementary particle that is part of all atoms (e =-1,60217733· 10^{-19} C) and mass (m_e = 9,1093897· 10^{-31} kg). Its life span is more than 10^{26} years. Its stability is due to the law of conservation of electrical charge. An antiparticle is a positron. The mass of an electron can be easily calculated from its momentum for velocities [15]. The pulse density $\mathbf{g}$ of the electromagnetic field can be found by dividing the Poiting vector $\mathbf{\Pi} = \varepsilon_0 c^2 \mathbf{E} \times \mathbf{B}$ by c^2, where c is the speed of light,

$$\mathbf{g} = \varepsilon_0 \mathbf{E} \times \mathbf{B}, \tag{1.14}$$

We will consider the electron as a charged sphere with radius a and chargee, which moves at a constant speed, whose vector is $\mathbf{v}$. At some point, located at a distance r from the center of the rod and an angle to the line of its motion, the electric field is radial, and the lines of force of the magnetic field appear in circles around the line of motion

$$\mathbf{B} = \frac{\mathbf{v} \times \mathbf{E}}{c^2}. \tag{1.15}$$

According to (1.5) by definition

$$E = \frac{q}{4\pi\varepsilon_0 r^2}; \quad \varepsilon_0 = \frac{1}{4\pi k}. \tag{1.16}$$

On the basis of (1.14)-(1.16), we can finally obtain [15]

$$\mathbf{p} = \frac{2}{3}\frac{\alpha^2}{ac^2}\mathbf{v}, \quad \alpha^2 = \frac{q^2}{4\pi\varepsilon_0}, \tag{1.17}$$

where $\mathbf{p}$ is the momentum vector of the moving electron.

The coefficient of proportionality between the momentum and velocity vectors in (1.17) is the electromagnetic mass of the electron

$$m_e = \frac{2}{3}\frac{\alpha^2}{ac^2}. \tag{1.18}$$

It was experimentally confirmed with an error of up to 15 millionths that the coefficient α at distances of 10^{-10} m. remains the same. Let's say that in classical physics its truth is also recognized at distances of 10^{-15} m.

Physicists do not disagree about the truth of expression (1.18). But the problem lies in something else – in the deviation from (1.18) of the mass of a stationary particle obtained by the universal expression of energy – $m_e = w/c^2$. If we assume that the charge of the particle is located on its spherical surface (m'), or is uniformly distributed over the volume of the sphere (m''), then:

$$m'_e = \frac{1}{2}\frac{\alpha^2}{ac^2}; \quad m''_e = \frac{3}{5}\frac{\alpha^2}{ac^2}. \tag{1.19}$$

There are no reservations regarding the proving of the first of them because it does not exceed the limits of distances of 10^{-16} m. And the second is in doubt because as a result of the bombardment of protons by fast electrons, it was established by their scattering that Coulomb's law does not work at distances of 10^{-16} m!

The mass deficit in both cases, as mentioned earlier, is still compensated by Poincar? "tensions" or "springs". There are still disputes about their existence.

Our idea is very simple. Without going beyond the limits of classical electrodynamics, reconcile all three masses (1.18), (1.19) in favor of the first of them. For that, we resolutely reject the concept of a point charge, and consider the real one to be distributed over the volume, but not uniformly, as in the case of m'' , but unevenly!

2. Conflict-free electron model (hypothesis of electric white holes).

The experimental fact of the collapse of Coulomb's law at distances of 10-16 m tells about one thing - there is no electric field in the radius of such a sphere, and it will be only when the particles can cross it. In this way, an electrical vacuum appears there, which we will conventionally call a "white hole". Of course, there is no need to talk about the laws of electromagnetism in such a vacuum. It is quite reasonable to look for the radius of such a white hole precisely in the elementary charge, which is the electron. In gravity, there is also something similar - a "black hole", or a Schwarzschild sphere. The physical body beyond this sphere also undergoes gravitational collapse.

By analogy with gravity, we will assume that the electron inside is also electrically hollow! Since the radius of the Schwarzschild sphere is called the gravitation radius, we will call the radius of our sphere the electric one. For a typical neutron star, the gravitational radius is about 1/3 of its radius. So we can expect that the electric radius will also be a multiple of 1/3 of its own.

The discrepancy between expressions (1.18), (1.19) unequivocally proves that the density of the particle must be unevenly distributed over the volume of the particle. You can look for different variants of this non-uniformity, but the simplest of them, as experience has shown, is the quark one.

Quarks were invented in 1964 by Gell-Mann and independently by Zweig to explain the symmetry in the properties of strongly interacting particles - hadrons. According to the imagination of quantum physics, the electron consists of three quarks (although there is an opinion that the electron as an elementary particle is indivisible), having an electric charge multiple of e/3. This multiplicity occurs quite often in physics, for example, the ratio of the magnetic moments of a neutron and a proton is -2/3, and the ratio of a hyperon and a proton is -1/3, etc. And indeed, as will be shown later, the electric radius of an electron is about 2/3 of its own effective radius a. Why really? – Because the conditional m due to the uncertainty of the digital coefficients in (1.18), (1.19), tending to (1.18), for the real masses me and the charge is overestimated by 3/2 times.

Quarks are written in different ways. Experimenters consider them structureless, point-like, which "has been tested up to $5{\cdot}10^{-18}$ m". Quantum chromodynamics believes that a "colorless" electron consists of three conditionally "colored" quarks (red, yellow, blue), and each of two of them has a charge of -e2/3, and the quark of the third color has +e1/3. But there is also a sincere one: "*Currently, there are no experimental or theoretical ideas about the distribution of quarks in the volume of the electron... From this point of view, the hypothesis about the electron in the form of a sphere is the simplest and most acceptable [15].*"

We do not consider the electron as a quark structure, but only accept the quark distribution of charge densities in three active zones of the same volume at the radius r: -e2/3, -e2/3, +e1/3. Moreover, their sequence is determined by condition (1.18). This even somewhat simplifies the analysis, because it allows the first two zones to be combined into one. In separate zones, the density of the charge is considered constant. Such an electron model is almost the only one that does not affect the interests of either classical or quantum electrodynamics. Because it preserves the monolithicity of an elementary particle in accordance with classical theory, and in accordance with quantum theory it interprets individual tuned zones as individual discrete quarks. And besides, the power of such an electron design is reminiscent of the miraculous power of a wooden wheel (-), compressed by a red-hot iron rim (+) in ancient vehicles.

We do not consider the electron as a quark structure, but only accept the quark distribution of charge densities in three active zones of the same volume at the radius r: -e2/3, -e2/3, +e1/3. Moreover, their sequence is determined by condition (1.18). This even somewhat simplifies the analysis, because it allows the first two zones to be combined into one. In separate zones, the density of the charge is considered constant. Such an electron model is almost the only one that does not affect the interests of either classical or quantum electrodynamics. Because it preserves the monolithic of an elementary particle in by classical theory, and in by quantum theory, it interprets individual tuned zones as individual discrete quarks. And besides, the power of such an electron design is reminiscent of the miraculous power of a wooden wheel (-), compressed by a red-hot iron rim (+) in ancient vehicles.

With such a structure of active zones and the presence of a white hole with a radius in the center, the internal energy of a charged hollow sphere can be easily found according to Maxwell's postulate, as the sum of the energies of its zones

$$w_{ei}(\xi) = \frac{\alpha^2}{2a}\left(\frac{m_1}{4b^2}\left(\frac{k_{r2}^5-\xi^5}{5}\right) - \xi^3\left(k_{r2}^2-\xi^2\right)+\xi^6\left(\frac{1}{\xi}-\frac{1}{k_{r2}}\right)+\frac{m_2^2}{5b^2}\left(1-k_{r2}^5\right) - \right.$$

$$-\left(\frac{m_2^2 k_{r2}^3}{b^2}+\frac{m_1 m_2}{b}\right)\left(1-k_{r2}^2\right)+\left(\frac{m_2^2 k_{r2}^6}{b^2}+\frac{2m_1 m_2}{b}+m_1^2\right)\left(\frac{1}{k_{r2}}-1\right)\Bigg), \tag{1.20}$$

where $m_1 = -4/3;\ m_2 = +1/3;\ r_e = \xi a,\ r_1 = k_{r1}a,\ r_2 = k_{r2}a$ are the radii of the white hole, the first and second active zones; the rest of the coefficients are found based on the condition of equality of the volumes of individual active zones:

$$k_{r1} = \sqrt[3]{(k_{r2}^3+\xi^3)/2}\,;\ k_{r2} = \sqrt[3]{(2+\xi^3)/3};\ \ b = 1-k_{r2}^3.$$

The only value ξ satisfying condition (1.18) is found as a solution of the nonlinear equation

$$w_{ei}(\xi) = \frac{\alpha^2}{6a}. \tag{1.21}$$

As a result $\xi = 0.6308965 \approx 0.6309,$ it is, as expected, around 2/3*a* with a deviation of 5%.

By substituting the numerical value ξ in (1.20) and dividing the obtained result by c^2, we obtain the mass of the electron determined by its internal electrical energy

$$m_{ei} = \frac{1}{6}\frac{\alpha^2}{ac^2}. \tag{1.22}$$

The mass appearing in (1.19) is determined by its external electrical energy. This follows from the limits of integration during its derivation: $a \le r \le \infty$. By adding $m_e = m'_e + m_{ei}$, we get a result that is identical to (1.18). Which had to be proved.

Since both masses now coincide, the true radius of the electron can be taken as its natural value *a*.

Let's assume that the laws of electricity are meaningless inside a "white hole" with a radius of $r_e = 1{,}185246 \cdot 10^{-15}$ m, since electric charges cannot penetrate it. This is a very important conclusion because it *eliminates yet another problem of infinite energy, and at the same time, the mass of a point-like object at* $r \to 0$. *Because r cannot exceed the limits of the radius of the "white hole" of the electron:* $r \ge r_e$.

The harmony of the outer spheres of the white hole and all three active zones is impressive [19, 22, 23, 25, 26]

0	$\xi = 0.6309$	$k_{r1} = 0.7901$	$k_{r2} = 0.9087$	1
$0 = \sqrt[3]{0/4}a$	$r_e = \sqrt[3]{1/4}a$	$r_1 = \sqrt[3]{2/4}a$	$r_2 = \sqrt[3]{3/4}a$	$a = \sqrt[3]{4/4}a$

According to H. Poincare, objective reality can only be harmony expressed by mathematical laws. On this occasion, I will quote one of the daily entries. It concerns not only directly obtained results but also opens the veil to the mystery of creativity.

26.11.2017. Lviv. I discovered mistakes in the energy equation of the electron. And archival materials in Volyn. I had to prove everything from the beginning. It took three days of fruitless superhuman efforts, as well as swallowing the most difficult thing in a scientist's life – despair. But what Poincare said about the universal harmony of the world, into which the previous results fit so well, did the impossible – the result obtained today is even more perfect. It was not without another, if not the only, miracle in science: *the non-linear (6th order) algebraic equation of the electric radius was solved bypassing mathematical operations, based only on the harmony of the spheres, as:* $x = \sqrt[3]{1/4}$ *! Not knowing whether there is anywhere else a more convincing confirmation of the dualistic interpretation of existence.*

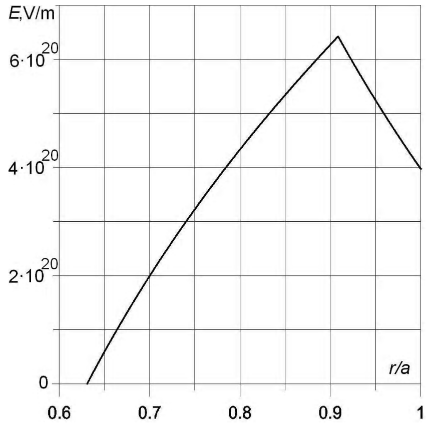


Fig. 1.1. Distribution by radius of the electric field intensity in the body of the electron

If such an electron structure is considered as a quark structure, then based on this harmony, a white hole can be interpreted as a fourth white (neutral) quark. Moreover, the estimated radius of the spherical quark we obtained coincides with the electric radius r_e with a difference of 5%. But in this case, for the sake of the presence of orbital moments, we will not forbid our quarks to "virtually rotate" concerning to each other.

The simulation results are shown in fig. 1.1.

The proposed model of the electron eliminates at least two important problems of electricity without contradicting its classical laws.

Interestingly, J. Zweig called quarks aces, but this name did not catch on, because there were four aces, and there were three quarks in the primary model. Perhaps our white is the fourth one (?).

Everything said here once again confirms the wisdom: "never say the never". Because how else to explain what was said in quantum physics [36]: "Nowadays, most physicists already understand that attempts to create any classical model of the electron do not make sense."

* * *

The main subject of our interest in the next chapter will be the force laws of statics (1.1), (1.2), (1.10), associated with the famous names of I. Newton, S. Coulomb, and H.-A. Lorenz.

2. BASIC LAWS OF DYNAMICS

2.1. Newton's law of moving masses

For moving masses in the range of pre-light (pre-relativistic) velocities in classical physics, Newton's gravitational law (1.2) is still used, which is created to ensure sufficient accuracy not only in terrestrial conditions but also in space research. Based on his own Law of Universal Gravitation, Newton deduced the laws of planetary motion previously discovered by Kepler. Newton's theory laid the foundation for the dynamics of the solar system and opened the possibility of accurately predicting the movement of the planets, their satellites, and comets.

However, with a meticulous approach to the dynamics equations of classical physics, the situation worsens somewhat. If you look into the quantum theory of the microcosm, you can find even more claims. Limiting the immobility of gravitating masses can be interpreted in a different way – instantaneous gravitational interaction. In fact, according to modern ideas, the gravitational field, like the electric field, propagates with the maximum possible physical speed of light in a vacuum, $c = 3{\cdot}10^8$ ms^{-1}.

But there are practical problems that are completely unsatisfied by (1.2) and one has to turn to the incredibly complex equations of the general theory of relativity (GRT) in the curved Riemannian space-time, which cannot always be used. Therefore, a reasonable question arises, why not adapt the law (1.2) to the case of moving masses in our familiar flat Euclidean space and thereby simplify the problem beyond recognition?

It is clear that such a solution to the problem is not in favor of relativism, so they are left with one thing – to declare Galileo's transformation outlawed, despite A. Poincare's long-standing warning about Lorentz transformations [9] that "no physical experience can confirm the truth of some transformations and reject others as unacceptable".

"The origins of the misunderstanding of Poincare's views, we read further in [9], lie in the disclosure of the conditional nature of simultaneity. As a result, it became possible to misunderstand this theory, in which the main attention was focused on the "inability" of Galileo's transformations. This misunderstanding was reflected in the accepted logic of building the theory of relativity when new properties of motion at high speeds are derived from the relativistic properties of space and time."

So, to adapt the law (1.2) to real conditions, it is enough to consider the fact of time gravitational delay! Otherwise, at the frozen moment of time t, we will take the distance not to the actual location of the gravitating mass, but to the gravitating point, taking into account the time delay Δt.

We will make mathematical constructions according to the geometric interpretations of fig. 2.1. Without loss of generalization, let's consider one of the masses, for example, m_1 stationary, the other m_2 – moving along the direction of the velocity vector $\mathbf{v}$. Let the distance between the masses be R at the frozen moment of time t. But their gravitational interaction will be determined by some delay in the angle β, caused by the delay in the passage of the gravitational wave with the speed of light c to the corresponding point of the trajectory in some time Δt. The distance covered by the moving mass during this time will be $v\Delta t$, where v is the instantaneous speed of the moving mass. The time Δt can be easily found as

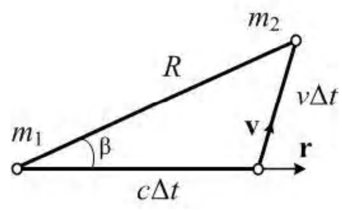


Fig. 2. 1. Towards a geometric interpretation of the propagation of a gravitational field with a finite velocity

$$\Delta t = \frac{R}{\sqrt{c^2 + v^2 + 2cv\mathbf{r}_0 \cdot \mathbf{v}_0}}. \qquad (2.1)$$

Then the real distance between the interacting masses, taking into account the time delay, will be

$$r = c\Delta t = \frac{R}{\sqrt{1 + \frac{v^2}{c^2} + 2\frac{v}{c}\mathbf{r}_0 \cdot \mathbf{v}_0}}. \qquad (2.2)$$

Substituting (2.2) into (1.2), we obtain the expression of Newton's adapted law for the case of moving masses [25, 26, 41, 43]

$$\mathbf{F} = G\frac{m_1 m_2}{R^2}\left(1 + \frac{v^2}{c^2} + 2\frac{v}{c}\mathbf{r}_0 \cdot \mathbf{v}_0\right)\mathbf{r}_0. \qquad (2.3)$$

where $\mathbf{r}_0$, $\mathbf{v}_0$ are the unit vectors directed from the center of the gravitating mass to the point of gravity and according to the speed at this point.

The required value $\mathbf{r}_0 \cdot \mathbf{v}_0$ is found from the corresponding coordinate equations of mechanical motion. Law (2.3) has been successfully tested in problems of the micro- and macro world at sublight and light velocities.

Below, we will focus on individual cases in which (2.3) is significantly simplified.

Individual cases. 1. *The direct trajectory of movement passes through the centers of interacting masses (longitudinal interaction).* Then $\mathbf{r}_0 \cdot \mathbf{v}_0 = 1$ when the masses move away and $\mathbf{r}_0 \cdot \mathbf{v}_0 = -1$ then get closer. So (2.3) simplifies

$$\mathbf{F} = G\frac{m_1 m_2}{R^2}\left(1 \pm \frac{v}{c}\right)^2 \mathbf{r}_0, \tag{2.4}$$

moreover, the "+" sign appears when the masses are moving away, and the "-" sign, on the contrary, when they are approaching.

2. *A moving mass moves in a circle around a stationary one (transverse interaction).* In that case $\mathbf{r}_0 \cdot \mathbf{v}_0 = 0$. Then (2.3) takes a different form

$$\mathbf{F} = G\frac{m_1 m_2}{R^2}\left(1 + \frac{v^2}{c^2}\right)\mathbf{r}_0. \tag{2.5}$$

3. *Immovable masses.* Under the condition $v = 0$, expressions (2.3)–(2.5) degenerate to the original Newton's law (1.2). There is no such direct transition in GRT. Relativists have to go to the top in the variational principles, change the scalar curvature of space to the usual energy function of Lagrange and pass all this through their inherent mathematical labyrinths, thus making a frank substitution of concepts [5].

Example 2.1. To find an expression for the gravitational radius of the Schwarzschild sphere R_g . This is the radius of a spherical body at which its second cosmic velocity is equal to the speed of light in a vacuum. When an object is compressed into a sphere with a radius equal to or less than the gravitational one, irreversible gravitational collapse occurs - the object turns into a black hole. Gravitational radius is determined by body mass. For the Sun, it is 2.95 km, and for the Earth – 8.86 mm. But the Sun will not shrink to such a radius, since the mass is too small, and the gravitational forces will not be able to overcome the interelectron repulsion forces caused by the Pauli exclusion principle.

The first solution of the GRT equations was obtained by K. Schwarzschild in 1916 for a fixed spherical body, finding the corresponding metric in spherical coordinates (see (5.23) on p. 134), and at the same time the gravitational radius of the gravitating mass M

$$R_g = \frac{2GM}{c^2}. \tag{2.6}$$

We will solve this problem much more simply - bypassing the Schwarzschild metric in the curved Riemannian space, and at the same time (due to the principle) bypassing the classical energy balance. At the same time, we will use the indisputable principle of GRT equivalence – the equality of gravitational and inertial masses. Nowadays, this equivalence is confirmed experimentally with a relative error of up to 10^{-12}, and, frankly, is a far-fetched problem. Doubts can arise here, except for the speed of light, for example. In problems of interaction of gravitational and electric fields.

The surface properties of the Schwarzschild sphere can already be discussed at the level of the first cosmic velocity – the balance of orbital forces. It can be proved that at $v = c$, first, and second space velocities in front of the singularity coincide.

For angular acceleration

$$a = \frac{v^2}{R}, \tag{2.7}$$

we write the balance of forces according to (2.5), (2.7)

$$\frac{mc^2}{R_g} = G\frac{mM}{R_g^2}\left(1 + \frac{c^2}{c^2}\right). \tag{2.8}$$

Where

$$R_g = \frac{2GM}{c^2}. \tag{2.9}$$

The doubling of the result (2.9) compared to the classical one indicates that the magnetic component of the force $v = c$ according to (2.8) equal the electric one.

The coincidence of (2.6) and (2.9) is not accidental. It proves not only the adequacy of the expression proposed by us, but at the same time the adequacy of GRT in the problems of statics, which is increasingly criticized, especially in our fast-paced time. Suffice it to say that there are about 13 alternative theories that postulate more radical changes or contradict the GRT altogether. They also have different degrees of development. Therefore, in line with what has been said, this result should not be interpreted as an alternative to GRT, but only as an imitation of the above-mentioned warning of Poincare regarding the "inability" of Galileo's transformations. To avoid misunderstandings, we draw attention to the fact that our work is distanced from the total non-perception of GRT, as a deeply elaborated, albeit regeometrized, image on the way of a step-by-step approach to a majestic physical cosmic phenomenon, which once again testified to the phenomenon of mathematics as a universal language!

It must be said that this task is beyond the reach of either Newton's classical law (1.2) or SRT!

In the next paragraph, we will consider the practical use of the gravitational law of moving masses in conjunction with coordinate levels in the space practice of longitudinal interaction.

2.2. Dynamics of free gravitational fall

The analysis of transient mechanical processes in celestial mechanics occupies one of the key places in the study of the universe. Based on the theoretical results obtained in the previous paragraph, we will show how to easily solve one of the practical space problems, namely: the dynamics of free gravitational fall, when the centers of gravitating masses are located on the same straight line.

In this case, the analysis is simplified, because there is no need to find angular coordinates, and if so, then the scalar product in (2.3) is known in advance. It takes the value $+1$ when the masses are moving away, or -1 when they are approaching. In this case, we use formula (2.4), which proves that when falling with a limiting speed ($v = c$) the gravitational interaction disappears by itself ($F \to 0$). But when taking off ($v = -c$), the force increases fourfold ($F \to 4F$). This is what probably explains gravitational effects such as the gravitational delay of signals.

Denoting the gravitating mass as M, and the gravitated (falling) mass as m, we write the balance of forces of free fall of the gravitating masses based on (2.4) and Newton's second law in scalar notation

$$F = mg. \tag{2.10}$$

Taking into account that the acceleration g is defined as

$$g = \frac{dv}{dt}, \tag{2.11}$$

the balance of power will look like this

$$m\frac{dv}{dt} = G\frac{mM}{R^2}\left(1 - \frac{v}{c}\right)^2. \tag{2.12}$$

As a result of the reduction of the gravitating mass m that appears in (2.12), we obtain the equation of motion, in which only the gravitational field of the source mass in the surrounding space appears, which conditionally takes over the force functions

$$\frac{dv}{dt}=\frac{GM}{R(v)^2}\left(1-\frac{v}{c}\right)^2. \tag{2.13}$$

In order to use the differential equation (2.13) in practice, it is necessary to specify the nonlinear function $R(v)$. Yes, for the black hole case

$$R=R_g+h, \tag{2.14}$$

where R_g, h is the radius of the gravitating body and the height of the fall of the gravitating mass on this body.

If we substitute (2.14) into (2.13), we obtain the first coordinate equation

$$\frac{dv}{dt}=\frac{GM}{(R_g+h)^2}\left(1-\frac{v}{c}\right)^2. \tag{2.15}$$

The second coordinate equation is obvious

$$\frac{dh}{dt}=-v. \tag{2.16}$$

The Cauchy problem for differential equations of free fall in a gravitational field based on (2.15), and (2.16) will take on a complete form

$$\frac{dv}{dt}=\frac{GM}{(R_g+h)^2}\left(1-\frac{v}{c}\right)^2; \quad \frac{dh}{dt}=-v; \quad \frac{v_0\le v\le c;}{h_0\ge h\ge 0,} \tag{2.17}$$

where v_0, h_0 are the initial conditions.

Example 2.2. We simulate the free fall of a gravitating mass onto a collapsar, a stellar-sized black hole with a huge gravitational field. Collapsers have their gravitational radius R_g and mass ranging from about 5 to several tens of solar masses $M_\odot$.

Let's stop the selection on the specific collapsar GRO J0422+32/V518 Per, with a mass $M=4M_\odot$ on distance 8500 l.y. The results of the integration of the nonlinear gravity equations (2.17) are shown in fig. 2.2 and fig. 2.3 for constant parameters:

$$M = 7{,}96 \cdot 10^{30}\ \text{kg};\ R_g = 11{,}82 \cdot 10^3\ \text{m};$$
$$G = 6{,}67 \cdot 10^{-11}\ \text{kg}^{-1}\ \text{m}^3\text{s}^{-2};\ c = 2{,}99 \cdot 10^8\ \text{ms}^{-1}.$$

and under initial conditions: $v_0 = 0;\ h_0 = 1 \cdot 10^6$ m.

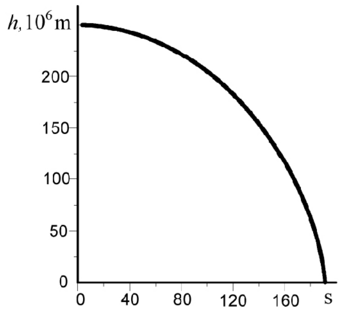


Fig. 2.2. Time dependence of the trajectory of free fall $h = h(t)$ from a height 250000 km on kollapsar GRO J0422

For a visual comparison of the influence of motion effects on the transient gravitational process of free fall, both figures show the curves also obtained using force action only according to Newton's classical law of gravity (1.2).

At the opportunity, we will dispel one of the most glaring myths, not SRT, but the incorrect interpretation by relativists of the physics of the process about the functional dependence of mass on the speed of its movement

$$m = \frac{m_0}{\sqrt{1 - \dfrac{v^2}{c^2}}}, \qquad (2.18)$$

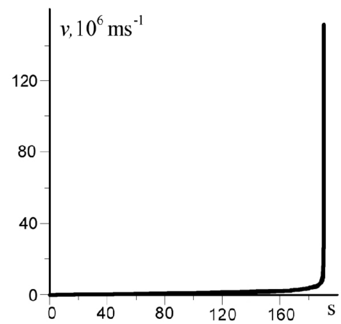


Fig. 2.3. Time dependence of free fall speed $v = v(t)$ in the transition process corresponding fig. (2.2).

where m_0 is the so-called rest mass. The mass of the body is given from above and is its inalienable property as a measure of a fraction of the global energy of relative rest. And the Lorentz radical appearing in the denominator of formula (2.18) is the result of the finite propagation of the field, which characterizes not the mass, but its force interaction with the field.

In our research, this role is taken over by the square of the factor in parentheses of formula (2.4) in addition to (1.2). This becomes especially clear if we delve into the mathematical derivation of the generalized law of gravitation (2.3) with the participation of the geometric constructions of fig. 2.1.

2.3. Coulomb's law of moving electric masses

Based on electromechanical analogies $m \to q,\ G \to k$, where q is an electric charge and k is an electric constant, it is possible to adapt Coulomb's law of electrostatics to the case of motion, similar to (2.3) [25, 26, 41-44]

$$\mathbf{F} = k\frac{q_1 q_2}{R^2}\left(1 + \frac{v^2}{c^2} + 2\frac{v}{c}\mathbf{r}_0 \cdot \mathbf{v}_0\right)\mathbf{r}_0. \tag{2.19}$$

Expression (2.19) is fully consistent with the geometric constructions shown in fig. 2. 1.

Below we will focus on individual cases in which (2.19) is also simplified.

Individual cases.

1. *A moving body moves along the force action.* Then $\mathbf{r}_0 \cdot \mathbf{v}_0 = 1$ when the masses move apart and $\mathbf{r}_0 \cdot \mathbf{v}_0 = -1$ when they get closer. Then (2.19) is simplified [21]

$$\mathbf{F} = k\frac{q_1 q_2}{R^2}\left(1 \pm \frac{v}{c}\right)^2 \mathbf{r}_0, \tag{2.20}$$

moreover, the "+" sign indicates that the bodies are moving away, and the "-" sign indicates their convergence.

When moving towards convergence in the natural direction with the limiting speed ($v = c$), the electrical interaction disappears by itself ($F \to 0$). However, during braking (against electric action ($v = -c$), the relativistic coefficient increases fourfold ($F \to 4F$).

2. *A moving body moves across the force action*. In this case $\mathbf{r}_0 \cdot \mathbf{v}_0 = 0$. Then (2.19) takes a slightly different form

$$\mathbf{F} = k\frac{q_1 q_2}{R^2}\left(1 + \frac{v^2}{c^2}\right)\mathbf{r}_0, \tag{2.21}$$

3. *Нерухомі тіла*. За умови $v = 0$ вирази (2.19)–(2.21) вироджуються до вихідного закону (1.1).

Далі розглянемо практичну задачу руху електрона в нерівномірному електричному полі. Розв'язання такої задачі покаже реальні можливості виразу (2.19) у практичному аналізі.

Individual cases. 1. *The direct trajectory of movement passes through the centers of interacting masses (longitudinal interaction).* Then $\mathbf{r}_0 \cdot \mathbf{v}_0 = 1$ when the masses move away and $\mathbf{r}_0 \cdot \mathbf{v}_0 = -1$ then get closer. So (2.3) simplifies

$$\mathbf{F} = G\frac{m_1 m_2}{R^2}\left(1 \pm \frac{v}{c}\right)^2 \mathbf{r}_0, \tag{2.4}$$

moreover, the "+" sign appears when the masses are moving away, and the "-" sign, on the contrary, when they are approaching.

2. *A moving mass moves in a circle around a stationary one (transverse interaction).* In that case $\mathbf{r}_0 \cdot \mathbf{v}_0 = 0$. Then (2.3) takes a different form

$$\mathbf{F} = G\frac{m_1 m_2}{R^2}\left(1 + \frac{v^2}{c^2}\right)\mathbf{r}_0. \tag{2.5}$$

3. *Immovable masses.* Under the condition $v = 0$, expressions (2.3)–(2.5) degenerate to the original Newton's law (1.2). There is no such direct transition in GRT. Relativists have to go to the top in the variational principles, change the scalar curvature of space to the usual energy function of Lagrange and pass all this through their inherent mathematical labyrinths, thus making a frank substitution of concepts [5].

Example 2.1. To find an expression for the gravitational radius of the Schwarzschild sphere R_g . This is the radius of a spherical body at which its second cosmic velocity is equal to the speed of light in a vacuum. When an object is compressed into a sphere with a radius equal to or less than the gravitational one, irreversible gravitational collapse occurs - the object turns into a black hole. Gravitational radius is determined by body mass. For the Sun, it is 2.95 km, and for the Earth – 8.86 mm. But the Sun will not shrink to such a radius, since the mass is too small, and the gravitational forces will not be able to overcome the interelectron repulsion forces caused by the Pauli exclusion principle.

The first solution of the GRT equations was obtained by K. Schwarzschild in 1916 for a fixed spherical body, finding the corresponding metric in spherical coordinates (see (5.23) on p. 133), and at the same time the gravitational radius of the gravitating mass M

$$R_g = \frac{2GM}{c^2}. \tag{2.6}$$

The coordinate equation is the usual one

$$\frac{dx}{dt} = -v. \tag{2.26}$$

The range of variables in (2.25), (2.26) is for the speed $v_0 \le v \le c;$: for the coordinate: $x_0 \ge x \ge 0$, where v_0, x_0 are the initial conditions. An electric field can accelerate a charged particle, attracting or repelling it, and it can decelerate if it moves by inertia against the forces of the field, which is represented by the signs "-", "+" (approach-distance).

Example 2.3. We simulate the electromechanical process of free attraction of an electron in a non-uniform electric field of a charged sphere with a radius r_e and a positive charge Q ; we will consider the electron to be a point. Recall that an electron is a material particle with a negative electric charge, the value of which is $e = -1{,}6 \cdot 10^{-19}$ C. The mass of an electron is $m = 9{,}1 \cdot 10^{-31}$ kg. The rest of the parameters:

$$Q = +3.16 \cdot 10^{-4}\ \mathrm{C};\ r_g = 0.10\,\mathrm{m};\ k = 8.99 \cdot 10^9\ \mathrm{N\,m^2\,C^{-2}};\ c = 2{,}99 \cdot 10^8\ \mathrm{ms^{-1}}.$$

Initial conditions: $v_0 = 0;\ x_0 = 10\ \mathrm{m}.$

Simulation results. The results of the simultaneous integration of differential equations (2.25), and (2.26) with the above values of coefficients and initial conditions are shown in fig. 2.4 and fig. 2.5. In order to qualitatively and quantitatively assess the manifestation of the relativistic effect on the dynamics of electron motion in a non-uniform electric field, duplicating time functions obtained according to the classical Coulomb law (1.1) are presented.

Based on the analysis of the obtained results of the computer simulation, it is possible to quantitatively evaluate the conclusion of classical electronics that "in the usual electrovacuum devices, the speed of electrons does not exceed $0.1c$, therefore the mass of the electron can be considered constant." If you are critical of these words, then it is worth quoting [7]: "Physical modeling disproves the myth of mass growth. The conditions of the interaction of the masses themselves, including the distance between them, change." We fully share the correctness of what was said, which is convincingly proved by the expression (2.19). Because here you cannot drive the relativistic coefficient (which is in brackets) into the charge of a moving body, as SRT specialists do with a moving mass. Because the fundamental law of conservation of charge stands in the way here!

Analysis of digital data fig. 2.4. showed that at a speed of 0.1 s in this problem we have a speed difference of 4600 km/s, which is a relative error of 16%. Such a striking error can only be attributed to the specific irregularity of the electric field.

2.5. The Lorentz force of the vortex electric field

The Lorentz force of the vortex electric field

The main use of the Lorentz force (its special case – the Ampere force) is in electric machines. It is also widely used in electronic devices for influencing charged particles (electrons, ions), for example in electron beam tubes, as well as

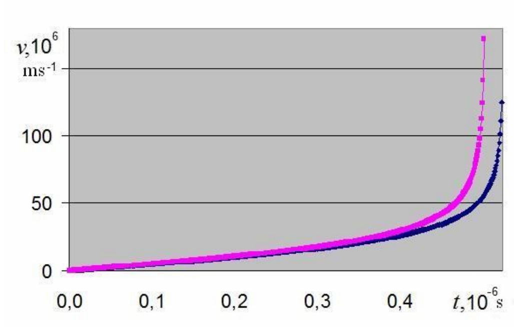


Fig. 2.4. Time dependence of speed $v = v(t)$. The abscissa shows time in microseconds, and the ordinate shows speed in thousands of kilometers. The upper curve is the result obtained according to the classical Coulomb law (1.1), the lower curve is according to the adapted law of moving arms (2.20).

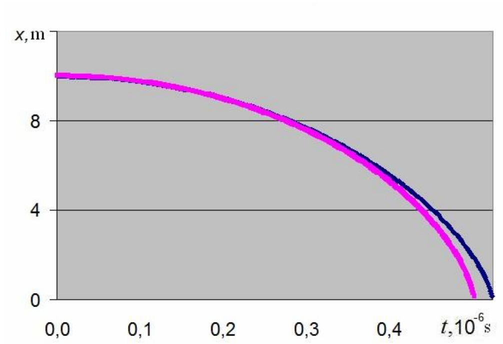


Fig. 2.5. Time dependence of the motion trajectory $x = x(t)$. The abscissa shows the time in microseconds, and the ordinate shows the distance traveled in meters. The lower curve is the result obtained according to the classical Coulomb law (1.1), the upper curve is according to the adapted law of moving arms (2.20)

in mass spectrometry, and MHD-generators. In charged particle accelerators, it sets the orbit along which these particles move. The Lorentz force is successfully used in the non-contact measurement of the speed of movement of a conducting fluid. When molten metal or conductive liquid moves through a magnetic field, eddy currents appear inside the liquid, the interaction of which with the resulting field leads to the appearance of the Lorentz force, which, in turn, depends on the electrical conductivity and speed of the liquid. Recently, the Lorentz force has found an interesting application in electrodynamic mass accelerators (railmotors), as a promising weapon – electromagnetic guns (railguns). The use of gunpowder for the shooting has reached its limit – the speed of a gun fired with their help is limited to 2,5 kms^{-1}. У той час як сучасна електромаґнетна гармата розганяє струмопровідний снаряд до 7,2 kms^{-1}. The defeat of the target is equated to a nuclear one. But there is a bright side to this story – the possibility of using new weapons in the future fight against asteroids threatening our planet.

In most cases, the electromagnetic field is heterogeneous and very complex in structure. Therefore, the dynamics of the movement of charged bodies in such a field is a complex problem of theoretical electric engineering.

The expression of the Lorentz force in vector form is well-known (1.10)

$$\mathbf{F} = q_2(\mathbf{E}_q + \mathbf{v} \times \mathbf{B}_q), \tag{2.27}$$

where $\mathbf{F}$ is the force vector; where $\mathbf{B}_q$ is the magnetic induction vector; $\mathbf{E}_q$ is the electric field intensity vector by definition:

$$\mathbf{E}_q = k_q \frac{q_1}{r^2} \mathbf{r}_0. \tag{2.28}$$

How SRT operates with the Lorentz force can be judged from [32]. They write down the expression for the Coulomb force of a point charge Q relative to a frame of reference K' moving in a vacuum with a speed $\mathbf{u}$ relative to a system K in which the charge Q is at rest and the charge q moves with a speed $\mathbf{v}$ relative to it (Q). If you enter a designation

$$\mathbf{E} = \frac{Q\gamma\mathbf{r}}{\left(r^2 + \gamma^2 \frac{(\mathbf{r} \cdot \mathbf{u})^2}{c^2}\right)^{\frac{3}{2}}}; \quad \mathbf{B} = \frac{1}{c}[\mathbf{u} \times \mathbf{E}]; \tag{2.29}$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{u^2}{c^2}}}, \tag{2.30}$$

then formula (2.27) takes the form

$$\mathbf{F} = q\left(E\mathbf{r} + \frac{1}{c^2}\left(\mathbf{v}\times E\gamma\left[\mathbf{u}\times\mathbf{r}\right]\right)\right) = q\mathbf{E} + \frac{q}{c}\left[\mathbf{v}\times\mathbf{B}\right]. \tag{2.31}$$

From this, it is obvious that the magnetic field is a relativistic effect associated with the delay in the displacement of the electric field (due to the finiteness of the propagation speed of the interaction) when its source moves with speed $\mathbf{u}$, or, purely kinematically, through the transformation of the expression of the interaction force when moving from one inertial system countdown to another. In the case when the charge creating the field is at rest, the expression for the Lorentz force turns into Coulomb's law (1.4).

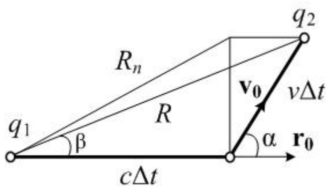


Fig. 2. 6. Geometrization of the time delay of the field interaction

Similar results can be arrived at by bypassing SRT in physical space and time [25, 43], without tying oneself to inertial or non-inertial frames of reference. What will be shown below is also shown by us, but it is much simpler and more generalized.

But let's go back to the Lorentz force. To do this, we will also express the time interval Δt according to the same geometric constructions of fig. 2.1, and at the same time its duplicates fig. 2.6, but somewhat differently

$$\Delta t = R_n / \sqrt{c^2 + v_n^2}; \quad v_n = v\sin\alpha, \tag{2.32}$$

where v_n is the normal component of the velocity (Fig. 2.6).
Then the real distance (2.2) of interaction will be

$$r = c\Delta t = \frac{R_n}{\sqrt{1 + \frac{v_n^2}{c^2}}}. \tag{2.33}$$

Now, based on (2.32), (2.33), formula (2.19) can be written in the form

$$\mathbf{F} = q_2\left(E + v_n\frac{k_q q_1 v_n}{R_n^2 c^2}\right)\mathbf{r}_0; \tag{2.34}$$

moreover, the modulus of the electric field intensity vector is written according to the definition (1.5)

$$E = k\frac{q_1}{R_n^2}. \tag{2.35}$$

Next, we will use the Biot-Savar law in the form (1.15), moreover

$$c = \sqrt{\frac{\nu_0}{\varepsilon_0}}, \tag{2.36}$$

where υ_0 is the magnetic reluctance

$$\nu_0 = \varepsilon_0 c^2 = 7.957749 \cdot 10^5 \text{ m/H}.$$

If we take into account (1.15), (2.32), (2.33), (2.35), the expression (2.34) coincides identically with the expression of the Lorentz force (2.27), which should have been shown!

By the way, formula (2.21) can be obtained using the methods of classical electricity. To do this, it is enough to substitute (1.15) into (2.27), as a result of which we get

$$\mathbf{F} = q_2(\mathbf{E}_q + \frac{1}{c^2}(\mathbf{v} \times (\mathbf{v} \times \mathbf{E}_q)). \tag{2.37}$$

Having performed the double vector product in (2.37) under the conditions (2.35) and $\mathbf{r}_0 \cdot \mathbf{v}_0 = 0$, we uniquely arrive at (2.21). It is easiest to illustrate what has been said in cylindrical coordinates, when $\mathbf{E} = -\mathbf{r}_0 E;\ \mathbf{v} = \boldsymbol{\alpha}_0 v$:

$$\mathbf{F} = q_2(-\mathbf{r}_0 E + \frac{1}{c^2}(\boldsymbol{\alpha}_0 v \times (\boldsymbol{\alpha}_0 v \times (-\mathbf{r}_0 E))) = q_2 E\left(1 + \frac{v^2}{c^2}\right)\mathbf{r}_0. \tag{2.38}$$

Formulas (1.1), (2.21), (2.37) comprehensively reveal the physical essence of the first two terms of the speed coefficient (2.19) out of three. The first of them is mainly responsible for the Coulomb force, and the second - for the Lorentz force caused by the transverse component of the speed of motion of the charged body in the electric field. As will be shown in the next paragraph, the third term is involved in the longitudinal component of the speed of movement. This is self-explanatory, because the intensity of the electric field, and the value of the speed of movement are clearly not enough to determine the force as a vector, for this, the spatial orientation of the involved quantities is also required. It is not the speed that is responsible for this orientation, but the speed vector, or in a specific coordinate system, its projections.

Thus, the relativistic effect of motion in electricity is successfully encoded in the magnetic field as the relativistic effect of the electric field. The creators of magnetism knew about this [15], but over time this truth was kindly forgotten by electricians. But relativists, judging by the expression (2.31) and the comment to it, remember and creatively operate on this truth. This is important for us because we came to the same understanding of the physical process with an unconventional approach.

We will return to the expression of the Lorentz force (2.27), but from a different point of view - from the standpoint of the theory of gravitation.

2.6. Protoformula of movement

The visual similarity of laws (2.3) and (2.19) is not accidental, behind it lies a deep physical meaning. It will become the leading idea throughout the next chapter, which will deal with the unified theory of electricity and gravitation. Based on the formal similarity of laws (2.3), and (2.19), we will write them both in a general unified form

$$\mathbf{F} = k_\xi \frac{\xi_1 \xi_2}{r^2}\left(1 + \frac{v^2}{c^2} + 2\frac{v}{c}\mathbf{v}_0 \cdot \mathbf{r}_0\right)\mathbf{r}_0, \quad \xi = q, m, \tag{2.39}$$

where $\mathbf{F}$ is the force vector of the interaction of two point bodies ξ_1 and ξ_2; r is the instantaneous distance between them; k_ξ is constant-coefficient; $\mathbf{r}_0$ is a unit radius vector. Moreover, $\xi = m$ (in the case of gravitational interaction) and $\xi = q$ (in the case of electrical interaction), where is the mechanical mass; q is electric mass (charge).

The required orientation of space and velocity vectors is found from the corresponding coordinate equations of mechanical motion! Next, we will show that formula (2.39), as a triune symbiosis of Newton's, Coulomb's laws, and our All-Encompassing motion (Panta rhei), describes the motion of the entire unique material world. On its basis, it is possible to unify all known laws of mechanics based on the laws of electricity. Not only that, this miracle formula is filled to the brim with deep philosophical content.

Along with the proto formula (2.39), we also unify its separate cases both from the mechanics' side (2.4), (2.5) and from the electricity side (2.20), (2.21).

Individual cases. 1. *The direct trajectory of movement passes through interacting point bodies (longitudinal interaction).* Then $\mathbf{r}_0 \cdot \mathbf{v}_0 = 1$ when the masses move away and $\mathbf{r}_0 \cdot \mathbf{v}_0 = -1$ when get closer. Under such conditions (2.39) is simplified

$$\mathbf{F} = k_\xi \frac{\xi_1 \xi_2}{r^2} \left(1 \pm \frac{v}{c}\right)^2 \mathbf{r}_0, \quad \xi = q, m, \tag{2.40}$$

moreover, the "+" sign indicates that the bodies are moving away, and the "-" sign, on the contrary, indicates their convergence.

2. *A moving body moves across the force action (transverse interaction)*. In this case $\mathbf{r}_0 \cdot \mathbf{v}_0 = 0$. Then (2.39) takes a different form

$$\mathbf{F} = k_\xi \frac{\xi_1 \xi_2}{r^2} \left(1 + \frac{v^2}{c^2}\right) \mathbf{r}_0, \quad \xi = q, m, \tag{2.41}$$

3. *Immovable bodies*. Under the condition $v = 0$, expressions (2.39)-(2.41) degenerate to the original laws (1.1) and (1.2), which, like (2.39), can be written in a unified form

$$\mathbf{F}_N = k_\xi \frac{\xi_1 \xi_2}{r^2} \mathbf{r}_0, \quad \xi = q, m. \tag{2.42}$$

There is no such direct transition in GRT. They have to go to the top in the variational principles, change the scalar curvature of space to the usual energy function of Lagrange and pass all this through the mathematical labyrinths inherent in them, thereby making a frank substitution of concepts.

Since the effect of motion in electricity is successfully encoded in the magnetic field, now there is nothing to prevent us from introducing a formula similar to (2.27) in the gravitational field based on the universal formula (2.39) using the same algorithm

$$\mathbf{F} = m_2 (\mathbf{E}_m + \mathbf{v} \times \mathbf{B}_m). \tag{2.43}$$

Here and in what follows, the index m indicates involvement in electrical and mechanical quantities of the same name.

Mathematical substantiation of formula (2.43) from the point of view of mechanics will be done a little later after obtaining the necessary theoretical material.

From the daily record.

11.06.2020. Zahoriv. 400. Miracle morning. Before the eyes of the dawn glow and the crescent moon overhead appeared a village drowned in a thick fog with a barely visible grove to the musical accompaniment of a water bull, from whose efforts the pond moaned, and jackdaws cried. I looked at this never-before-seen beauty and wondered: because my proto-formula, as a triune symbiosis of the laws of Newton (1687), Coulomb (1785), and my All-encompassing motion (2020) given by Heraclitus of Ephesus (535-475 BC), arises from the description of the movement of this entire non-repetitive material world. I dedicate the proto formula to my beautiful daughter Lyubov, who turned 11 the day before. In the morning, I fell asleep for an hour in order to meet Stepan Bandera in a dream, who apparently wanted to support my (in his words) "national competition in the plane of spirituality and culture" with his own aphorism: "nothing will stop an idea whose time has come".

2.7. Differential equations of motion

To make it more convenient to operate with new physical concepts, let's write the force vector (2.3) component by component. The first component, and it is the main one, embodies almost the most secret properties of the world structure – these are the laws of force interaction of immovable physical masses concerning to each other, mechanical and electrical. As a logical disclosure of the essence of (2.39), it is previously written as (2.42). The rest of the components will be recorded similarly

$$\mathbf{F}_L = k_\xi \frac{\xi_1 \xi_2}{r^2} \frac{v^2}{c^2} \mathbf{r}_0, \quad \xi = q, m; \tag{2.44}$$

$$\mathbf{F}_T = \left(2k_\xi \frac{\xi_1 \xi_2}{r^2} \frac{v}{c} \mathbf{v}_0 \cdot \mathbf{r}_0 \right) \mathbf{r}_0, \quad \xi = q, m. \tag{2.45}$$

Let's introduce the concept of longitudinal and transverse projections of movement speed

$$v_\rho = v \cos\alpha; \qquad v_n = v \sin\alpha. \tag{2.46}$$

According to (2.33), the second of them is used in (2.44), and the first as a scalar product of unit vectors is used in (2.45). If we now accept in (2.46) $\alpha = 0, \pi$, then we come to (2.40), and if $\alpha = \pi / 2$, then to (2.41).

Thus, *the force component (2.44) at the transverse speed of movement represents the magnetic force in the electric field, and when it is extended to the gravitational field, it represents the so-called gravitomagnetic force. The appearance of the multiplier v^2 / c^2 in (2.44) corresponds to the observations, which in the classical formulation sound like: "magnetic interaction time weaker v^2 / c^2 than electric interaction"!*

The force component (2.45) at the longitudinal speed of movement represents a new radial force component that closes the trinity of the force vector acting on moving bodies in electric and gravitational fields.

At angles that are not multiples of $\pi/2, \pi$, expressions (2.44) and (2.45) are simultaneously and inseparably responsible for the longitudinal and transverse components of the single velocity vector $\mathbf{v}$.

In practical analysis, there is no need to divide the single force vector (2.39) into components. Our division is made only in order to get closer to the understanding of the physical essence of the phenomena caused by motion. On the contrary, it should be viewed holistically, drawn in one or another coordinate system.

Let's write down the obvious equations of moving mass in the classical notation of Newton's second law

$$\mathbf{F} = m\frac{d\mathbf{v}}{dt}; \qquad \frac{d\mathbf{r}}{dt} = \mathbf{v}. \tag{2.47}$$

We will remind that in our theoretical developments $m \neq m(v)$. The dependence on speed concerns only the interaction of masses. This was discussed earlier.

We write the balance of forces (2.39), (2.47) in coordinate terms

$$\begin{aligned}
&\frac{dv_x}{dt} = -k_\xi \frac{\xi_1 \xi_2 r_x}{mr^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y + r_z v_z}{cr}\right); \quad \frac{dr_x}{dt} = v_x;\\
&\frac{dv_y}{dt} = -k_\xi \frac{\xi_1 \xi_2 r_y}{mr^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y + r_z v_z}{cr}\right); \quad \frac{dr_y}{dt} = v_y; \ \xi = q, m,\\
&\frac{dv_z}{dt} = -k_\xi \frac{\xi_1 \xi_2 r_z}{mr^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y + r_z v_z}{cr}\right); \quad \frac{dr_z}{dt} = v_z;\\
&\qquad r = \sqrt{r_x^2 + r_y^2 + r_z^2}; \qquad v = \sqrt{v_x^2 + v_y^2 + v_z^2},
\end{aligned} \tag{2.48}$$

where *r, v* are the modules of the radius vector r and the velocity vector **v**.

Expressions (2.48) form a complete system of algebraic-differential equations for the analysis of transient processes in electric and gravitational fields in 3D Euclidean space and physical time. The uniqueness of the solution is provided by the initial conditions: $r_x(0),\ r_y(0),\ r_z(0), v_x(0), v_y(0), v_z(0)$.

Next, we will provide computer support for the theoretical results (2.48).

2.8. The equation of motion of celestial bodies.

The analysis of transient processes in gravitational and electric fields will be carried out based on the numerical integration of differential equations (2.48).

According to our concept of the unity of the cosmos, we will consider a number of transitional, and sometimes steady-state, processes at all three levels: mega-, macro-, and microcosm. Since singularities will come to light in our research, we will proceed from simpler, recognized ones to more complex, newly discovered ones. And this prompts us to start with the mega world.

The equation of motion of celestial bodies in the gravitational field is obtained directly from (2.48) under the condition $\xi = m$

$$\frac{dv_x}{dt} = -\frac{GMr_x}{r^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y + r_z v_z}{cr}\right); \quad \frac{dr_x}{dt} = v_x;$$
$$\frac{dv_y}{dt} = -\frac{GMr_y}{r^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y + r_z v_z}{cr}\right); \quad \frac{dr_y}{dt} = v_y;$$
$$\frac{dv_z}{dt} = -\frac{GMr_z}{r^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y + r_z v_z}{cr}\right); \quad \frac{dr_z}{dt} = v_z; \qquad (2.49)$$
$$r = \sqrt{r_x^2 + r_y^2 + r_z^2}; \qquad v = \sqrt{v_x^2 + v_y^2 + v_z^2}.$$

Thus, the time course of the transient process is determined only by the values of the gravitational mass *M*, the gravitational constant *G*, and the initial spatial and velocity conditions. And the fact that the gravitational mass does not appear in equations (2.49) fits perfectly into the principle of equivalence in favor of the properties of the space filled with the gravitational field.

2.8.1. Black trap.

We simulate one of the wonders of celestial mechanics - the capture of a celestial body by a black hole at sublight speed. To simplify the problem, let's model in 2D space in the cross-sectional plane of the centers of the gravitating M and gravitating m masses in the Cartesian coordinate system x, y. Under such conditions, algebraic differential equations (2.49) are simplified [25,26]

$$\frac{dv_k}{dt} = -\frac{GM\,r_k}{r^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y}{rc}\right); \quad \frac{dr_k}{dt} = v_k;$$
$$k = x, y; \quad r = \sqrt{r_x^2 + r_y^2}; \quad v = \sqrt{v_x^2 + v_y^2}. \qquad (2.50)$$

As we can see, the transient process is defined by the values of the gravitational mass, the gravitational constant, and the initial spatial and velocity conditions $r_x(0), r_y(0), v_x(0), v_y(0)$. And the fact that the gravitational mass does not appear in equations (2.49), as was said before, really fits into the principle of equivalence in favor of the properties of the space filled with the gravitational field.

In order to show the real threshold of the possibilities of Newton's celestial mechanics, below we present an example of the simulation of two variants of capture by a black hole of a moving celestial body at pre- and relativistic velocities.

Example 2.4. *The case of relativistic speed (megaworld)*. As an object of research, we will use the same black hole – collapsar GROJ 0422, with the mass $M = 4M_{\odot}$ from example 2.2, which is on p. 27, with the calculation parameters: $GM = 53{,}1 \cdot 10^{19}\,\mathrm{m^3 s^{-2}}$. We significantly reduce the conditional zone of gravitational capture not so much in order to reduce monotonous computational operations as to enhance the expressiveness of the graphical support of the simulation results: $r_x(0) = -10000\,\mathrm{km}$; $r_y(0) = 100\,\mathrm{km}$. We set the initial speed conditions in two ways – for the conditional limit of pre relativistic velocities (if in fact, it is significantly overestimated for of the possibilities of Newton's celestial mechanics): $v_x(0) = 0{,}1c$; $v_y(0) = 0$; for relativistic velocities: $v_x(0) = 0{,}3\,c$; $v_y(0) = 0$.

The results of the simultaneous integration of the nonlinear differential equations of gravity (2.50) are shown in fig. 2.7 – fig. 2.13. Illustrative material is selected in such a way as to show interesting possible courses of the real cosmic transition process.

The first four illustrations (fig. 2.7– fig. 2.10) present the transient process of pure capture by the gravitational mass (under the Schwarzschild sphere) of a flying celestial body at sublight speed. In fig. Figure 2.8 shows the case when the gravitating mass managed to escape from the tight embrace of the black hole at the cost of distorting its free-flight trajectory. This is one of the possible scenarios of the physical process. But given the given initial conditions, he pursues another goal – to show the inability of Newton's celestial mechanics to adequately describe the real process at sublight speeds. The last three illustrations (fig. 2.11 – fig. 2.13) show how this transitional process actually proceeds.

One cannot help but be enchanted by the rational beauty of the course time trajectory of the figures. 2.11. We became the first witnesses mathematically described in real space and time of celestial harmony of the process of capture at sublight speeds into one of its own stationary satellite orbits by one celestial body of another. According to the analysis of digital simulation data: the radius of the orbit $R = 145{,}33\,\mathrm{km}$ (eccentricity of the orbit $e = 0{,}000231$); frequency rotation period $T = 0,0114794\,\text{s};$, normal and cyclic: $f = 67,60\ \text{s}^{-1}$; $\omega = 2\pi f =$ $= 424,71\ \text{s}^{-1}$; linear velocity $v = 61707\,\text{km}\,\text{s}^{-1}$. It is interesting that during the transitional process the gravitated celestial body extinguished the linear velocity from 0.30 s to 0.21 s (fig. 2.13).

Let's compare at least one characteristic of the obtained steady-state process with the classical Newtonian process (this is permissible in a circular orbit!). Let it be the first cosmic cyclic frequency without taking into account the gravitomagnetic

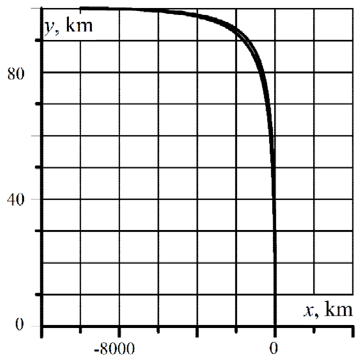


Fig. 2.7. The trajectory of capture of the celestial body $r_y = r_y(r_x)$ under the initial conditions $v(0) = 0,1c$. The upper curve is obtained according to (2.4), the lower one – according to (1.2).

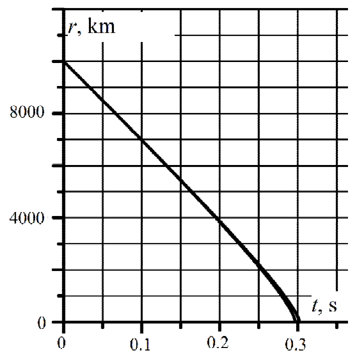


Fig. 2.8. Time dependence of the distance between gravitating celestial bodies $r = r(t)$, in the transitional process corresponding to fig. 2.7 The upper curve is obtained according to (2.4), the lower one - according to (1.2).

action ω_1 it is taken into account ω_2. Then, from the balance of the centrifugal force ($m\omega^2 R$) and the corresponding forces (1.2) and (2.5) in a stationary orbit, we obtain

$$\omega_1 = \sqrt{\frac{GM}{R^3}} = 415.96; \quad \omega_2 = \frac{c}{R}\sqrt{\frac{GM}{Rc^2 - GM}} = 424.69. \qquad (2.51)$$

As you can see, in comparison with the simulation result (424.71 s^{-1}), the purely Newtonian result ω_1 is underestimated by 2.1%, and taking into account

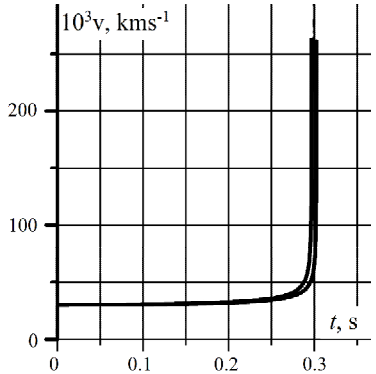


Fig. 2.9. The falling speed of a gravitated celestial body $v = v(t)$, in the transient process corresponding

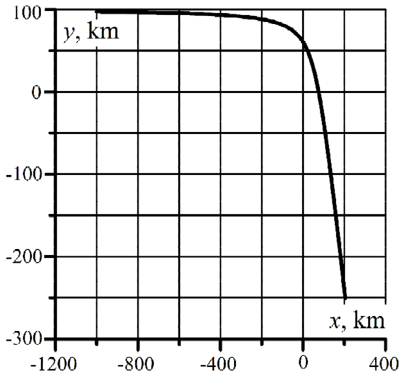


Fig. 2.10. Curvature of the trajectory of a gravitating celestial body $r_y = r_y(r_x)$ under initial conditions $v(0) = 0{,}3c$. The curve is obtained according to (1.2).

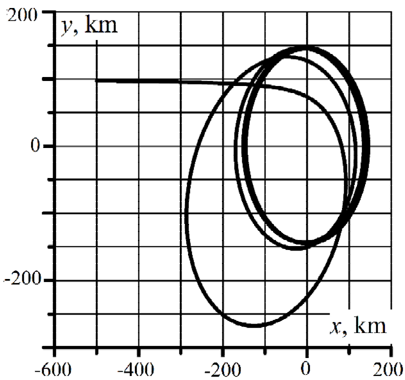


Fig. 2.11. Trajectory of gravitational capture of a celestial body $r_y = r_y(r_x)$ to a stationary collapsor orbit under initial conditions $v(0) = 0{,}3c$.. The curve is obtained according to (2.4).

the vortex effects of the motion ω_2 – by only 0.0047%. Therefore, the simulation results fully correspond to the physics of the process.

One can only wonder how, from the first time, randomly selected four initial conditions – coordinates and speeds of movement – were lucky enough to arrive at such an unexpected exotic transitional process! It is something like the selection of world constants according to the anthropic principle, which provoked our biological life. Here, it is as if the starry Sky itself rewarded the author for the immoderately difficult brain work in its distant boundless starry spaces. Be that as it may, but from now on, for me, the rational miracle beauty of the celestial star GRO J0422 is not inferior to the irrational miracle beauty of Volyn, on whose bright land the mathematical model of such a black miracle trap was born.

2.8.2. Precession of elliptical orbits.

Our studies convincingly showed that the mechanical movement of elliptical orbits in the field of electric and mechanical attraction in the mega-, macro-, and micro-world is accompanied by the inevitable precession of the trajectory in the direction of rotation. So, in our current time, in heliocentric coordinates, the precession of the orbit of the solar planet Mercury is measured $(574{,}1 \pm 0{,}65)''$ in arcs per Earth century.

U. Le Verrier falsely explained the phenomenon of the precession of the planet solely by the influence of the rest of the planets of the solar system. His

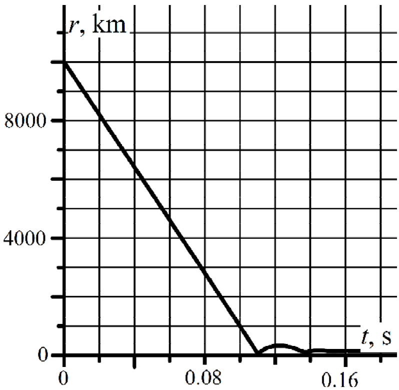


Fig. 2.12. Time dependence of the distance between gravitating celestial bodies $r = r(t)$, in the transition process corresponding to fig. 2.11.

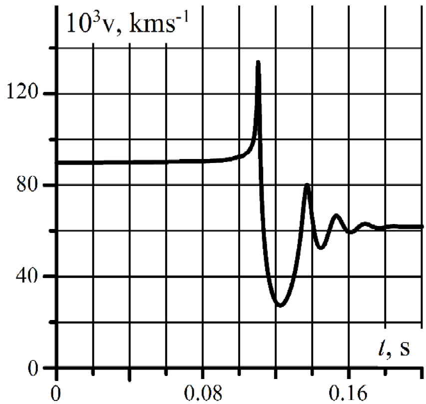


Fig. 2.13. The time dependence of the speed of descent into orbit of a gravitating non-free body $v = v(t)$ in the transition process corresponding to fig. 2.11.

result is 526.7" of arc. And the fact that he discovered the planet Neptune in the predicted place in 1846 caused such confidence in his result that no one dares to question it until now. All subsequent theories, instead of looking for the physical essence of the phenomenon, were engaged in substantiation of those 43" of arc, which was lacking in Leverier's results up to the 570" of arc known at that time from observations. According to modern, refined data, this difference is somewhat larger and amounts to about $(47{,}3 \pm 0{,}65)''$ an arc arcs per Earth century. In order to justify the scarce 43" arcs of that time, mainly two types of attempts were made:

– to explain precession by the influence of some unknown matter located near the Sun;

– to improve the Newtonian theory of gravity, or to offer an alternative to it.

But the actual cause of the phenomenon has not yet been established.

Attempts to improve Newton's law of universal gravitation began at the end of the 19th century. Models without dependence and with dependence on the speed of movement were offered. But all of them were built around the fundamental laws of nature. Let us dwell, for example, on four typical ones given in [39].

Models without dependence on speed. 1. S. Newcomb saw the improvement of Newton's law as early as 1895

$$F = G\frac{mM}{R^{2+\delta}}, \tag{2.52}$$

where F is the gravitational force of masses m, M; R is the distance between the centers of mass; G is gravitational constant; δ is a correction factor. Precession of the perihelion $\delta\varphi$ by one revolution in (1) is equal to

$$\delta\varphi = \frac{2\pi}{R^{2+\delta}} = 2\pi\left(1+\frac{\delta}{2}\right). \tag{2.53}$$

2. Soon H. Seeliger and K. Neumann proposed another modification of the law of universal gravitation with an exponential correction of the gravitational interaction.

$$F = G\frac{mM}{R^2}e^{-\lambda R}, \tag{2.54}$$

In it, an additional factor provides a decrease in gravity with a distance faster than Newton's.

Speed-dependent models. 1. P. Gerber in 1898 proposed a formula for the gravitational potential

$$V = \frac{4\pi^2 A^3}{RT^2\left(1-\frac{1}{c}\frac{dR}{dt}\right)^2}, \tag{2.55}$$

where T is the rotation period; A is the semimajor axis of the orbital ellipse; c is the speed of light in a vacuum.

2. In 1915, A. Einstein successfully calculated this deviation and obtained an

almost exact match with the 43" of arc per Earth century observed at that time

$$\delta\varphi = \frac{24\pi^3 A^2}{c^2 T^2 \left(1-\varepsilon^2\right)}, \tag{2.56}$$

where ε is the eccentricity of the ellipse of the trajectory of the movement. For Mercury, this formula gives 42.98" per century.

From this brief review, one can conclude that all these recommendations are obtained as a result of the approximation of the real trajectory of a specific planet in a specific quasi-stationary orbit, and in addition, for closed orbits. We can name two objective reasons for the then failures in explaining the precession of the studied elliptical orbits:

1. The lack of computer technology made it impossible not only to solve non-linear differential equations of motion, but even to set such problems;

2. Mathematical methods of electricity and mechanics of moving bodies in a space-time form do not apply to the analysis of chaotic motion in the force field of electric and gravitational fields.

Successful mathematical modeling of the transitional precession of the perihelion of cosmic planets is possible only based on celestial mechanics equations (2.49), which involve the adapted Newton's law for the case of moving masses (2.3). We focus on its three components (2.42), (2.44), and (2.45). The marginal fate participation in the force interaction of components (2.44) and (2.45), based on the speed and orientation characteristics, is obvious

$$\mathbf{F}_L = (0 \div 1)\mathbf{F}_N; \qquad \mathbf{F}_T = ((-2) \div (+2))\mathbf{F}_N. \tag{2.57}$$

The force component (2.44) is determined by the transverse component of the velocity, so it practically does not affect the precession of the orbits. The component (2.45) is responsible for it. Its dependence on the speed of movement is higher than in (2.44), because under the condition $v \le c$ the multiplier v / c in (2.44) is raised to the second power, and in (2.45) to the first. This will be confirmed by the results of the computer simulation presented below.

Example 2.5. The case of prelight speed (mega world). Let us explain the physical essence of the precession of elliptical planetary orbits. We will use the trajectory of Mercury around the Sun as an object of study. We will solve the problem in 2D space.

The results of integration (2.50) are shown in Fig. 2.14 – 2.17 at constant parameters $GM = 13,27128 \cdot 10^{19}$ m^{3}s^{-2} corresponding to the Sun. In fig. 2.14 shows the time dependence of the spatial radius hodograph under the initial conditions:

$$v_x(0) = 59000;\ v_y(0) = 0;\ r_x(0) = 0;\ r_y(0) = 0,46 \cdot 10^{11}.$$

The temporal dependence of the spatial radius itself, is shown in fig. 2.15. She testifies that the transitional process continues and is far from an established meaning.

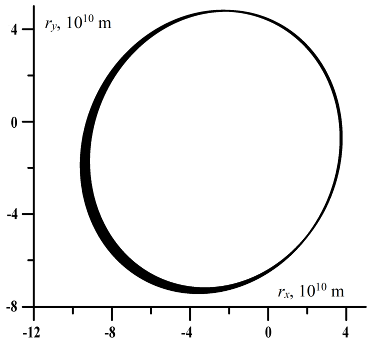


Fig. 2.14. Hodograph of the distance of a gravitating planet near of the trajectory of Mercury under initial conditions:

$$v_x(0) = 59000;\ v_y(0) = 0;$$
$$r_x(0) = 0;\ r_y(0) = 0,46 \cdot 10^{11}.$$

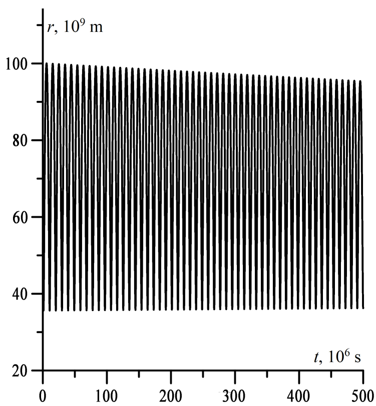


Fig. 2.15. The time dependence of the radius $r(t)$ of the gravitating planet in the transient process is shown in fig. 2.14

For comparison, fig. 2.16 shows the same transient process, under the same initial conditions, within the same time limits as in fig. 2.14, but calculated according to classical equations with the participation of only one force component, namely Newton (2.44). From the comparison of the results, we can see that both processes differ not only quantitatively, but also qualitatively. If the first of them is transient, then the second is steady-state, because there is no radial force component that would correct the orbit, including its precession!

Based on the real graphic and time resolution capabilities, to judge the course of the transient process of fig. 2.14, which is close to actual existing conditions, is not appropriate. Therefore, in fig. 2.17 shows the transitional process in which the mass planet several times had been nearer to the mass of the Sun many times. Now one can clearly see not only the precession of the perihelion in the direction of the planet's rotationbut also the gradual convergence of the planet with the star (disruption of the orbit).

Although, according to the curve of fig. 2.15, the transitional process continues, we are still lucky enough to come close enough to the observed results on the real planet. According to the analysis of the digital data of the last turn from fig. 2.14 we have (observation results in parentheses): eccentricity 0.2024 (0.2056), the maximum distance between the centers of gravitating masses 69.59.109 (69.82.109) m, the minimum distance between the centers of gravitating masses 46,15.109 (46.00.109) m, maximum orbital velocity 58805 ms^{-1}, minimum orbital velocity 38999 ms^{-1} average linear velocity $v = 48902$ (47360) ms^{-1}. Still, this is not enough to judge the quantitative characteristics of the precession of a real object. Because we are talking about a fragmentary state of a transitional process frozen in time, and we need a steady-state process. And this is connected with the finding of initial conditions that exclude a transient reaction. But in order to use mathematical methods to find them, the condition of closedness is imposed on the fixed orbit. And in fact, according to the indications of fig. 2.17, it is not.

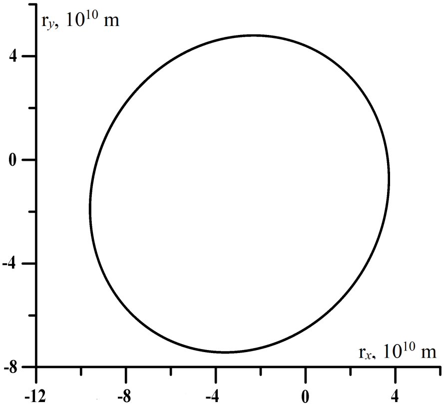


Fig. 2.16. The hodograph of the distance of the gravitating planet, corresponds to the transient process of fig. 2.14, but calcu-lated according to Newton's law of gravity (2.43)

A careful analysis of the hyperbolized transient process based on digital data of computer simulation is summarized in a table, which presents the limit values of the distance of the planet from the center of the Sun and the limit orbital speeds of the elliptical orbit.

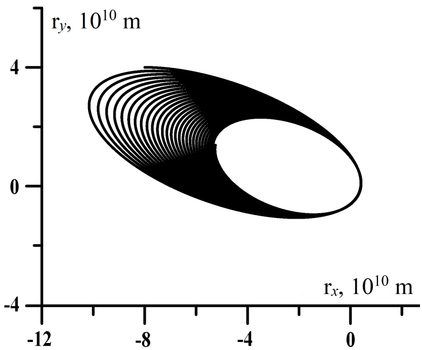


Fig. 2.17. Hodograph of a gravitational planett he distances several times closer to the Sun under initial conditions::

$$r_x(0) = -0{,}8 \cdot 10^{11};\ r_y(0) = 0{,}4 \cdot 10^{11}.$$

$$v_x(0) = 25000;\ v_y(0) = 0;$$

The first four rows of the table are obtained from the last turns of the planet with the physical time of the process in the time interval 0-80 megaseconds. The data of the fifth line correspond to the data of the first one for the time of integration 1.5 times more. The data of all rows of the table and fig. 2.17 obtained under the same initial conditions! More details:

– the data of the first and fifth

lines are obtained as a result of the integration of the complete equations of state (2.50);

– the data of the second line are obtained in the absence of the third component (2.45), which has a striking effect on the course of the transient precession of the elliptical orbits of the planets;

– the data of the third row are obtained according to Newtonian mechanics (the presences (2.44), (2.45)); we see: the result almost coincides with the previous one;

No	$t_e, 10^6 \cdot s$	$r_{min}, 10^9 \cdot m$	$r_{max}, 10^9 \cdot m$	v_{min}, m	v_{max}, m
1	80	3,989	70,420	14200	251016
2	80	3,903	109,422	9139	256254
3	80	3,903	109,422	9139	256191
4	80	3,989	70,420	14200	251029
5	120	4,049	55,247	18100	247159

– the data of the fourth row are obtained under the condition that only the second term (2.44) is absent, which presents relativistic gravitymagnetic forces. The data of the first and fourth lines almost coincide. This was to be expected, because already in the second half of the 19th century. it was known that relativistic forces barely affect the precession of the perihelion of Mercury's orbit (no more than 6-7" per century). It is interesting to note that as the planet "falls" toward the star, the eccentricity of the quasi-elliptical trajectory

$$\varepsilon = \frac{r_{max} - r_{min}}{r_{max} + r_{min}} \tag{2.58}$$

is decreasing. So, according to the data of the first and fifth lines of the table, it decreased from 0.8947 to 0.8634 in 40 mega seconds.

Thus, according to the analysis of the table, we conclude that the third force (2.45) is responsible for the precession of the perihelion of the elliptical orbits of the planets. It is clear that in the case of a circular orbit, the force (2.45) is identically zero! Therefore, the phenomenon of trajectory precession is impossible in circular orbits.

The force (2.45) closes the triune force of gravity in addition to the two recognized – Newton's, gravitomagnetic (like Lorentz in electricity).

As it was said, the force (2.44) is determined by the tangential component of the velocity, and the force (2.45) by the normal one. Therefore, the equations of classical physics worked successfully only on stationary trajectories, where the normal component of force is known to be absent – on closed ideal circular orbits. This became the main reason, as was said earlier, for which the methods of classical physics were hastily relegated to the backyards of the microcosm. That only harmed the physical-mathematical unity of the universe.

Based on the new differential equations of motion (2.49), we managed to explain the true reason for the precession of the perihelion of elliptical orbits. It mus take place in all physical situations at the level of the mega-, macro-, and microcosm.

And is it possible to obtain the exact result of the precession of the elliptical trajectory of Mercury based on of the differential equations of motion? – You can. But at the same time, it is necessary to know the exact initial space-velocity conditions that Nature laid down during the evolution of the Solar System, or the corresponding initial conditions that exclude a transient reaction (if a steady-state process exists (?). By the way, in the 18th century, a scientific hypothesis appeared that Mercury is a former satellite of Venus. And in 1976, T. Flandern and K. Harrington showed that this hypothesis even somewhat explains the larger deviations in Mercury's orbit. Such conditions can, of course, be selected, but this is too time-consuming work. But the effect itself and its causes are explained for the first time! We were lucky, as it was said above, to reach a state close to the actual conditions (see fig. 2.14), but as a fragmentary state of the transition process, therefore our results of the perihelion precession shift, which is quite logical, turned out to be overestimated. Because, as the analysis shows, as the transition process fades, the eccentricity of the elliptical orbit decreases, and at the same time, the precession of the trajectory, while in the circular orbit, it disappears altogether.

Finally, we can say that the physical essence of the perihelion precession of the planet has been established! As for the precessional quantitative characteristics of the phenomenon based on the differential equations of motion, the complications are only related to the difficulty of finding the initial space-velocity conditions laid down by Nature in the process of the evolution of the star system, or of the difficulty of finding the appropriate initial conditions that exclude the transient reaction. This applies to any differential equations, including GRT equations!

2.9. Electron movement in a vortex electric field

Many scientific publications, for example [4], are devoted to the dynamics of the movement of electrically charged bodies in an electric field, but all of them mostly cover the range of sublight velocities. There is still a misconception that in this range sufficient accuracy is provided by the law of electric Coulomb interaction and transverse magnetic interaction, the so-called Lorentz force. But this, as we will show, is far from reality, because the third component of the electrical force interaction – the radial component – is not taken into account. It is this component that will be discussed in our conversation, about its influence on the dynamics of the motion of charged bodies in an electric field. As for the relativistic velocities of motion of charged bodies, things are much worse here. Because this range of velocities is not at all compatible with the classical physics of real space and time.

Our goal is to return to the time of Charles Auguste Coulomb with his law of force interaction of charged bodies and start moving in a different direction. One wonders, why so far back? And because another component of this force later became an obstacle – magnetic interaction, the so-called Lorentz force. As it was shown earlier, this power is quite fair. But it was she who overshadowed the third component of electrical interaction. This study is devoted to this component and its significance. But this does not mean that we are the first to set such a goal. For example, work [6] can be mentioned, but it also did not exceed the Lorentz force.

We will perform the analysis based on of differential equations of motion (2.50) in 2D space. In Cartesian coordinates, provided they take the form

$$\frac{dv_x}{dt} = -\frac{kqQ\,r_x}{mr^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y}{cr}\right); \quad \frac{dr_x}{dt} = v_x;$$
$$\frac{dv_y}{dt} = -\frac{kqQ\,r_y}{mr^3}\left(1+\frac{v^2}{c^2}+2\frac{r_x v_x + r_y v_y}{cr}\right); \quad \frac{dr_y}{dt} = v_y; \qquad (2.59)$$
$$r = \sqrt{r_x^2 + r_y^2}; \qquad v = \sqrt{v_x^2 + v_y^2},$$

where Q is the charge generating the field; q, m are charge and mass of the moving body.

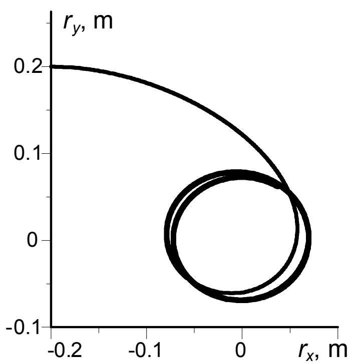


Fig. 2.18. Time dependence of the electron motion trajectory $r = r(t)$.

Expression (2.59) is the differential equations of motion of one electrically charged body in the field of another charged body. The unambiguity of their solution is provided by the initial conditions $v_x(0), v_y(0)$, $r_x(0), r_y(0)$.. The real course of the transition process is too sensitive to these conditions!

Exemple 2.6. The case of sublight speed (macrocosm). Let's solve the problem of capture by a body ball with charge Q on its own orbit of a moving electron with charge $q = e$. The initial data for the computer simulation are taken as follows: under the initial conditions:

$Q = 3{,}163\cdot10^{-7}$; $q = -1{,}602\cdot10^{-19}$; $k = 8{,}988\cdot10^{9}$; $m = 9{,}109\cdot10^{-31}$ under the initial conditions: $r_x(0) = -0{,}2$; $r_y(0) = 0{,}2$; $v_x(0) = 0{,}1c$; $v_y(0) = 0$.

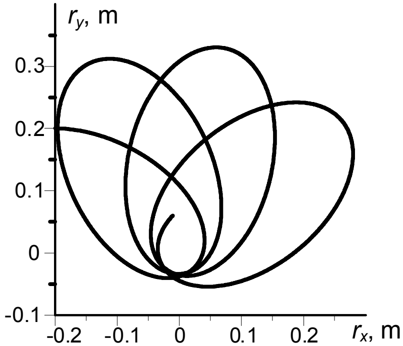


Fig. 2.18. Time dependence of the electron motion trajectory $r = r(t)$, which corresponds to the transient process of fig. 2.18 under the condition of neglecting the force component F_T (2.45).

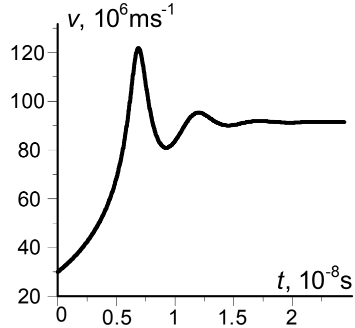


Fig. 2.20. The transient linear velocity of the electron $v = v(t)$, which corresponds to the transient process of fig. 2.18 F_C (2.42)

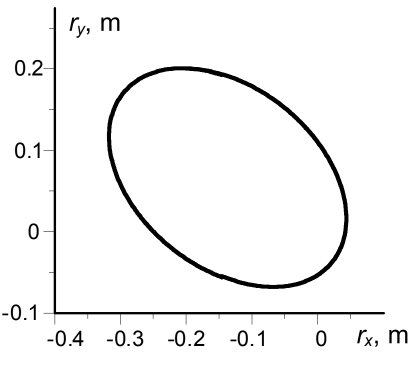


Fig. 2.21. The transient process $r = r(t)$, which corresponds to the transient process of fig. 2.18 under the condition that only one force component is involved – the Coulomb F_C (2.42)

In fig. 2.18 shows the results of the simulation of the trajectory of the capture of an electron by a charged ball into one of the possible proper orbits.

According to the digital data of the transient process, the electron is practically trapped on a circular orbit with an average orbital radius r = 0.0654 m. The eccentricity of the orbit $\varepsilon = 0{,}0000497$. In fig. 2.19 shows the same transient process as in fig. 2.18, but under the condition that there are no terms in the equations of motion (2.59) corresponding to the radial force F_T (2.45). The transitional curve of fig. 2.19 differs from the corresponding curve in fig. 2.18 not only quantitatively, but also strikingly qualitatively! And this indicates that in practical analysis, the third component (2.45) of the resultant force (2.39) cannot be dispensed with at all!

The absence of the Lorentz force (2.45) introduces an error in the calculation process of the trajectory of the orbit of fig. 2.18 less, which does not exceed 9.45%.

The velocity characteristic of an electron is shown in fig. 2.20. As we can see, the linear speed of the electron increased from 0.1 c to 0.3 c. The increase in the linear speed of moving charged bodies when they are captured into orbit by other tuned bodies is a characteristic physical phenomenon, which is especially noticeable in the problems of electromechanical states in the microcosm.

It would be inappropriate to bypass the limited possibilities of electromechanics involving only the Coulomb force (2.42). For this purpose, the transition process shown in fig. 2.21 was simulated, which corresponds to the transitional process of fig. 2.18. Such a striking discrepancy between the electron trajectories shown in fig. 2.18 and fig. 2.21, could be expected in advance based on physical considerations alone.

2.10. Electrical interaction of the "electron-proton" tandem

Unfortunately, the methods of classical physics were displaced beyond the microcosm. But in this, the fault lies with the methods themselves, which were in a spatiotemporal form not applicable to the analysis of real problems. Unlike the classical description, in which particles are considered as material points, and their movement is described by coordinates and speed, the state of a quantum mechanical system is described by a complex wave function that is not localized at a point, and occupies the entire non-infinite space (the Schredinger and Dirac equations in the linear approximation). In such a description, the concept of trajectory does not make sense, and the movement is described in terms of the flow of energy and momentum.

Quantum physics does not allow the methods of classical physics to exceed the numerical value of a certain variable with the dimension J.s of an elementary quantum of action, commensurate with Planck's constant $h = 6{,}626 \cdot 10^{-34}$. And in our examples, the moment of momentum emv of an electron in orbit is exactly in such a zone. Still, the analysis of the relationship between classical and quantum physical representations cannot fail to be important for the foundations of quantum physics. Therefore, it is possible to prematurely drive a wedge between the natural-mathematical unity of the world, on the one hand, with the mega- and macro world, and on the other, with the microworld. After all, the creators of quantum physics themselves understand this. Thus, the author of [3] warns: "The smallness of the variable action does not always indicate the complete inapplicability of the classical theory. In many cases, it can give a certain qualitative idea about the behavior of the system, which can be precise using a quantum mechanical approach."

In order to justify the expressed confidence, we will show that the electromechanical state of the electron-proton atomic structure, despite the tiny spatial dimensions of the microcosm, can still be successfully described with the benefit of understanding the unity of the physical process.

We will be interested not only in transient processes but also in steady-state ones, the search for which was somewhat discussed in the tasks of the mega world. The steady-state from the point of view of mental labor costs is easiest to obtain by differentiating (2.59) until the transient process fades out. But such a way is unacceptable because the transition process can be too long, and the accumulation of numerical integration errors can distort the final result. Therefore, in practice, they try to find such initial conditions that exclude the transient reaction. For this, reliable general methods of finding such conditions have been developed, based on the equations of the first variation of the equations of the electromechanical state [18]. But this can be discussed only in a separate study. Here we will consider a separate analytical case related to the circular orbital motion of an electron around a proton ($\mathbf{r}_0 \cdot \mathbf{v}_0 = 0$) – the most common case in the practice of microlight, but without taking into account quantum laws.

In this case, (2.41) is simplified in the polar coordinate system

$$F_r = -\frac{kqQ}{mr^2}\left(1+\frac{v^2}{c^2}\right), \tag{2.60}$$

where F_r is the radial component of the force.

The expression of the mechanical radial force in this case has the form

$$F_r = \frac{mv^2}{r}. \tag{2.61}$$

Виходячи з балансу сил (2.60), (2.61), одержуємо потрібний вираз, який пов'язує орбітальну лінійну швидкість з радіусом траєкторії

$$v = \sqrt{\frac{a}{br-d}}, \tag{2.62}$$

where a, b, d are constant coefficients

$$a = kqQc^2; \quad b = mc^2; \quad d = kqQ. \tag{2.63}$$

For the "electron-proton" pair, the coefficients (2.63) take numerical values:

$$a = 20,735435\cdot 10^{-12}; \quad b = 81,871112\cdot 10^{-15}; \quad d = 23,070425\cdot 10^{-29}.$$

An important feature of formula (2.62) is that it simultaneously takes into account both classical forces – Coulomb and Lorentz. In order to neglect the Lorentz force, in (2.62) it is enough to divide the numerator and denominator by c2 in the radical expression and make a limit transition. Then we come to the result

$$v = \sqrt{\frac{d}{mr}}. \tag{2.64}$$

Formula (2.62) makes it possible to calculate the orbital linear velocity for a given radius of the electron's circular orbit. Such velocities and radii, being used as initial conditions for the differential equations of state (2.59), in the process of their integration exclude the transient reaction. Thus, we enter directly into the steady-state process.

If we are talking about any stationary circular orbits of an electron in an atom, then expression (2.62) can be replaced by a simpler one with accuracy up to the fifth sign

$$v = \frac{15{,}91455}{\sqrt{r}} \cdot 10^5. \tag{2.65}$$

If we are talking about stable quantum orbits of an electron in a hydrogen atom with quantum numbers $n1, n2, n3\ldots$, then (2.65) is further simplified

$$v = \frac{21{,}8773}{n} \cdot 10^5, \tag{2.66}$$

where n is the principal quantum number.

Units of measurement are given in the SI system.

In [11] there is a table of linear orbital velocities of the electron, obtained by various approaches, based on the conditions of static equilibrium for quantum numbers: $n1$, $n2$, $n3$, $n4$. If we supplement it with our calculations, we will have

,

n	$r_o \cdot 10^{-10}$	$v_B \cdot 10^5$	$v_Q \cdot 10^5$	$v_P \cdot 10^5$	$v_T \cdot 10^5$
1	0.529	21.90	–	17.08	21.88
2	2.116	10.90	7.69	8.54	10.94
3	4.760	7.70	5.94	5.69	7.29
4	8.464	5.47	4.72	4.27	5.47

where r_o is the specified radius of the atom corresponding to a certain quantum number; $v_i (i = B, Q, P, T)$ are orbital linear velocities, indices B, Q, P, T indicate involvement in the Bohr, quantum, Piskunov [11] and author's approaches according to formula (2.66), respectively. If necessary, they can be recorded more precisely

$$v_1 = 21,8773 \cdot 10^5,\ v_2 = 10,9386 \cdot 10^5,\ v_3 = 7,2924 \cdot 10^5,\ v_4 = 5,4693 \cdot 10^5.$$

These values are consistent with observations. If we use (2.64), neglecting the Lorentz force, then, for example, for the main orbit (Bohr radius) we have: $v_1 = 21,8767 \cdot 10^5$. Such a small deviation should have been expected, because given the speed, the relativistic effect is too small.

Since we are working with electronic orbits, we can ask questions about the presence of electromechanical gray holes in the depths of the microcosm, similar to gravitational black holes in celestial mechanics. We will find their radii in the usual way. For this, it is enough to make the balance of forces (2.60) and (2.61) at the speed of light ($v = c$), which corresponds to the first and second cosmic speeds in the mega world. Under conditions (2.63), we obtain

$$r_{em} = 2\frac{d}{b} = 5,635791 \cdot 10^{-15}. \qquad (2.67)$$

It is clear that beyond the limits of $r < r_{em}$ the laws of mechanics collapse.

Example 2.7. We simulate some interesting surreal (in light of the total prohibitions of the quantum physics of

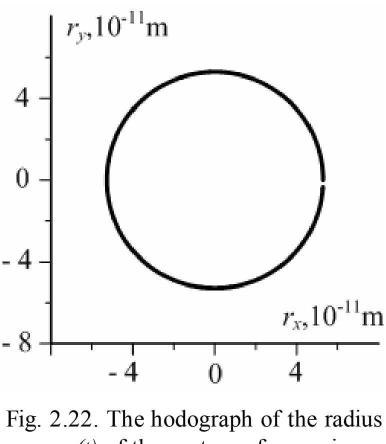


Fig. 2.22. The hodograph of the radius $r = r(t)$ of the capture of a moving electron into the circular orbit of the nucleus n1 of the Hydrogen atom.

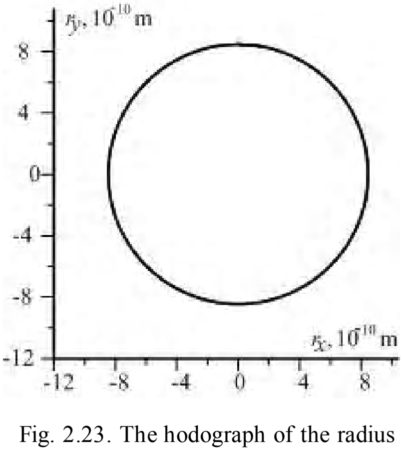


Fig. 2.23. The hodograph of the radius $r = r(t)$ of the capture of a moving electron into the circular orbit of the nucleus n4 of the Hydrogen atom

the microcosm) dynamics of the electron-proton pair. Starting numerical information for the integration of differential equations of state (2.59):

$$Q = 1,602 \cdot 10^{-19};\ q = -Q;\ k = 8,988 \cdot 10^{9};\ m = 9,109 \cdot 10^{-31};$$

The initial conditions that exclude the transition reaction for the orbit $n = 1$::

$$r_x(0) = 0;\ r_y(0) = 0,529 \cdot 10^{-10};\ v_x(0) = 2,188 \cdot 10^{6};\ v_y(0) = 0,$$

aand for $n = 4$:

$$r_x(0) = 0;\ r_y(0) = 8,467 \cdot 10^{-10};\ v_x(0) = 5,469 \cdot 10^{5};\ v_y(0) = 0,$$

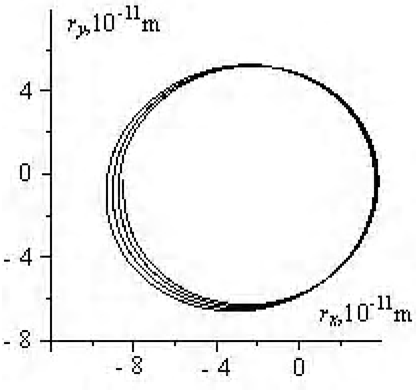


Fig. 2.24. The hodograph of the radius $r = r(t)$ of the capture of a moving electron on the circular quantum orbit $n4$ of the nucleus of a Hydrogen atom in the case of unbalance of the initial conditions that exclude a transient reaction.

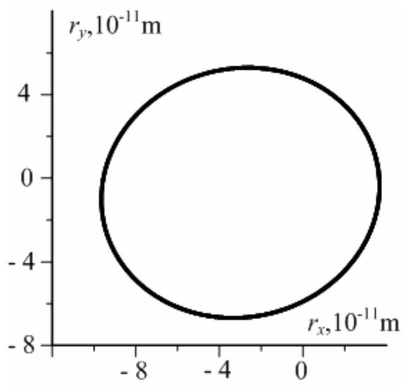


Fig. 2.25. The hodograph of the radius $r = r(t)$, which corresponds to the hodograph of fig. 2.24, is calculated only with the participation of the classical. Coulomb law.

obtained by expression (2.66).

The simulation results are shown in fig. 2.22 – fig. 2.26.

In fig. 2.22 shows the trajectory of the electron of the atomic nucleus, which, according to the analysis of digital data, reached an almost circular orbit with the classical radius $r = 0.529 \cdot 10^{-10}$ m and the orbital linear speed $v = 2 \cdot 188.10^{6}$ ms^{-1}. And in the next fig. 2.23 shows the hodograph of the electron trajectory, which, based on the analysis of digital data, resulted in an almost circular quantum ($n4$) orbit with a classical radius $r = 8,464 \cdot 10^{-1}$m and an orbital linear at a speed of $v = 5,469 \cdot 105$ ms^{-1}. According to the simulation data, $r = 8,457 \cdot 10^{-10}$ m, $v = 5,473 \cdot 10^{5}$ ms^{-1}.

Processes fig. 2.22, fig. 2.23 were also simulated according to the laws of classical mechanics – under the force action of only the Coulomb force. The results practically coincide with ours. This is understandable because, for the given values of the orbital speed of the electron, the relativistic effect (Lorentz force) is negligible.

And the fact that in the electromechanical process fig. 2.22 and fig. 2.23 there are no transient reactions, it only proves the incredible accuracy of experimental measurements that a person is able to make on an invisible physical object! It is enough to make a small deviation from the experimental initial conditions, as the transition process cannot be avoided, and it is sufficiently long in time. If we are talking about a circular quantum ($n1$) orbit with a classical radius $r = 0.529 \cdot 10^{-10}$ m and an orbital linear speed $v = 21.877105$ ms^{-1}, then it was enough to shift the initial condition $r_x(0) = 0$ to the left by half an atomic radius $r_x(0) = -0,2645 \cdot 10^{-10}$ as a transitory the process declared its own right to exist (Fig. 2.24). In fig. 2.25, the transient process shown in fig. 2 is duplicated 2.24, but under the condition that only one component of the Coulomb force (2.42) is involved. As we can see, the transient processes shown in fig. 2.24 and fig. 2.25 go strikingly differently.

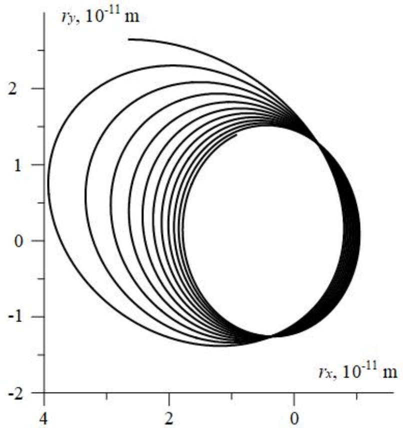


Fig. 2.26. The hodograph $r = r(t)$ of the capture of an electron into an unreal elliptical orbit of an atomic nucleus with an eccentricity $\varepsilon = 0.448$ and hyperbolic precession of the trajectory.

Based on the real graphic and time resolutions, to judge the course of the transition process in fig. 2.24, which is close to actually existing conditions, does not occur. Therefore, in fig. 2.26 shows a hyperbolized transition process in which an electron is artificially brought closer to the nucleus of an atom. Now one can clearly see not only the precession of its orbit in the direction of the electron's rotation but also its gradual convergence with the atom's nucleus. On the last turn of the electron's trajectory, the coordinates and speed fit within completely logical limits:

$$0.981 \cdot 10^{-11} \le r \le 1.810 \cdot 10^{-11}; \; 3.205 \cdot 10^{6} \le v \le 5.857 \cdot 10^{6}.$$

The neoclassical approach works, strictly speaking, with open elliptical orbits with a gradual decrease in their eccentricities and a noticeable precession of trajectories in the direction of rotation. And this makes it possible to look into the world of elliptical orbits and successfully explain the effect of the precession of the electron orbit. It is interesting that a similar phenomenon was predicted by Sommerfeld [37].

As for the analysis of multi-electron shells, this is a question of the superposition of forces (2.49) acting on each mass involved in motion.

In the process of studying the electromechanical processes of the "electron-proton" pair, it became possible to look beyond the critical limit (2.67) of the

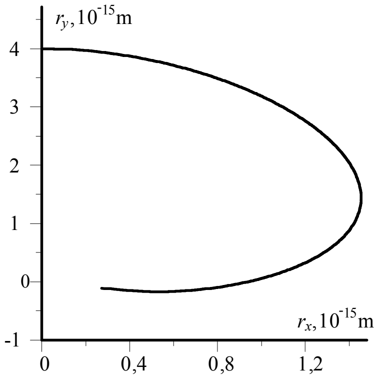


Fig. 2.27. The hodograph of the radius $r = r(t)$ of the collapse of the electron trajectory inside the electromechanical gray hole in the force field of the proton

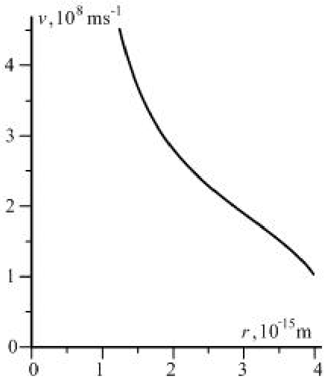


Fig. 2.28. Dependence v = v(r), which demonstrates the collapse of the laws of mechanics in the depths of matter

tandem ($r < r_{em}$). The simulation results are shown in fig. 2.27 and fig. 2.28. Indeed, the collapse of the mechanical interaction was discovered, but with the preservation of the electrical interaction, because the radius of the proton $r_p = 0{,}15 r_{em}$, which is demonstrated by the curve of the speed of the electron's movement deep into the unreal matter, which crossed the threshold of the speed of light. But there is another interesting thing: the computer program, as a sign of mathematical solidarity with the physics of the process, also "explodes" – it stops due to numerical overflow. So, what a well-thought-out world this is.

Simulated transient processes are shown in fig. 2.24, fig. 2.26–2.28, beyond the reach of the methods of classical physics. Having solved these problems, we thereby supported the unity of the fundamental laws of nature inherent in all levels of the mega-, macro-, and mega world. But this in no way denies the existence of specific laws of nature that exist in each of these levels, in particular the famous quantum laws in the microcosm [3, 30]!

The graphically presented results of calculations of model transient processes of the force interaction of the "electron-proton" pair clearly illustrate the possibilities of the neoclassical approach in solving many fundamental problems of the electromechanical equilibrium of moving charged bodies that are not possible for the methods of classical physics.

PS. The fact that we came across concepts such as the radius of a gray hole r_{em} and the singularity of the velocity $v > c$ in space $r < r_{em}$ obliges the author not to be silent on this matter. We will use the quoted opinions taken from [6] to help you so that you don't get the impression that scientists don't think about it.

Firstly. Based on K. Gedel's theorem about the incompleteness of our knowledge, "there are more and more reasons to believe that it is already difficult to do without the concept of other universes." In the literature, you can even find the idea that these universes are not found elsewhere, but in elementary particles. "And the channels of communication (with them) can serve as singularities that occur in our universe in the case of black holes. It is possible that the space-time barriers that separate us from other universes are not so impregnable. It is possible that they will eventually be overcome by science and will bring our ideas about the universe to a qualitatively new level." In this case, the singularity of the velocity, and together with it, according to (2.39), the singularity of the force interaction in such a wonder-space are inevitable, as required by the boundary, on both sides of which different physical laws operate. Of course, it is nice that the conversation is conducted at the level of hypotheses. This singularity concern those who see the multiplicity of universes in the depths of matter.

Secondly. We are talking about the speed threshold c, established experimentally as the speed of light in a vacuum. The impossibility of crossing it is a well-known postulate of the special theory of relativity. That is why Lorenz's radical rests on him. By the way, the name of the radical was given by Poincar? himself. At the same time, he treated the mentioned postulate with a certain reservation [9]. But it is not for us to judge such truths in an unknown world. Time will tell about them. We remain for the time being and will remain for a long time on this side of the threshold, if not constant, then quasi-constant, because otherwise, we do not know how to live. Another thing is to talk. Because such conversations dramatically activate our tired brain.

2.11. Solar acceleration of spacecraft

Wandering through the labyrinths of the International Web, I came across the problems of unsolved problems of theoretical physics, among which is the following: "What causes the additional acceleration in the direction of the Sun of space vehicles, which is not described by the classical theory?" The first thing that came to my mind was that my latest theoretical developments make it possible to successfully solve this problem. But here a number of inconveniences arise due to the lack of sufficient quantitative initial data, which is absolutely necessary in such a case for confident movement forward, fastened by the necessary feedback. But it was not possible to pass by the problem either, because that would be an escape into the shadow of irresponsibility.

First of all, let's make a small excursion into the problem known in scientific publications as the "Pioneers anomaly".

"Pioneers anomaly" [36]. Pioneer 10 is a NASA space probe designed primarily to study Jupiter and the heliosphere. Launched on March 3, 1972, Pioneer 10 became the first spacecraft to fly by Jupiter and photograph the planet, and the first to develop enough speed to overcome the Sun's gravity. After him, on April 6, 1973, "Pioneer-11" was launched, designed to study Jupiter and Saturn.

For the first time, the anomaly of the flight path of space probes was discovered in the 1980s, when they passed about 20 AU, that is, 20 distances from the Earth to the Sun, on a trajectory outside the Solar System. By this point, the probes have already fulfilled their main mission. Pioneer 10 flew by Jupiter in December 1973, determining its mass and measuring its magnetic field. "Pioneer-11" approached the planet exactly one year later: in December 1974. After taking detailed pictures, it went to Saturn. In 1979, the apparatus transmitted images of the planet and its satellite Titan to Earth. The main mission ended, but they decided to use the monitoring data of the flight path of the Pioneer-10 device to search for what was then supposed to be the tenth planet in the Solar System. And now it's the ninth (after the demotion of Pluto). If there was a deviation in the trajectory, then, as scientists believed, it would be a consequence of the gravity of an as-yet-undiscovered planet. Deviations were found, but the cause of this anomaly was by no means a planet at the edge of the solar system. But, what is most interesting, later the anomaly was also found in the twin probe. Today, the devices are flaying in different directions. "Pioneer-10" is moving to the edge of the Milky Way, in the direction of the constellation Taurus. Its twin, on the contrary, flies toward the center of the Galaxy, in the direction of the constellation Shield. Both probes are now in free flight. Only previously obtained acceleration and external forces (gravitational and non-gravitational) affect the flight of spacecraft.

Among the non-gravitational forces is, for example, solar radiation pressure, which causes acceleration directed away from the Sun. And the Sun's gravity, on the contrary, pulls the devices towards the star, causing an acceleration directed toward the Sun, that is, it slows them down. All forces that can affect the flight of space vehicles are calculated and taken into account. Except for one. One unknown and incomprehensible force pulls the probes back. It is she who is the cause of the "Pioneers" mystery. The power is tiny, but it is there. The latest calculations, obtained before 2002, say that the magnitude of the unexplained negative acceleration was (8.74 ± 1.33).10-10 ms-2 (at a certain fixed distance and a certain speed). This has already led to the deviation of the devices by approximately 400,000 km from the calculated trajectory. It would seem that the probes have flown billions of kilometers. At the time of losing contact with Pioneer-10 (January 23, 2003), it flew away from us by more than 12 billion kilometers. This is 82 AU. Communication with Pioneer-11 was lost on September 30, 1995, the device was already at a distance of 6.5 billion kilometers, or 43 AU, from the Sun. We read in [36]: "And what are these hundreds of thousands compared to billions of kilometers? But for science, these tiny values can be of great importance. Deviations from the norm, from the usual understanding of things, that is, anomalies can indicate the presence of something significant, but still undiscovered, especially in astrophysics." An anomaly in the movement of Uranus led to the discovery of a new planet – Neptune. Anomaly in the motion of Mercury, discovered in 1859, was explained based on differential equations of motion only recently by us (see 2.8.2). Or else: "The solution to the "Pioneers" anomaly may revolutionize modern physics or, on the contrary, will be completely trivial. That is why it does not give rest to many scientists."

Some argue that the boundary of the Solar System is defined as the point where the Sun's gravity ceases to affect an object. But gravity, as you know, determines the universe on a huge scale. And this point is 50,000 times greater than the distance from the Sun to the Earth. Yes, "Voyager-1" covered 123 AU. and it will take another 14,000 years to leave the Sun's gravitational grip at its current speed.

For all the years devoted to the search for a solution to the problem of the "Pioneers" anomaly, many assumptions have been put forward. And the first is errors in observations and interpretation of the received data. But he was rejected almost immediately. The anomaly was explained by various reasons. Braking in the interplanetary environment (dust, gas clouds, etc.). The gravitational attraction of Kuiper belt objects. Leakage of gas, such as helium, used as a working medium in radioisotope generators. The reason was also sought in the electromagnetic forces caused by the accumulated probes of electric charges. And, of course, they attributed it to the influence of dark matter or dark energy. They turned to the effect of clock acceleration, caused by the expansion of the universe, and thus by the increase in the background "gravitational potential", which in turn accelerates cosmological time. By changing inertia due to interaction with vacuum energy. The possible non-equivalence of atomic and astronomical time. The background space-time described by the Friedman-Lemaitre-Robertson-Walker cosmological metric, which is not flat according to Minkowski, was not left out. But one of the most common explanations was thermal radiation – a thermoelectric generator. It was not without proposals to adjust the existing physics. Thus, in 1983, was proposed the so-called theory of modified Newtonian dynamics, according to which "Newtonian mechanics needs corrections" to describe the movement of bodies with extremely low acceleration. All this clearly demonstrates an interesting epistemological situation, how the human mind in a state of helplessness searches for the way to the Truth, the essence of which will be discussed separately at the end of the book (see 5.6).

Since the Pioner-10 and Pioner-11 spacecraft flew almost without additional stabilization of the engines during the "cruise", the density of the environment of the Solar System can be characterized by the strength of its influence on the movement of the spacecraft. In the outer solar system, this effect can be easily calculated based on ground-based measurements of the distant space environment. When these effects were taken into account, along with all other known effects, the Pioneers' calculated position did not agree with measurements based on the return times of radio signals from the spacecraft. They consistently showed that both spacecraft were closer to the inner solar system than they should be. The Pioneers were uniquely suited to detect the effect because they flew for long periods of time without additional course adjustments. Most of the deep space probes launched after the Pioneers have either stopped on one of the planets or used the engines to run throughout their mission.

The line of thought of the opponents of the revision of gravitational physics is as follows [36]. If the "Pioneer Anomaly" was a gravitational consequence of some long-range modifications of the known laws of gravity, why did it not affect the orbital motion of large natural bodies in the same way. Therefore, for a gravitational explanation, it is necessary to violate the principle of equivalence, which states that the force of gravity acts on all objects equally. Therefore, some argued that increasingly accurate measurements and simulations of the motion of the outer planets and their satellites rejected the possibility that the "Pioneer Anomaly" is a phenomenon "Pioneer Anomaly" of gravitational origin, while others believed that our knowledge of the motion of the outer planets and the dwarf planet Pluto was insufficient to refute gravitational nature of the anomaly.

Regarding the search for the cause of a possible cosmological origin, gravitationally bound objects such as the Solar System or even the Milky Way should not participate in the expansion of the Universe - this is known from conventional theory and by direct measurement

Finally, let us say that in this interesting story, attempts to establish contact with "Pioneer-10" on February 7, 2003, were unsuccessful. NASA experts consider the depletion of the radioisotope power source to be the reason for the loss of radio communication. It is assumed that the device continues its flight. Its speed is sufficient to leave the Solar system, and the course lies towards the star Aldebaran. If nothing happens to Pioneer 10 along the way, its flight to the outskirts of this star will take more than two million years.

Classical celestial mechanics at non-relativistic velocities of the studied objects is completely derived from the greatest law of nature - I. Newton's law of universal gravitation (1.2), aka (2.42). It can be assumed that the appearance of additional acceleration of space vehicles is still caused by their movement even in the range of pre-light (pre-relativistic) velocities. The classical law (1.2) is a law of statics, not dynamics. Because of this, the problem arises. Therefore, the law (1.2) adapted to the case of motion (2.3), aka (2.39), is suggested here.

The first term in (2.39) presents the actual static force (2.42), the second - the so-called gravity(electro)magnetic (2.44), and the third term corresponds to the force (2.45) due to longitudinal motion, oriented along the radius-vector of the force interaction.

Since our problem deals with the sublight velocities of space vehicles, the force (2.44) is practically insignifiфcant due to the ratio of velocities. However, the force (2.45) is still an order of magnitude greater. Therefore, it is in this force that we must look for the reason for the appearance of additional acceleration in the Sun's gravitational field because this is exactly what we are talking about.

If we write down the equations of the moving mass in the classical notation of Newton's second law (2.47), and express the force according to the law (2.39), then we come to the equations of motion (2.48), they are (2.49) too. Thus, in the process of a mass movement, we have all parameters of movement r and v. In this problem, we can safely limit ourselves to equations (2.50) in two-dimensional space.

If we take into account that

$$\frac{d\mathbf{v}}{dt} = \mathbf{a}, \tag{2.68}$$

where **a** is the acceleration vector, then the right-hand parts of the first three differential series of equations (2.49) are the required accelerations.

If the gravitational mass of the Sun is denoted as $m_2 = M$, then based on Newton's second law ($F = ma$, here a is the acceleration), the formula for the total heliocentric acceleration a_{12} based on (2.39) can be given the form

$$a_{12} = G\frac{M}{r^2}\left(1 + \frac{v^2}{c^2} + 2\frac{v}{c}\mathbf{v}_0 \cdot \mathbf{r}_0\right), \tag{2.69}$$

From the expression (2.69), we isolate the third term. It will be the expression of the sought additional heliocentric acceleration [46]

$$a = 2G\frac{M}{r^2}\frac{v_r}{c}; \quad v_r = v\,\mathbf{v}_0 \cdot \mathbf{r}_0, \tag{2.70}$$

where v_r is the radial velocity component.

Since our task is specifically related to the Solar System, then on the condition that $G = 6{,}67438 \cdot 10^{-11}$; $M = 1{,}9891 \cdot 10^{30}$; $c = 2{,}99792 \cdot 10^{8}$; AU = $1{,}49598 \cdot 10^{11}$, formula (2.70) can be somewhat formalized (for $r = n \cdot \mathrm{AU}$):

$$a = 0{,}39575 \frac{v_r}{n^2} 10^{-10}. \tag{2.71}$$

Example 2.8. The available starting data about the Pioneer-10 probe, obtained as a result of space contacts on the indicated dates:

1. Start 02.03.1972 – $n = 1.00$;
2. Calculation option – $n = 25.00$; $v_r = 12500$ ms^{-1}; $a_2 = ?$
3. Contact 01.23.2003 – $n = 82.19$; $v_r = 12224$ ms^{-1}; $a_3 = ?$
4. Contact 01.23.2012 – $n = 106.96$; $v_r = 12048$ ms^{-1}; $a_4 = ?$

By substituting the initial data into a formalized expression, we obtain the desired fixed additional accelerations:

$$a_2 = 7{,}915 \cdot 10^{-10}\ \mathrm{ms^{-2}};\ a_3 = 0.716 \cdot 10^{-10}\ \mathrm{ms^{-2}};\ a_4 = 0.417 \cdot 10^{-10}\ \mathrm{ms^{-2}}.$$

As for the additional acceleration a_2, it fits perfectly into the result of the experiment: $(8.74 \pm 1.33) \cdot 10^{-10}$

$$7.41 \cdot 10^{-10} < 7.92 \cdot 10^{-10} < 10.07 \cdot 10^{-10},$$

although, to be honest, in this variant, the result of a logical assumption was introduced into the raw data.

For a preliminary assessment of the quantitative ratios of the component action of the Sun's gravity, we calculate the total acceleration on the basis of (2.69),

$$a_{12} = 9{,}492 \cdot 10^{-6}(1 + 0{,}174 \cdot 10^{-8} + 0{,}834 \cdot 10^{-4}) =$$
$$= 9{,}492 \cdot 10^{-6} + 1{,}650 \cdot 10^{-14} + 7{,}915 \cdot 10^{-10}\ (\mathrm{ms^{-2}}).$$

As we can see, the coefficient of gravitomagnetic acceleration $0{,}174 \cdot 10^{-8}$ is small, so it can be neglected in practice, which cannot be said about the coefficient of additional solar acceleration $0{,}834 \cdot 10^{-8}$, and therefore this acceleration is noticeable in space practice.

In order to reliably keep the starting information in sight, it is interesting to know the average speed of the probe (at least v_3). This can be done based on the dates of start and experimental contact (11284 days), as

$$v = r/t = (82{,}19 \cdot \mathrm{AU})/(11284 \cdot 24 \cdot 3600) = 12613 > 12224\ (\mathrm{ms^{-1}}),$$

which makes the estimated discrepancy with the experiment only 3%.

Based on the obtained result, it can be said.

1. The dominant opinion that classical properties of the fundamental laws of statics can be successfully used in the celestial mechanics of low speeds ($v \ll c$) does not always satisfy the practice of operating artificial space vehicles. The involvement of relativistic methods also does not improve the situation, because the gravitomagnetic acceleration is too small.

2. Known classical methods of the theory of motion operate only with the transverse component of the velocity vector in relation to the orientation of the radius-vector of the gravitational interaction. While the effect of the longitudinal component turned out to be an order of magnitude higher than the effect of the transverse one.

3. The appearance of experimentally perceptible additional solar acceleration in the applied task of the flight of space vehicles only confirms the trinity of force gravitational interaction – static, transverse, and longitudinal dynamic. What should have been expected.

2.12. Multi-mass systems

The study of multi-mass systems in separately taken gravity and electricity is interesting not so much in the theoretical aspect as in the acquisition of practical skills of using already obtained results. Let us consider two problems – the interaction of the orbits of moving planets in a gravitational field and the movement of a multi-charge system in an electric field.

2.12.1. Interaction of orbits of moving planets. Much attention has long been paid to the problem of the mutual influence of the gravitational attraction forces of individual planets on their orbital trajectories. One of the most famous is the justification of the precession of the perihelion of Mercury's orbit. It is enough to remind us that this precession was wrongly explained by U. Leverier exclusively as the influence of the rest of the planets of the Solar System (see 2.8.2, p. 44). Our studies have convincingly shown that the mechanical movement of elliptical orbits in the field of electric and mechanical gravity in the mega-, macro-, and microcosm is itself accompanied by the precession of the trajectory in the direction of rotation. But this by no means excludes the mutual influence of moving planets. We will talk about the real extent of this influence below.

Let's write down the obvious equations of n masses interconnected by gravity

$$\frac{d\mathbf{v}_i}{dt} = \frac{1}{m_i}\sum_{k=1}^{n}\mathbf{F}_{ik}; \quad \frac{d\mathbf{r}_i}{dt} = \mathbf{v}_i, \quad i,k = 1,2,...,n, \tag{2.72}$$

where $\mathbf{r}_i, \mathbf{v}_i$ is the radius vector of the trajectory and the velocity vector of the i-th mass is the vector of the gravitational interaction of the i-th and k-th masses; t is time.

We write the force vector in its general form as (2.3)

$$\mathbf{F}_{i,k} = G\frac{m_i m_k}{r_{ik}^2}\left(1+\frac{v_{ik}^2}{c^2}+2\frac{v_{ik}}{c}\mathbf{r}_{ik0}\cdot\mathbf{v}_{ik0}\right)\mathbf{r}_{ik0}, \tag{2.73}$$

Given constant parameters and initial conditions, equations (2.72), (2.73) are quite sufficient to solve the given problem.

For the sake of certainty, consider the transient process of the interaction of three cosmic masses: the Sun m_1, Mercury m_2, and Venus m_3. The balance of forces (2.72) under the condition of a relatively motionless Sun is written as

$$\frac{d\mathbf{v}_2}{dt} = \frac{1}{m_2}(\mathbf{F}_{21}+\mathbf{F}_{23});\quad \frac{d\mathbf{r}_2}{dt} = \mathbf{v}_2;\quad \frac{d\mathbf{v}_3}{dt} = \frac{1}{m_3}(\mathbf{F}_{31}+\mathbf{F}_{32});\quad \frac{d\mathbf{r}_3}{dt} = \mathbf{v}_3. \tag{2.74}$$

The distances between the planets and their relative velocities are found by the results of integration (2.74)

$$\mathbf{v}_{23} = \mathbf{v}_2 - \mathbf{v}_3;\quad \mathbf{r}_{23} = \mathbf{r}_2 - \mathbf{r}_3. \tag{2.75}$$

To simplify the analysis, we will solve the problem in 2D space due to the logical orientation of the Cartesian coordinate system with the center coinciding with the center of the star,

$$\begin{aligned}
&\frac{dv_{2x}}{dt} = \frac{1}{m_2}(F_{21x}+F_{23x});\quad \frac{dr_{2x}}{dt} = v_{2x};\quad \frac{dv_{2y}}{dt} = \frac{1}{m_2}(F_{21y}+F_{23y});\quad \frac{dr_{2y}}{dt} = v_{2y};\\
&\frac{dv_{3x}}{dt} = \frac{1}{m_3}(F_{31x}+F_{32x});\quad \frac{dr_{3x}}{dt} = v_{3x};\quad \frac{dv_{3y}}{dt} = \frac{1}{m_3}(F_{31y}+F_{32y});\quad \frac{dr_{3y}}{dt} = v_{3y}.
\end{aligned} \tag{2.76}$$

We write the projections of gravitational forces according to (2.73)

$$\begin{aligned}
F_{21k} &= -\frac{Gm_1 m_2 r_{21k}}{r_{21}^3}\left(1+\frac{v_{2k}^2}{c^2}+2\frac{r_{21x}v_{2x}+r_{21y}v_{2y}}{cr_{21}^2}\right);\\
F_{31k} &= -\frac{Gm_1 m_3 r_{31k}}{r_{31}^3}\left(1+\frac{v_{3k}^2}{c^2}+2\frac{r_{31x}v_{3x}+r_{31y}v_{3y}}{cr_{31}^2}\right);\qquad k = x, y;\\
F_{23k} &= -\frac{Gm_2 m_3 r_{23k}}{r_{23}^3}\left(1+\frac{v_{23k}^2}{c^2}+2\frac{r_{23x}v_{23x}+r_{23y}v_{23y}}{cr_{23}^2}\right);\quad F_{32k} = -F_{23k},
\end{aligned} \tag{2.77}$$

where

$$r_{23k} = r_{21k} - r_{31k}; \quad v_{23k} = v_{21k} - v_{31k}, \quad k = x, y. \qquad (2.78)$$

$$r_k = \sqrt{r_{kx}^2 + r_{ky}^2}, \quad k = 21, 31, 23; \quad v_k = \sqrt{v_{kx}^2 + v_{ky}^2}, \quad k = 2, 3, 23. \qquad (2.79)$$

Expressions (2.77)-(2.79) form a complete system of algebraic-differential equations for the analysis of transient processes in the space system "star-two planets". To obtain the desired unique solution, it is necessary to set constant parameters and space-velocity initial conditions:

$$r_{2k}(0),\ r_{3k}(0); \quad v_{2k}(0),\ v_{3k}(0), \quad k = x, y.$$

Given the condition $F_{23} = F_{32} = 0$, differential equations (2.77) describe independent physical processes of individual planets.

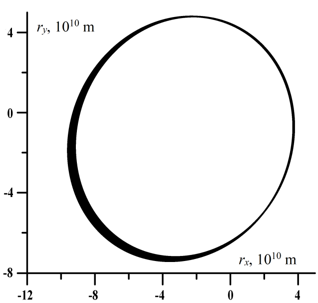


Fig. 2.29. Hodograph of the distance $r_{21}(t)$ of the planet around the trajectory of Mercury:

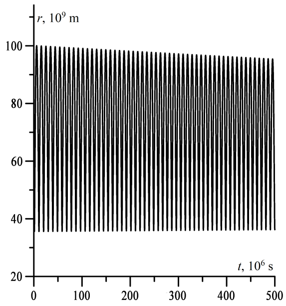


Fig. 2.30. The time dependence of the radius $r_{21}(t)$ in the transient process is shown in Fig. 2.29

Example 2.9. The results of the combined implementation of (2.77)–(2.79) are shown in fig. 3.29 – fig. 3.33 with constant parameters:

$Gm_1 = 13{,}27128 \cdot 10^{19}$, $Gm_2 = 2{,}19185 \cdot 10^{13}$, $Gm_3 = 32{,}47926 \cdot 10^{13}$ ($\mathrm{m^3 s^{-2}}$), corresponding to the Sun, Mercury, and Venus. All dimensions in the simulation results are in SI.

Fig. 2.29 shows the time dependence of the hodograph of the spatial radius $r_{21}(t)$ obtained under the initial conditions:

$$v_{2x}(0) = 59000; \ v_{2y}(0) = 0; \ r_{2x}(0) = 0; \ r_{2y}(0) = 0{,}4600 \cdot 10^{11};$$

$$v_{3x}(0) = 35020;\ v_{3y}(0) = 0;\ r_{3x}(0) = 0;\ r_{3y}(0) = 1,0821 \cdot 10^{11}$$

The duration of the transition process is 5.108 s, which is approximately 15.844 Earth years. The temporal dependence of the spatial radius itself, shown in Fig. 2.30. Confirms that the transitional process is ongoing and is far from an established value.

For comparison, Fig. 2.31 shows the same transient process, under the same initial conditions, within the same time limits as in Fig. 2.29, but calculated according to classical equations with the participation of only one force component - Newton's force. From the comparison of the results, we can see that both processes differ not only quantitatively, but also qualitatively. The first of them is transitory, and the second is steady-state due to the absence of a radial force component that would correct the orbit, including its precession!

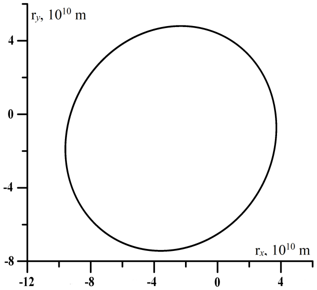


Fig. 2.31. The hodograph of the distance $r_{21}(t)$ corresponding to the transition process from fig. 2.29, but calculated only for Newtonian gravity

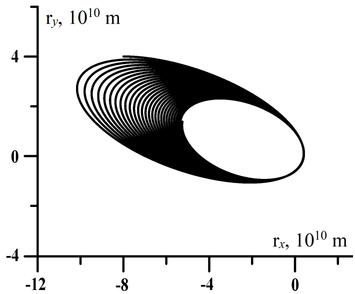


Fig. 2.32. Distance hodograph $r_{21}(t)$ for planets artificially close to the Sun under hyperbolized initial conditions

Analysis of digital data of the transient process of fig. 2.29 showed that the gravitational mutual influence of the planets on their orbits is very small, including on the precession of these orbits. In the case $F_{23} = F_{32} \neq 0$ for a fixed time $t =$ 3.80675·10^6 s, the maximum radius is 69941273166 m, the minimum speed is 38803.91 ms^{-1}. In this case $F_{23} = F_{32} = 0$, these numbers differ little: 69941584666 m, 38803.91 ms^{-1}, that the influence of all planets on the precession of Mercury's orbit will be the same. While U. Le Verrier attributed 53% of the physical phenomenon to Venus. Based on the real graphic and time resolutions, to judge the course of the transition process in fig. 2.29, which is close to actual existing conditions, does not occur. Therefore, in fig. 2.32 shows the transition process in which the planets are artificially brought closer to the gravitating mass (the Sun) under the initial conditions:

$$v_{2x}(0) = 25000;\ v_{2y}(0) = 0;\ r_{2x}(0) = -0,8000;\ r_{2y}(0) = 0,4000 \cdot 10^{11};$$

$$v_{3x}(0) = 42140;\ v_{3y}(0) = 0;\ r_{3x}(0) = 0;\ r_{3y}(0) = -0,9400 \cdot 10^{11};$$

Now one can see not only the precession of the perihelion in the direction of the planet's rotation but also the gradual approach of the planet to the star (openness of the orbit).

The duration of the transient process is 1.10^8 s.

Although, according to the curve of fig. 2.30, the transition continues, we are still lucky enough to get close enough to the observed results on the real planet. According to the analysis of the digital data of the last rotation from fig. 2.29 we have (observation results in brackets): eccentricity (2.58) 0.1932 (0.2056), the maximum distance between the centers of gravitating masses 68.79.109 (69.82.109) m, the minimum distance between the centers of gravitating masses = 46.51.109 (46 ,00.109) m. It is interesting that as the planet "falls" towards the star, the eccentricity of the quasi-elliptical trajectory decreases. So, in the transitional process of fig. 2.29 in $5 \cdot 10^8$ s it decreased from 0.2064 to 0.1932. Still, this is not enough to judge the quantitative characteristics of the precession of a real object. Because we are talking about a fragmentary state of a transitional process frozen in time, and we need a steady-state process. And this is connected with the finding of initial conditions that exclude a transient reaction. But to use mathematical methods to find them, a condition of closedness is imposed on the fixed orbit. And in fact, according to the indications of fig. 3.32, it is not. So, we conclude that the third force (2.45) is responsible for the precession of the perihelion of elliptical orbits. It is clear that in the case of a circular orbit, the force (2.45) is identically zero! Therefore, the phenomenon of trajectory precession is impossible in circular orbits.

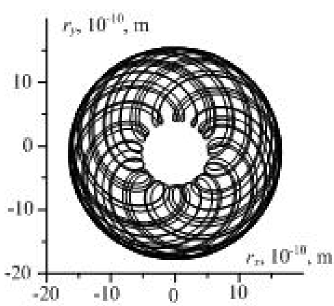


Fig. 3.33. The hodograph of the interplanetary distance $r_{23}(t)$ in the transition process shown in fig. 3.29 during mutual rotation around the star for a time of $1 \cdot 10^8$ s

And is it possible to obtain the exact result of the precession of the elliptical trajectory of Mercury based on the differential equations of motion? You can. But at the same time, as has already been said, it is necessary to know the exact initial space-velocity conditions that Nature laid down during the evolution of the Solar System or the corresponding initial conditions that exclude a transient reaction (if a steady-state process exists). Such conditions can, of course, be chosen, but it is too time-consuming work.

Those who do not believe in the mathematical beauty of nature should admire the computer prints of the hodograph of the distance between Mercury and Venus, obtained as a solution of differential equations (2.76). This scientific and artistic work makes us think in a new way about what the great H. Poincare said: "Objective reality can only be harmony expressed by mathematical laws. It is this harmony that is the only objective reality, the only truth that we can achieve".

2.12.2. Motion of a multi-charge system in an electric field. The problem of taking into account the mutual influence of the forces of interaction of separate moving physical bodies on their trajectories in the electric field is given no less attention than in the gravitational one. Let us at least name the problem of building electro-mechanical models of the atomic structures of the elements of the periodic table. Unfortunately, the methods of classical electricity turned out to be powerless to solve it, and were practically pushed out of the microcosm. But, as we can see, it was done hastily. In connection with this, we will consider the differential equations of electro-mechanical motion in a closed system of charged bodies under the force action of their resulting electric field. To provide strict mathematical support to a real physical process, it was necessary to take into account the finite speed of propagation of force interaction, despite the small geometric dimensions of the microcosm. We will construct the differential equations of motion in close cooperation with the corresponding equations of the previous problem (2.72-2.80), in which we use the adapted law of Sh. Coulomb for the case of moving charges (2.19). The inertial equations of moving n electrical masses interconnected by electric force interaction are the same (2.72). Gravitational interaction in (2.72) is neglected as negligible compared to electric interaction.

We write the force vector in a general form similar to (2.73)

$$\mathbf{F}_{i,k} = g\frac{q_i q_k}{r_{ik}^2}\left(1+\frac{v_{ik}^2}{c^2}+2\frac{v_{ik}}{c}\mathbf{r}_{ik0}\cdot\mathbf{v}_{ik0}\right)\mathbf{r}_{ik0}, \tag{2.80}$$

where g is the fundamental electrical constant.

For the sake of certainty, consider the transient process of the interaction of three charged bodies: the Helium nucleus q_1 and its two orbital electrons q_2 and q_3, placed in the same orbit, which rotates in the same direction with an angular shift of 180^0. Such a model brings us closer to the real system of the second firstborn of the periodic system of elements. But it by no means claims its adequacy

to the physics of the process. Because the physics of the microcosm of Helium is still far from being researched like Hydrogen. We will only find ourselves in the field of convenient mathematical modeling with a certain approximation to a possible real physical process. For the sake of finding curiosities, several unreal transient processes will be considered! Our goal is to create a means of analysis, and the subject area of its application can be any. And in general, our examples are all surreal, because, in reality, we are dealing with established processes. And the task of finding space-velocity initial conditions that exclude a transient reaction is still not resolved in the general case.
We write the balance of forces in the system of a fixed core as (2.76)

$$\frac{d\mathbf{v}_2}{dt}=\frac{1}{m_2}(\mathbf{F}_{21}+\mathbf{F}_{23});\quad \frac{d\mathbf{r}_2}{dt}=\mathbf{v}_2;\quad \frac{d\mathbf{v}_3}{dt}=\frac{1}{m_3}(\mathbf{F}_{31}+\mathbf{F}_{32});\quad \frac{d\mathbf{r}_3}{dt}=\mathbf{v}_3. \qquad (2.81)$$

The vectors of the distance between the electrons and their mutual velocity are found by the results of integration (2.81), similar to integration (2.75). To simplify the analysis, we will also solve the problem in 2D space due to the logical orientation of the Cartesian coordinate system with the center coinciding with the center of the virtual atom. Then we can directly use equations (2.76) assuming that m_1 is the mass of the nucleus; m_2, m_3 are masses of orbital electrons.

We write the projections of the electrical interaction forces according to (2.19)

$$\begin{aligned}
F_{21k} &= -g\frac{q_1q_2r_{21k}}{r_{21}^3}\left(1+\frac{v_{2k}^2}{c^2}+2\frac{r_{21x}v_{2x}+r_{21y}v_{2y}}{cr_{21}^2}\right);\\
F_{31k} &= -g\frac{q_1q_3r_{31k}}{r_{31}^3}\left(1+\frac{v_{3k}^2}{c^2}+2\frac{r_{31x}v_{3x}+r_{31y}v_{3y}}{cr_{31}^2}\right);\\
F_{23k} &= -g\frac{q_2q_3r_{23k}}{r_{23}^3}\left(1+\frac{v_{23k}^2}{c^2}+2\frac{r_{23x}v_{23x}+r_{23y}v_{23y}}{cr_{23}^2}\right);\\
F_{32k} &= -F_{23k};\qquad k=x,y;
\end{aligned} \qquad (2.82)$$

Expressions (2.75), (2.76), and (2.82) form a complete system of algebraic differential equations for the analysis of transient processes in a closed system of three moving charges. To obtain the desired unique solution, it is necessary to set constant parameters $g, q_1, q_2, q_3, m_2, m_3$ and space-velocity initial conditions (2.80). Given the condition $F_{23}=F_{32}=0$ differential equations (2.82) describe independent physical processes of interaction of individual charges.

WARNING. Expressions (2.82) are written taking into account the signs of individual charges, therefore, in practical analysis, only their moduli should be used.

Example 2.10. The results of the combined implementation of (2.75), (2.76), and (2.82) are shown in fig. 2.34 – fig. 2.39 with constant parameters:

$$g = 8.987742 \cdot 10^{19}; \quad m_2 = m_3 = 9.1093826 \cdot 10^{-31};$$
$$q_1 = 2q_2; \quad q_2 = q_3 = 1.602176629 \cdot 10^{-19},$$

corresponding to the nucleus and electron shell of the Helium atom. All dimensions are in SI.
In the microcosm, only steady-state processes are of practical interest. Such an electromechanical process of a Helium atom is shown in fig. 2.34. We obtained it according to the specified space-velocity initial conditions:

$$v_{x2}(0) = 4.0420 \cdot 10^6;\ v_{y2}(0) = 0;\ r_{x2}(0) = 0;\ r_{y2}(0) = 31 \cdot 10^{-12};$$
$$v_{x3}(0) = -v_{x2}(0);\ v_{y3}(0) = 0;\ r_{x3}(0) = 0;\ r_{y3}(0) = -r_{y2}(0),$$

which excludes the transient reaction. We calculate them according to (2.62), (2.63)

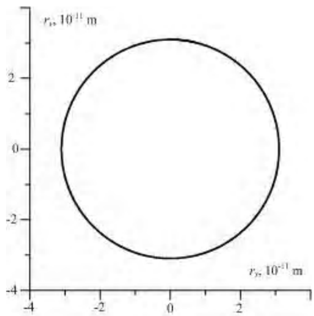


Fig. 3.34. Hodograph of the distance $r_{21y}(r_{21x})$ of the orbital electron. Duration time T = 0.15·10^-15 s

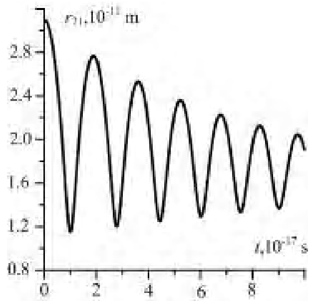


Fig. 3.35. The time dependence of the radius $r_{21}(t)$ in the transient process is shown in fig. 3.34 when the nuclear charge is doubled

$$v_{ik}(0) = \sqrt{\frac{g q_i q_k c^2}{m_i c^2 r_{ik}(0) - g q_i q_k}}. \tag{2.83}$$

Since our task concerns the calcu-lation of transient processes, in the following we will unbalance the original system. First of all, to speed up the course of transient processes, let's double the charge of the nucleus $q_1 = 2q_{1He}$, where q_{1He} is the charge of the nucleus of the Helium atom! Under the same initial conditions, the transient process of the system proceeds much more intensively! To do this, we additionally unbalance the initial conditions:

$$v_{x2}(0) = 0.5469 \cdot 10^5;\ v_{y2}(0) = 0;\ r_{x2}(0) = 0;\ r_{y2}(0) = 8.467 \cdot 10^{-10};$$
$$v_{x3}(0) = -v_{x2}(0);\ v_{y3}(0) = 0;\ r_{x3}(0) = 0;\ r_{y3}(0) = -r_{y2}(0).$$

The course of the corresponding transient process under such initial conditions is shown in fig. 3.36.

The previous graphic materials were subordinated to one goal - the qualitative assessment of the obtained simulation results since the physical processes behind them were approximated to the real physical system. Now let's consider an unreal

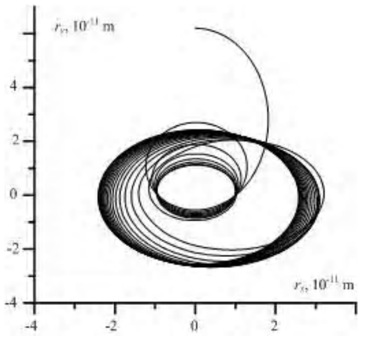


Fig. 3.36. The hodograph of the distance $r_{21y}(r_{21x})$ corresponding to the transient process in fig. 1, but calculated when the initial conditions are unbalanced

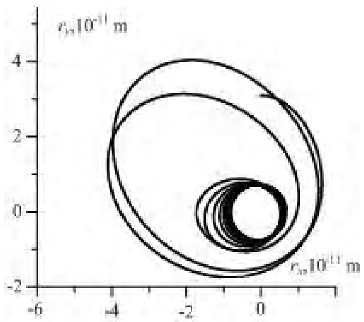


Fig. 3.37. The hodograph of the distance of the electron $r_{21}(t)$ with the planetary placement of the electron orbits:

system similar to the cosmic planetary system. For this, it is enough to place the orbit of the electron q_3 slightly above the orbit of the electron q_2, as a result of which the initial conditions change:

In fig. 3.37 shows the hodograph of the trajectory of the electron closer to the nucleus with the planetary placement of the orbits during the duration of the transition process - $1{,}2 \cdot 10^{-15}$ s. In fig. 3.38 shows the hodograph of the trajectory of the movement of the electron farther from the nucleus during the planetary placement of the orbits in the transition process, which corresponds to the process in fig. 3.37.

It turns out that the distance between moving interacting bodies in the force field occupies a special place in the harmony of the universe. This is the trajectory of the distance $r_{23}(t)$ shown in fig. 3.39 in the transitional process corresponding

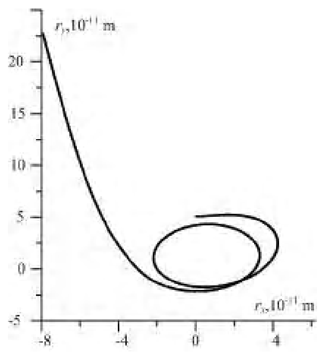


Fig. 3.38. The hodograph of the distance $r_{31}(t)$ of the electron in the transient process corresponding to the process fig. 3.37.

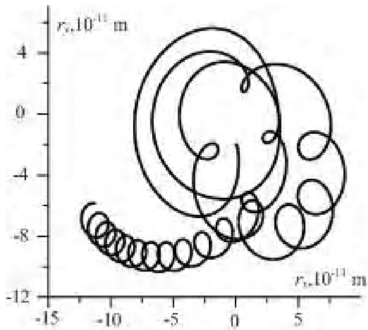


Fig. 3.39. The hodograph of the distance $r_{23}(t)$ between the moving electrons in the planetary arrangement of their orbits with a long time of duration of the transient process T = 5.10-15 s

to the process of fig. 3.37 and fig. 3.38. Who would have thought of such mathematical beauty. In the electric field, due to the strong interaction, this beauty is somewhat dulled, and in the gravitational field, the force interaction of which is significantly inferior to the electric field, this beauty cannot but be enchanted by earthly aesthetics (see fig. 3.33).

The presented results of calculations of model transient processes of the force interaction of a system of three moving charged bodies clearly illustrate the possibilities of our new approach in solving many fundamental problems of electrodynamics, beyond the reach of the methods of classical physics.

2.13. To energy approaches

Maybe we will repeat something, but this is necessary for a comprehensive understanding of the essence of the problem. The analysis of mechanical and electrical dynamic processes becomes a key place in physical research. For moving masses even in the range far enough from the speed of light, Newton's law of universal gravitation does not always provide the necessary accuracy, not to mention sublight speeds. Therefore, it is necessary to turn to overly complex levels of the general theory of relativity (GRT) in the distorted Riemannian space-time, which cannot always be used in practice. So, a reasonable question arises, why not adapt the mentioned law to the case of moving masses in our familiar flat space and physical time, thereby greatly simplifying the problem?

It is clear that such a solution to the problem is not in favor of relativism, which is why at one time Galileo's transformations were outlawed by it, despite the warnings made more than a hundred years ago by Henri Poincare (1854-1912) about the hasty use of Lorentz transformations [9]: "It does not mean that they were forced to do it; they think that the new agreement is more convenient – that's all. And those who do not hold their opinion and do not want to give up their old habits, have every right to keep an old deal. Speaking between us, I think that they will continue to do so for a long time." In [9] we read further: "Poincare's special view of the new theory was not given serious importance. Much later, already in the second half of the 20th century. it became obvious that Poincare was absolutely right when he claimed that no physical experience could confirm the truth of some transformations and reject others as inadmissible. The origins of the misunderstanding of Poincare's views lie in the disclosure of the conditional character of simultaneity. As a result, a misunderstanding of this theory became possible, in which the main focus was on the "failure" of Galileo's transformations. This misunderstanding was reflected in the accepted logic of building the theory of relativity when new properties of motion at high speeds are deduced from the relativistic properties of space and time."

Reflecting on what has been said, it becomes quite clear that the great scientist, even though he himself was the initiator of relativistic mechanics, managed to see the danger from those who undertook to develop the ideas of new physics without having the necessary resource of knowledge and scientific intuition.

A much more radical statement a hundred years later is found in [5]: "The statements of relativists about the inability of classical physics in general, as well as Newton's law of universal gravitation, to describe dynamic processes, are erroneous. To adapt Newton's law to the dynamic fields, all that is required is the correct consideration of the finiteness of the speed propagation of the gravitational field. At the same time, corresponding multipliers appear already in the region of low velocities, and when moving to the speed of light, nonlinear effects are manifested, which are described by transcendental equations - something that can never be described either within the framework of SGT or within the framework of GRT. The inability of relativism to describe dynamic processes arises precisely from the conditions under which their basic formulas appeared, invented for their external similarity to Poisson's law for static fields with the addition of non-physical, also far-fetched postulates... The theory of relativity was the result of a symbiosis of a formalistic approach to the issue of space and arbitrary parcels The consequence of this is its complete inability to answer the real questions of the time. The continuation of the addition of new and new non-obvious assumptions and statements increasingly pushes scientists away from the real study of processes in the universe. Only a return to the original three-dimensional linear space and time of classical physics will return scientists to the path of studying physical processes, rather than juggling symbols and searching for non-existent covariance."

Our attitude to GRT will be discussed in the last chapter (pp. 126-127).

The fate of electricity was much happier. James Clerk Maxwell (1831-1879) united previously separate electricity, magnetism, and optics into one whole, thus creating a unified theory of electromagnetism. This theory covered not only the fundamental laws of statics but also partially the dynamics in all possible ranges of speeds.

The mechanics of moving masses had to catch up with electricity. But along the way, she fell into the trap of mathematical formalism. As a result, a whole series of bright pseudo-effects were imposed on her, with which she naively plays until now, driving herself to a dead end.

The purpose of this work is quite logical - to turn mechanics into the direction of electricity so that it can use all the assets of its glorious theory. And this means continuing the unification of the theory of physical processes begun by Maxwell, but now we are talking about electricity and mechanics. The result of their union can be tentatively called an electro-gravitational field. The absence of the concept of magnetism in this name is not accidental, because it is only a manifestation of the effects of motion in electricity (2.37). But the most important thing is that it was a magnetism that overshadowed the path to the unification of mechanics and electricity, at least for a hundred years.

The experimental laws of statics – I. Newton's law of universal gravitation (1687) (1.1) and Sh. Coulomb's law of electrical interaction (1785) (1.2) was adopted as the basis of unifying efforts. But for the sake of the goal, they had to be adapted to the case of their moving components – masses (2.3) and charges (2.19). But in order to adapt the law (1.2) to real conditions, it is sufficient to consider the time delay of the field interaction! Otherwise, at the frozen moment of time *t,* we will take not the real distance R of the interacting bodies, but the interacting point of the trajectory, taking into account the time lag. Δt .

Since vectors **B** according to (1.15) are of pure vortex origin, their differences must be zero. For electricity $\nabla \cdot \mathbf{B}_q = 0$, this is an experimental fact, for mechanics, it is provable because by definition, the angular velocity vector $\boldsymbol{\omega}$ is the vortex component of the linear velocity $\mathbf{v}$. On this basis, we can write the equation of their continuity as the identity through some vector potential $\mathbf{A}$ of the electric and gravitational fields

$$\nabla \cdot \mathbf{B}_k = \nabla \cdot (\nabla \times \mathbf{A}_k) = 0; \quad k = q,\ m, \tag{2.84}$$

Now the main vectors of the electric and gravitational fields can be expressed in the same way, like the electric field

$$\mathbf{E}_k = -\frac{\partial \mathbf{A}_k}{\partial t}; \quad \mathbf{B}_k = \nabla \times \mathbf{A}_k; \quad k = q,\ m, \tag{2.85}$$

where $\mathbf{A}$ is the vector potential of the electric and gravitational fields. Derived vectors can be found as follows

$$\mathbf{D}_k = \varepsilon_{0k} \mathbf{E}_k; \quad \mathbf{H}_k = \nu_{0k} \mathbf{B}_k; \quad k = q,\ m, \tag{2.86}$$

where **H** is the field intensity vector; ε_{0k} is medium permeability; ν_{0k} is reluctivity of the medium.

Warning **B** and **H** are exclusively vortex vectors, which, according to (1.15), present the effects due to the propagation of the electrygravitational field with a finite speed *c*, and they are by no means expressions of some mythical field like the magnetic field in electricity. That is why we will call them the vectors of induction and intensity of eddy electric and gravitational fields.

Permeability of the medium is found by the constants (1.1), (1.2)

$$\varepsilon_{0k} = 1/(4\pi k_k), \quad k = q,\ m. \tag{2.87}$$

For a vacuum, their numerical values will be::

$$\varepsilon_{0q} = 8.854188 \cdot 10^{-12}\ \mathrm{kg^{-1} m^{-3} s^4 A^2}; \quad \varepsilon_{0m} = 1.192378 \cdot 10^{9}\ \mathrm{kg\ m^{-3} s^2}.$$

The reluctivities of the medium is found by the speed of light (2.36)

$$\nu_{0k} = \varepsilon_{0k} c^2, \quad k = e, m. \tag{2.88}$$

ЇTheir numerical values for vacuum are as follows::

$$\nu_{0q} = 7.957749 \cdot 10^5 \text{ kg}^{-1}\text{m}^{-1}\text{s}^2\text{A}^2; \quad \nu_{0m} = 1.071370 \cdot 10^{26} \text{ kg m}^{-1}.$$

Having the vectors (2.86), we can write the expressions of the specific kinetic T_k , potential P_k and dissipation Φ_k energies as

$$T_k = \frac{\varepsilon_{0k} E_k^2}{2}; \; P_k = \frac{\nu_{0k} B_k^2}{2}; \; \Phi_k = \frac{1}{2}\int_0^t \gamma_k E_k^2 dt, \; k = q, m, \tag{2.89}$$

where γ_k is the dissipation conductivity of the medium.

Based on (2.89) and in accordance with (2.84), we write the energy function of the Hamiltonian action

$$S_k = \frac{1}{2}\int_{t_1}^{t_2} \left(\varepsilon_{0k} \left(-\frac{\partial \mathbf{A}_k}{\partial t} \right)^2 - \nu_{0k} \left(\nabla \times \mathbf{A}_k \right)^2 + \int_0^t \gamma_k \left(-\frac{\partial \mathbf{A}_k}{\partial t} \right)^2 dt \right) dt, \; k = q, \; m. \tag{2.90}$$

Using (2.90) based on the Hamilton-Ostrogradsky variational principle [16-18], we arrive at the equations of the vector potential of the electric and mechanical fields. Note that the GRT still does not have a functional of the type (2.78), which would be filled with energy content. The invariant arising from the Riemann tensor (the scalar curvature of a four-dimensional manifold) claims this role is only a geometric abstraction.

Expressions (2.89), and (2.90) completely cleared the way for us to the main goal – building the combined equations of electricity and gravity not only on a strong mathematical basis, but also on a strong physical one, behind which is the most mysterious substance of the universe – **energy**.

3. ENERGY APPROACHES

3.1. Energy of nonlinear systems

Energy is one of the amazing substances of nature, which we also amazingly use, without knowing its secret. Not only that, we have learned to distinguish its types, we have the principle of conservation of energy, which flows from the principle of least action, which together belong to the general principles of nature, They are wide and universal, subordinating the fundamental laws of physics and the rest of applied of natural sciences. They make it possible to describe the physical process as fully as possible, to find connections that may be inaccessible to classical approaches, and, most importantly, to analyze various physical processes based on a common mathematical apparatus.

In nonlinear systems, new requirements are placed on energy, which were hidden in the case of linear systems. We are talking about the energy of movement.. It turns out that kinetic energy does not work in the variational methods of energy approaches. Instead of it, it is necessary to take the so-called kinetic cooperative energy, which is abbreviated as co-energy. The essence of this relatively new physical quantity will be discussed a little later. Let's go ahead and skip a little wider material related to energy.

3.1.1. Energy densities. Many expressions of energy density can be obtained. It is difficult to judge which of them are true. But there is an agreement that these is the simplest ones. We offer expressions for the densities of all energies involved in (2.89), and (2.90) as follows

$$w_i = \int_0^{\boldsymbol{\eta}} S_i(\boldsymbol{\eta})\boldsymbol{\eta} d\boldsymbol{\eta},\ i = p, k, kc;\ w_\Phi = \int_0^t \int_0^{\mathbf{v}} S_\Phi(\mathbf{v})\mathbf{v} d\mathbf{v} dt;\ w_D = \int_0^t \mathbf{F}\mathbf{v} dt, \qquad (3.1)$$

where $\mathbf{v}, \mathbf{F}$ are velocity vectors and specific external forces; indices p, k, kc, Φ, D indicate involvement in the density of potential and kinetic energy, kinetic co-energy, dissipation energy, and energy of extraneous forces, respectively. As for the last integral, it reproduces sources of energy, which in each specific case is specified separately without any reservations due to external (external) forces and generalized velocities.

Variables $S_i(\boldsymbol{\eta}),\ S_\Phi(\mathbf{v})$ usually have the content of static matrices characterizing the medium or concentrated elements. If we add the contents of the vectors of generalized coordinates, then the left-hand expression (3.1) creates the potential energy density. If $\boldsymbol{\eta}$ it is given the content of generalized impulses, then it reproduces the density of kinetic energy. If it is given the content of generalized velocities, then it reproduces the density of kinetic co-energy. We will show this in the example of electrical and mechanical systems.

3.1.2. Electromagnetic field energy. Here it is customary to express the specific energies in terms of field vectors as derivatives of the vector-potential A (2.69)

$$\mathbf{E} = -\partial \mathbf{A} / \partial t; \quad \mathbf{B} = \nabla \times \mathbf{A}, \tag{3.2}$$

hence (1.7), (1.12)

$$\mathbf{D} = \mathrm{E}(\mathbf{E})\mathbf{E}; \quad \mathbf{H} = \mathrm{N}(\mathbf{B})\mathbf{B}. \tag{3.3}$$

As you can see, vector **B** can be interpreted as a generalized coordinate, and vector **E** as a generalized velocity. Therefore, in the theory of the electromagnetic field, magnetic energy should be interpreted as potential, and electric energy as kinetic [16].

Substituting (3.3) into (3.1), we obtain the expressions of the densities of potential energy and kinetic co-energy

$$w_p == \int_0^{\mathbf{B}} \mathrm{N}(\mathbf{B})\mathbf{B}d\mathbf{B}; \quad w_{kc} = \int_0^{\mathbf{E}} \mathrm{E}(\mathbf{E})\mathbf{E}d\mathbf{E}, \tag{3.4}$$

If $\boldsymbol{\eta}$ we give the meaning of generalized momentum, then expression (3.1) reproduces the density of kinetic energy

$$w_k = \int_0^{\mathbf{D}} \Xi(\mathbf{D})\mathbf{D}d\mathbf{D}, \tag{3.5}$$

where $\Xi(\mathbf{D})$ is the inverse matrix of static electrical permeabilities ($\Xi = \mathrm{E}^{-1}$).

In a linear environment (3.4), (3.5) are simplified to (2.76)

$$w_k = w_{kc} = \frac{\varepsilon E^2}{2}; \quad w_p = \frac{\nu B^2}{2}, \tag{3.6}$$

where ε, ν are constants.

Fig. 3.1 explains the concept of kinetic energy and co-energy in the field of **E-D** vectors. Thus, based on integral dependencies (3.4), and (3.5), the density of electrical energy is determined by the area of the upper curvilinear triangle. While the density of electric co-energy is conditionally determined by the area of the lower curvilinear triangle, which complements the area of the upper one to the area of the rectangle. Based on this, we can write both energies as

$$w_E = \int_0^D \mathbf{E}d\mathbf{D}; \qquad w_{EC} = \int_0^{\mathbf{E}} \mathbf{D}d\mathbf{E}. \tag{3.7}$$

The constructions of fig. 3.1 illustrate the well-known formula of integration by parts, whose members are integrals (3.7).

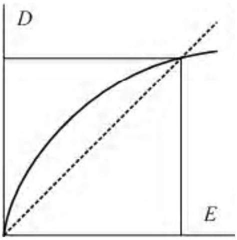


Fig. 3.1. To the concept of energy and co-energy

So, a reasonable question arises: kinetic co-energy is a calculated value, or does it have a deep physical meaning? – The first answer suggests itself: the fact that such universal laws of physics as the principle of conservation of energy and the principle of least action cannot lead to physics of the laws of nature, based on energy transformations of non-physical quantities. But we will try to discuss this in a little more detail. Although we will not get a comprehensive answer, we will shed some light on the problem.

In the theory of circles, everything is the other way around – electric energy is determined by the charges of capacitors q, and magnetic energy is determined by the currents i of the inductance coils and, as the rates of change of the charges. The derived quantities are found as

$$u = q / C'(q); \quad \Psi = L'(i)i, \tag{3.8}$$

where u, Ψ ares the voltage of the capacitor and the complete flux coupling of the inductance coil; $C'(q)$, $L'(i)$ are static capacitance of the capacitor and inductance of the coil.

The electric and magnetic energies of the electromagnetic field are determined by expressions

$$W_E = \int_V w_E dV; \qquad W_M = \int_V w_M dV, \tag{3.9}$$

where w_E, w_M, are the electric and magnetic energy densities

$$w_E = \int_0^D \mathbf{E}d\mathbf{D}; \qquad w_M = \int_0^B \mathbf{H}d\mathbf{B}. \tag{3.10}$$

In the case of a linear medium, expressions (3.10) are simplified and take the form (2.89)

$$w_E = \frac{\mathbf{ED}}{2}; \qquad w_M = \frac{\mathbf{HB}}{2}. \tag{3.11}$$

From the standpoint of the theory of the electromagnetic field, the values of the energy densities are postulated as follows: electric and magnetic energy are localized in the field and distributed over a volume with a certain density. They are postulated because many expressions for the field energy can be obtained, and it is still impossible to determine which of them is correct, and (3.11) are the simplest.

The corresponding (3.9) energy densities of electromagnetic circuits are similar to (3.10)

$$W_M = \int_0^{\Psi} i(\Psi)d\Psi; \quad W_E = \int_0^{i} u(q)dq, \tag{3.12}$$

In the theory of linear systems, kinetic and potential energy comprehensively describe the real process in a lossless system. When moving to non-linear, the concept of potential energy remains valid, and the concept of kinetic energy loses its meaning. Its place is occupied by the concept of kinetic co-energy, introduced for the first time by E. Cherry and U. Millar [27]. We first encountered the concept of kinetic co-energy in electrical systems with concentrated parameters in the works of the Americans D. White and H. Woodson [14], and in systems with distributed parameters – by the Ukrainian A. Chaban [16,17], who gave him such a weight, which we can rightfully say: the concept of kinetic co-energy is the key to interdisciplinary mathematical modeling of physical processes, to which there is still no alternative.

To the question: kinetic co-energy is a calculated value, or does it have a deep physical meaning? – We strongly adhere to the opinion that this is a real value and an initial value. But then another thought arises: can one abandon kinetic energy in favor of kinetic co-energy? – But before passing judgment on kinetic energy, we will show that it is possible to arrive at it based on the purely experimental Coulomb's law.

3.1.3. Regarding the steadfastness of the concept of electric energy. The temptation to replace kinetic energy with kinetic co-energy is at least in the fact that the first does not work in variational methods, and the second does. We came to the concept of energy from Maxwell's equations, and they involve both the postulate and the relativistic effect. So let's try to approach the problem from a purely experimental Lorentz equation. At the very least, the question should be removed: is it not possible to go to co-energy in the same way as we went to energy?

Let's give each of the Lorentz force terms (1.10) the following form

$$d\mathbf{F}_E = qd\mathbf{E}; \quad d\mathbf{F}_M = q\left(\mathbf{v}\times d\mathbf{B}\right). \tag{3.13}$$

Integrating (3.13), we obtain

$$\mathbf{F}_E = \int_0^{\mathbf{E}} qd\mathbf{E}; \quad \mathbf{F}_M = \int_0^{\mathbf{B}} q\left(\mathbf{v}\times d\mathbf{B}\right). \tag{3.14}$$

Let's analyze each of these expressions separately.

The kinetic energy of an electric field. The first expression (3.14) presents the Coulomb force in a vortex-free electric field ($\nabla\times\mathbf{E}=0$). If we take into account that the flow of the induction vector of the electric field is directed to the middle of the integration volume ($\nabla\cdot\mathbf{D}=-\rho$), where ρ is the density of the volumetric charge, then we can give the first expression (3.14) the form

$$\mathbf{F}_E = -\int_0^{\mathbf{E}}\int_V \rho dVd\mathbf{E} = -\int_V\int_0^{\mathbf{E}} (\nabla\cdot\mathbf{D})d\mathbf{E}dV. \tag{3.15}$$

We write the inner integral in (3.15) according to the theorem for vortex-free fields $(\nabla\times\mathbf{E}=0)$

$$\int_0^{\mathbf{D}(\mathbf{E})} (\nabla\cdot\mathbf{D})d\mathbf{E} = \nabla\int_0^{\mathbf{D}} \mathbf{E}d\mathbf{D}. \tag{3.16}$$

Substituting (3.16) into (3.15), we arrive at the classical expression

$$\mathbf{F}_E = -\nabla\int_V\int_0^{\mathbf{D}} \mathbf{E}d\mathbf{D}dV; \tag{3.17}$$

Which had to be proved.

The potential energy of the magnetic field. If we take into account Ampere's law

$$\rho\mathbf{v} = \boldsymbol{\delta} = \nabla\times\mathbf{H}, \tag{3.18}$$

then we can give the second expression (3.13) the form

$$\mathbf{F}_M = \int_0^{\mathbf{B}}\int_V \rho dV\left(\mathbf{v}\times d\mathbf{B}\right) = \int_V\int_0^{\mathbf{B}}\left(\nabla\times\mathbf{H}\times d\mathbf{B}\right)dV. \tag{3.19}$$

The inner integral in (3.19) under the condition $\nabla\cdot\mathbf{B}=0$ will be [21]

$$\int_0^{\mathbf{B}}\left(\nabla\times\mathbf{H}\times d\mathbf{B}\right) = -\nabla\int_0^{\mathbf{B}}\mathbf{H}d\mathbf{B}. \tag{3.20}$$

Substituting (3.20) into (3.19), we arrive at the second expression

$$\mathbf{F}_M = -\nabla\int_V\int_0^{\mathbf{B}}\mathbf{H}d\mathbf{B}dV. \tag{3.21}$$

Which had to be proved.

To be more consistent, we still arrive at (3.17), and (3.21) with the accuracy of the gradient. Thus, the postulated expressions of electric and magnetic specific energies in a nonlinear anisotropic medium (in a linear medium as a special case) can be arrived at based on the experimental fundamental laws of electromagnetism. Therefore, these concepts are unshakable. Therefore, it is necessary to look for fundamentally new ways to co-energy. We will give our opinion about both energies, but first, we will move on to their power manifestations.

3.1.4. Power characteristics. A measurable quantity of energy is force. We will look for the density of forces by their gradients

$$\mathbf{f}_{kc} = -\nabla w_{kc};\quad \mathbf{f}_k = -\nabla w_k. \tag{3.22}$$

Substituting here (3.4), and (3.5), we get

$$\mathbf{f}_{kc} = -\nabla\int_0^{\mathbf{E}}\mathbf{D}d\mathbf{E},\quad \mathbf{f}_k = -\nabla\int_0^{\mathbf{D}}\mathbf{E}d\mathbf{D}. \tag{3.23}$$

Since the gradient of the product of vectors is a complex expression, further analysis will be done by individual components

$$f_{kc\xi} = -\frac{\partial}{\partial\xi}\int_0^{\mathbf{E}}\mathbf{D}d\mathbf{E},\quad f_{k\xi} = -\frac{\partial}{\partial\xi}\int_0^{\mathbf{D}}\mathbf{E}d\mathbf{D},\quad \xi = x, y, z. \tag{3.24}$$

The second expression is the most important

$$f_{k\xi} = -\int_0^{\mathbf{D}} \frac{\partial \mathbf{E}}{\partial \xi} d\mathbf{D} - \int_0^{\partial \mathbf{D}/\partial \xi} \mathbf{E} d\frac{\partial \mathbf{D}}{\partial \xi}, \quad \xi = x, y, z. \tag{3.25}$$

Let's replace the differential in the second term

$$\int_0^{\partial \mathbf{D}/\partial \xi} \mathbf{E} d\frac{\partial \mathbf{D}}{\partial \xi} = \mathbf{E}\frac{\partial \mathbf{D}}{\partial \xi} - \int_0^{\mathbf{D}} \frac{\partial \mathbf{E}}{\partial \xi} d\mathbf{D}, \quad \xi = x, y, z. \tag{3.26}$$

Substituting (3.26) into (3.25), we obtain

$$f_{k\xi} = -\mathbf{E}\frac{\partial \mathbf{D}}{\partial \xi}, \quad \xi = x, y, z. \tag{3.27}$$

Adding terms (3.24) to each other and taking into account the theorem of integration by parts, we obtain

$$f_{k\xi} + f_{kc\xi} = -\frac{\partial}{\partial \xi}(\mathbf{ED}) = -\frac{\partial \mathbf{E}}{\partial \xi}\mathbf{D} - \mathbf{E}\frac{\partial \mathbf{D}}{\partial \xi}, \quad \xi = x, y, z. \tag{3.28}$$

Comparing (3.27) and (3.28), we get

$$f_{kc\xi} = -\frac{\partial \mathbf{E}}{\partial \xi}\mathbf{D}, \quad \xi = x, y, z. \tag{3.29}$$

To compare the force actions of kinetic energy and co-energy, let's give their expressions a slightly different form

$$f_{kc\xi} = -\frac{\partial \mathbf{E}}{\partial \xi}(\mathrm{E}'\mathbf{E}); \quad f_{k\xi} = -\mathbf{E}\left(\mathrm{E}''\frac{\partial \mathbf{E}}{\partial \xi}\right), \quad \xi = x, y, z, \tag{3.30}$$

where $\mathrm{E}'(E)$, $\mathrm{E}''(E)$ are the matrices of static and differential electrical permeability. Thus, the power characteristics of kinetic energy are manifested through the differential permeability of the medium, and kinetic co-energy through static ones. In everything else, these expressions almost coincide. In a linear environment, the forces $f_{k\xi} = f_{kc\xi}$ also coincide, because then $\mathrm{E}' = \mathrm{E}''$.

Let's turn to mechanical analogies: $\mathbf{A} \to \mathbf{r}, \mathbf{E} \to \mathbf{v}, \mathbf{D} \to \mathbf{p}, \boldsymbol{\delta}_b \to \mathbf{f}$, $\varepsilon \to m$, where, respectively, distance, speed, momentum, force, and mass (actually specific). From this point of view, a well-known expression can be seen in the analogy of Maxwell's postulate

$$\mathbf{f} = d\mathbf{p} / dt = m'' d\mathbf{v} / dt, \tag{3.31}$$

where m'' is the differential mass. Therefore, the appearance of the differential permeability matrix in (3.30) is quite natural. Therefore, the true power characteristic of the electromagnetic field should be recognized as the power action of kinetic energy, not co-energy. To understand this more deeply, let's turn to a mechanical problem.

3.1.5. Relativistic co-energy. We write the relativistic co-energy of a moving point mass as (3.4)

$$w_{kc} = \int_0^v m'(v) v dv, \tag{3.32}$$

where $m'(v)$ is the static relativistic mass

$$m'(v) = \frac{m_0}{\sqrt{1 - v^2 / c^2}}, \tag{3.33}$$

and m_0, c, v rest mass, the speed of light in a vacuum, the real speed of a point.

After integration, we obtain (3.32).

$$w_{kc} = m_0 c^2 \left(1 - \sqrt{1 - v^2 / c^2}\right). \tag{3.34}$$

For comparison with (3.34), we obtain the expression of the relativistic kinetic energy. Why do we use expression (3.5)

$$w_k = \int_0^p m'(v)^{-1} p dp, \tag{3.35}$$

where p is the relativistic momentum

$$p = \frac{m_0 v}{\sqrt{1 - v^2 / c^2}} \tag{3.36}$$

On the basis of (3.32)-(3.36), we obtain

$$dp = \frac{dp}{dv}dv = m''(v)dv, \qquad (3.37)$$

where $m''(v)$ is the differential relativistic mass

$$m''(v) = \frac{m_0}{(1 - v^2/c^2)^{3/2}}. \qquad (3.38)$$

Substituting (3.33) into (3.35), after integration we arrive at the well-known expression of the relativistic kinetic energy

$$w_k = m'(v)c^2\left(1 - \sqrt{1 - v^2/c^2}\right). \qquad (3.39)$$

When $v = 0$ both kinetic energies (3.34) and (3.39) are equal to zero $w_k\big|_{v=0} = w_{kc}\big|_{v=0} = 0$, and when $v = c$ they are different $w_k\big|_{v=c} = \infty$; $w_{kc}\big|_{v=c} = m_0c^2$. For velocities significantly lower than the speed of light in a vacuum $(v \ll c)$, the kinetic co-energy coincides with the kinetic energy – $w_k = w_{kc} = m_0v^2/2$. It was this coincidence that led to the fact that one of them stood in for the other and made the one represented invisible! To make sure of this, it is enough to expand the Lorentz coefficient according to the binomial theorem, limiting ourselves to terms of the second order of smallness,

$$\frac{1}{\sqrt{1 - v^2/c^2}} = 1 + \frac{1}{2}\frac{v^2}{c^2}, \qquad (3.40)$$

and substitute the obtained result in (3.34), and (3.39). The guarantee of formulas (3.34), and (3.39) is determined by the currently accepted curvature of relativistic space $p = p(v)$. If it is revised, then according to (3.31), and (3.35) they will also undergo corresponding changes!

3.1.6. Relativistic dynamics. It plays an important role in the theory of gravity, where bodies are subjected to external forces. So let's look for them in the general case – through the gradient of the corresponding energies

$$F_k = -\frac{\partial w_k}{\partial x}; \quad F_{kc} = -\frac{\partial w_{kc}}{\partial x}. \qquad (3.41)$$

Substituting (3.39) into (3.41) and taking into account that $x = x(v(t))$, after differentiation we obtain

$$F_k = \frac{m_0}{\left(1 - v^2 / c^2\right)^{3/2}} a = m''(v)a, \tag{3.42}$$

where $a = dv / dt$ is the acceleration.

Substituting (3.34) into (3.41), we obtain

$$F_{kc} = \frac{m_0}{\sqrt{1 - v^2 / c^2}} a = m'(v)a. \tag{3.43}$$

Comparing (3.42) and (3.43), we see that as a result of using energy and co-energy at relativistic velocities, we came to different results. But at speeds $v \ll c$, both forces are equal to each other, because $m'(v) = m''(v) = m_0$.

To answer the question of which of the forces F_k or F_{kc} is real for us, we need to turn to the time derivative of the momentum, which is common to both energies,

$$F = \frac{dp}{dt} = \frac{dp}{dv}\frac{dv}{dt} = m''(v)a = F_k. \tag{3.44}$$

Kinetic co-energy in relativism frees his theory from several contradictions:

1. Due to the nonlinearity of relativistic effects, kinetic energy does not work in variational methods. Therefore, specialists in the theory of gravitation, who do not know about the presence of co-energy, had to manually select the required function $-m_0 c^2 \sqrt{1 - v^2 / c^2}$ (convergent to (3.34), but without a constant term), which disappears during differentiation [15].

2. Moving to the dynamics at different energies w_k and w_{kc}, a crisis of relativistic mass, both longitudinal and transverse, arose. In our presentation, the transverse is static (3.33), and the longitudinal is differential (3.38).

Understanding the physical essence of kinetic co-energy is even more difficult than energy. But we consider it necessary to say our own opinion about its relation to energy. Variational methods as mediators of the principle of conservation of energy operate with the concept of only kinetic co-energy as "primary". Having passed through a certain medium or vacuum filling this space, it appears in the form of kinetic energy. In this medium, part of the electric co-energy is spent against its "non-linearity", therefore it is always $w_k < w_{kc}$. In relativism, the nonlinearity of space, on the contrary, by its very nature feeds co-energy, as a result of which there is always $w_k > w_{kc}$. In the absence of nonlinearity $w_k = w_{kc} = \; = pv/2$. In this way, the phenomenon of energy accompanying movement appears as kinetic co-energy and is manifested as kinetic energy and its corresponding force action (3.44). Therefore, the kinetic co-energy in this case $w_k > w_{kc}$ can be interpreted as active, which increases the kinetic energy, as a force manifestation, and in this case $w_k < w_{kc}$ – as passive, which decreases it in the process of movement. In the case of gravity, where analytical methods are applicable, in relation

$$\frac{w_{kc}}{w_k} = \sqrt{1 - v^2 / c^2} \tag{3.45}$$

the relativism of motion energy is clearly visible. And this gives grounds in the first approximation to generalize what has been said to the rest of the types of movement of the matter!

Summarizing this complex theoretical material, we must say, although not as the last truth, the following. *Kinetic energy and co-energy are inseparable from each other. Movement in any physical system is accompanied by the transformation of co-energy into energy as an expression of force action and the principle of energy conservation. Moreover, this transformation can be active and passive depending on the type of movement, electrical, mechanical, etc. The divide into two of kinetic energy into energy and co-energy is a consequence of the manifestation of the relativistic effect of motion. This movement can take place at the micro-, macro-, and mega-level.*

3.1.7. The formal essence of motion energy. We will try to penetrate deeper into the essence of kinetic energy and co-energy of moving mass from the point of view of SRT, based on the relativistic properties of motion. Kinetic energy. Based on (3.33), let's write the expression (3.39) of the kinetic energy in a slightly different way

$$w_k = \Delta m c^2, \qquad . \tag{3.46}$$

where Δm is the relativistic increase of static mass

$$\Delta m = \left(m'(v) - m_0 \right). \tag{3.47}$$

Expressions (3.46), and (3.47) suggest that the kinetic energy of motion is nothing but the energy of the relativistic surplus (increase) of the rest mass in the range of speeds $0 \le v \le c$!

To be sure of the interpretation of the thought in the non-relativistic case, it is enough to use the binomial theorem (3.40) in (3.33), (3.47)

$$\Delta m = m_0\left(1+\frac{1}{2}\frac{v^2}{c^2}-1\right)=\frac{m_0 v^2}{2c^2}. \tag{3.48}$$

kinetic energy Substituting (3.48) into (3.46), we obtain the known expression of the non-relativistic

$$w_k = \frac{m_0 v^2}{2}. \tag{3.49}$$

Which had to be proved.

Kinetic co-energy. Similar to (3.46), we also write the expression (3.34) of the kinetic co-energy

$$w_{kc} = \delta m c^2, \qquad . \tag{3.50}$$

where δm is the relativistic rest mass loss

$$\delta m = \left(m_0 - m_c(v)\right), \tag{3.51}$$

where $m_c(v)$ is the relativistic cooperative mass (co-mass), it is easily identified by the expression (3.34)

$$m_c(v) = m_0\sqrt{1-v^2/c^2}. \tag{3.52}$$

We dared to introduce the concept of cooperative mass not formally to the agreement of cooperative energy, which faithfully serves variational energy principles for more than half a century, but because without its legalization certain difficulties arise in the progress of the theory of nonlinear systems. Until now, we have operated only with two relativistic masses, static (3.33) and differential (3.38). Therefore, it is desirable to express its new form (3.52) in terms of the two previous, well-known ones. This can be easily done based on a comparative analysis of expressions (3.33), (3.38), and (3.52)

$$m_c(v) = \frac{m'(v)^2}{m''(v)}. \tag{3.53}$$

Based on (3.50), and (3.51) we can define the nature of the relativistic co-energy. *Kinetic co-energy is nothing but the energy of the relativistic deficit* *(loss) of rest mass in the speed range* $0 \le v \le c$ *!*

If we differentiate by speed (3.34) and (3.39), then based on (3.33), (3.36), and (3.38) we can write

$$\frac{dw_{kc}}{dv} = m'(v)v = p; \qquad \frac{dw_k}{dv} = m''(v)v \neq p. \tag{3.54}$$

As we can see, only kinetic energy is involved in force interactions in the principle of conservation of energy. It would seem that kinetic co-energy has been relegated entirely to the field of variational energy methods. But the expressions (3.54) deny this: the relativistic momentum p, which is the main characteristic of the curvature of space, is a property of co-energy, not energy!

It is worth comparing the limit values of the considered energies and masses:

швидкість	w_k	w_{kc}	m'	m''	m_c
$v=0$	0	0	m_0	m_0	m_0
$v=c$	∞	m_0c^2	∞	∞	0

Formula (3.53) raises the question: is co-mass involved in physical interactions, or is it only the result of mathematical manipulations with static and differential masses, as parameters of any nonlinear physical system. We lean in favor of physical interaction. Because the priority is energy, not mass. There is co-energy, there must be co-mass. But all this, it must be admitted, is a surreal antic of SRT.

3.2. General principle of conservation of energy

We began this chapter by thinking about two principles - least action and conservation of energy, as fundamental in nature. But since the first of them in nonlinear systems operate with the concept of kinetic co-energy instead of energy, it is necessary to know which of them should appear in the second. Moreover, in one case $w_k > w_{kc}$, and in another $w_k < w_{kc}$, which also gives rise to certain reservations.

But first, a few words about the typical fate of a great discovery. The authorship of the principle of conservation of energy belongs to the German scientist Julius Robert von Mayer. He expressed his thoughts in the work of 1841. "On the Quantitative and Qualitative Determination of Forces", which he sent first to the then-leading journal "Annalen der Physik und Chemie", where it was rejected by the editor-in-chief of the journal Johann Poggendorff, after which the article was published in "Annalen der Chemie und Pharmacie", where it remained invisible until 1862 when Clausius found it. Johann Hristiyan Poggendorff is a German physicist, an extraordinary professor at the University of Berlin, member of the Berlin, Swedish Royal, and St. Petersburg Imperial Academies of Sciences. Unfortunately, such poggendorffs also fit into Mayer's law - as indestructible in time!

3.2.1. The case of a non-linear electric circuit. Let's consider the simplest imaginary problem – the discharging of an excited nonlinear inductance coil with characteristic $i(\psi) = a\psi + b\psi^3$ on a resistor . In this case, the dissipation energy will be

$$W_\Phi = \int_0^t uidt = \int_0^t \frac{d\psi}{dt} idt = \int_0^t \frac{d\psi}{dt}\left(a\psi + b\psi^3\right)dt = \frac{1}{2}\left(a + \frac{1}{2}b\psi^2\right)\psi^2. \quad (3.55)$$

According to (3.12), we find the kinetic energy and co-energy of the coil

$$W_k = \int_0^\psi i(\psi)d\psi = \frac{1}{2}\left(a + \frac{1}{2}b\psi^2\right)\psi^2; \; W_{kc} = \int_0^\psi \psi(i)di = \frac{1}{2}\left(a + \frac{3}{2}b\psi^2\right)\psi^2. \quad (3.56)$$

As we can see, the law of energy is unshakable.

3.2.2. The case of gravity. Consider the imaginary problem of free fall of a rest mass m_0 from a height h onto a spherical supermassive body. In this case, the potential energy $w_p = m_0 gh$, where g is the gigantic acceleration of free fall at a given height, must be transformed either into kinetic energy (3.39) or into its corresponding co-energy (3.34):

$$m_0 gh = m_0 c^2 \left(\frac{1}{\sqrt{1 - v_k^2 / c^2}} - 1 \right); \; m_0 gh = m_0 c^2 \left(1 - \sqrt{1 - v_{kc}^2 / c^2}\right). \quad (3.57)$$

This is where the advantages of the energy approach over the traditional approach become apparent: we can determine the fall speed at zero height without delving into the gravitational effects during the fall. From (3.57) we have:

$$v_k = c\sqrt{1 - \left(1 - \frac{gh}{c^2}\right)^{-2}}; \quad v_{kc} = c\sqrt{1 - \left(1 - \frac{gh}{c^2}\right)^{2}}. \quad (3.58)$$

The justice of one of them can be obtained from a qualitative analysis at $gh \to \infty$: $v_k \to c$; $v_{kc} \to j\infty$. The second result takes us beyond the limits of reality.

And in this case, the legal right to energy is inviolable.

3.3. The general principle of least action

The principle of least action, together with the principle of conservation of energy, which follows from it, belong to the general principles of nature, are distinguished by their breadth and universality, and subordinate to them the fundamental laws of physics and the rest of the applied natural sciences. Let us show the superiority of the first of them in the electromagnetic field. It enables the most complete description of a physical process, to find connections that may be inaccessible to classical approaches, and, most importantly, to analyze various physical processes based on a common mathematical apparatus. Variational methods of mathematics are a direct expression of the principle of least action.

Variational methods operate primarily with the concepts of kinetic and potential energy. These concepts are usually relative and depend on the choice of certain generalized coordinates and generalized velocities. The part of energy related to coordinates is interpreted as potential, and the part related to velocities - as kinetic. In the electromagnetic field, the kinetic energy is the electric field energy, and the potential energy is the magnetic field energy. The relationship between the field vectors and the main vector of electromagnetism is decisive here [16,17].

Let's use the concept of action according to Hamilton

$$S = \int_{t_1}^{t_2} L dt. \tag{3.59}$$

The function L is often called the non-conservative Lagrange function

$$L = T - P + \Phi - D, \tag{3.60}$$

where T, P, Φ, D are the densities of kinetic and potential energy, dissipation, and external energy. These values according to (2.89), and (2.90) are written as

$$T = \frac{\varepsilon}{2}\left(-\frac{\partial \mathbf{A}}{\partial t}\right)^2; \; P = \frac{\nu}{2}(\nabla \times \mathbf{A})^2; \; \Phi = \frac{\gamma}{2}\int_0^t \left(-\frac{\partial \mathbf{A}}{\partial t}\right)^2 dt; \; D = 0. \tag{3.61}$$

Each path in space-time has its own number (3.59). According to the principle of least action, the path for which this number is minimal will be true. One way could be to count the action for a large number of paths and choose the smallest one. This path will be real. But we will proceed more simply: we will use the property of the minimum, that when deviate from it by the distance of the first order, the function deviates from its minimum only by the value of the second order And in any other place - also by the magnitude of the first order. If first-order changes occur with some deviation, then these changes in action are proportional to the deviation. They increase the effect otherwise it would not be a minimum. And since the changes are proportional to the deviation, then changing the sign affects the action differently. The only way to guarantee a minimum is that there are no changes in the first approximation and that these changes are proportional to the square of the deviation from the true path.

Denote by the $\mathbf{A}^*$ sought true path of the vector-potential in space-time. Some other one, which differs from the true one by a small amount $\mathbf{\Delta}$, will be denoted as **A**. The idea is that the difference between actions (3.50) in both cases for $\mathbf{A}^*$, and for **A** in the first approximation to $\mathbf{\Delta}$ should be zero. Individual actions may differ in the second order, but in the first order, the difference must be zero! And this must be followed for any $\mathbf{\Delta}$. At the same time, each path must begin at a certain point in time t_1 and end at a second certain point in time t_2. These points and moments are fixed. So our deviation $\mathbf{\Delta}$ must be zero at both ends $\mathbf{\Delta}(t_1)=0$ and $\mathbf{\Delta}(t_2)=0$. Under such conditions, our mathematical problem becomes completely defined.

We have successfully solved the problem of the vector potential of the electromagnetic field in such a direct formulation of the principle of least action. Its direct result [21]

$$\varepsilon\frac{\partial^2\mathbf{A}^*}{\partial t^2}+\gamma\frac{\partial\mathbf{A}^*}{\partial t}=-\nu\nabla\times\nabla\times\mathbf{A}^*. \tag{3.62}$$

The obtained result is difficult to overestimate. He shows that the electromagnetic process in space-time does not proceed arbitrarily, but is subject to the basic law of electromagnetism – the vector-potential equation, which in turn is subject to the general principle of nature – the principle of least action, which accompanies a physical process along a path that has a minimum of action! H. Poincare says about this: *"Here, each particle seems to know the point where they want to take it, predicts the time it will spend on this or that road, and finally chooses the most suitable one, becoming, as it were, a living being with free will."* These words unwittingly lead us to the philosophical trend of hylozoism – the doctrine of the spiritualization of nature.

According to its followers, the philosophical understanding of hylozoism as a doctrine of the general inspiration of nature is due to the urgent need to strengthen the awareness of the global responsibility of man for his actions and to form cosmic-planetary thinking with a special (respectful) attitude towards the surrounding world, which should contribute to raising the level of humanity's spirituality. Such a philosophy is designed to produce a generalized system of human views on the world, a person's place in it, and a socio-political, moral, and aesthetic relationship of a person to the world, to form the spiritual culture of mankind.

Next, we will show a simpler unified solution to similar problems.

3.4. Variational principle of Hamilton-Ostrogradsky

Depending on the presence of certain elements in the system, the physical process is described by differential equations with partial and ordinary derivatives. Usually, we come to them in different ways in the subject area of research: electricity, mechanics, thermodynamics, etc. In order to direct the further course of mathematical modeling in a single direction, we propose the known physics integral variational principle of Hamilton-Ostrogradsky, which is a mathematical expression of the general principle of least action. This principle makes it possible to combine all these disparate methods and present them as a single elegant mathematical apparatus for the analysis of processes of the most diverse origin. The starting point here is the total energy of the system. If it is possible to write it down, then the next stage is reduced to formal mathematical transformations, without delving into physical laws.

The Hamilton-Ostrogradsky equation is related to the variation of the integral

$$\delta\int_A^B L dt = \delta\int_{t_1}^{t_2} L dt = 0, \tag{3.63}$$

where L is a non-conservative Lagrange function (3.60); *A, B* are two points of S-dimensional space corresponding to two positions of the system at different moments of time.

The Hamilton-Ostrogradsky principle can be formulated as follows: the actual movement of the system between two given positions differs from the possible movements carried out in the same time between the same given positions, in that for the actual movement the variation of the action according to Hamilton is zero.

3.4.1. Protoenergy. Having gained some experience in constructing the fundamental differential equations of physical systems based on the formal mathematical apparatus (3.63), we could not help but pay attention to the formal expressions (3.1), and (3.61) of obtaining the sub integral energy function. So it is time to generalize the Lagrange function itself (3.60) on their basis

$$L = \int_0^{\mathbf{v}} S_v(\mathbf{v})\mathbf{v}d\mathbf{v} - \int_0^{\boldsymbol{\eta}} S_\eta(\boldsymbol{\eta})\boldsymbol{\eta}d\boldsymbol{\eta} + \int_0^t \int_0^v S_\Phi(\mathbf{v})\mathbf{v}d\mathbf{v}dt - \int_0^t \mathbf{F}\mathbf{v}dt, \qquad (3.64)$$

where $S_\eta(\boldsymbol{\eta}), S_v(\mathbf{v}), S_\Phi(\mathbf{v})$ are matrices of static parameters responsible for potential, kinetic, and dissipation energy; $\boldsymbol{\eta}$, $\mathbf{v}$ are vectors of generalized coordinates and velocities.

The expression (3.64) is evidence of how sciences, which do not have a direct connection, mutually illuminate each other through analogy. It reproduces not only real densities of potential energy, kinetic co-energy, and dissipation energy in any physical system, but also virtual values, as in the case of temperature fields. Due to these unique energy properties, the total integral (3.64) describing a specific physical action is called the protoenergy density. The combination of (3.63), and (3.64) with the principle of conservation of energy creates a closed cycle of formal analysis of nonlinear physical systems based on a common mathematical apparatus.

In linear physical systems, integrals (3.64) are significantly simplified

$$L = \frac{1}{2}\left(S_v v^2 - S_\eta \eta^2 + S_\Phi \int_0^t v^2 dt \right) - \int_0^t \mathbf{F}\mathbf{v}dt. \qquad (3.65)$$

Let's fill (3.65) with some specific content.

3.4.2. Equations of mechanical motion. Expanding the variation in (3.63) in detail, we write

$$\int_{t_1}^{t_2} \left(\sum_{i=1}^{n} \frac{\partial L}{\partial q_k} \delta q_k + \sum_{i=1}^{n} \frac{\partial L}{\partial \dot{q}_k} \delta \dot{q}_k \right) dt = 0. \qquad (3.66)$$

where $\dot{q}$ is the time derivative of the vector of generalized coordinates $q = (q_1, q_2, ..., q_n)$.

Let's transform the integral

$$\int_{t_1}^{t_2} \frac{\partial L}{\partial \dot{q}_k} \delta \dot{q}_k dt = \int_{t_1}^{t_2} \frac{\partial L}{\partial \dot{q}_k} \frac{d}{dt} \delta q_k dt = \int_{t_1}^{t_2} \frac{\partial L}{\partial \dot{q}_k} d\delta q_k \ . \qquad (3.67)$$

Applying integration by parts to (3.67), we have

$$\int_{t_1}^{t_2} \frac{\partial L}{\partial \dot{q}_k} d\delta q_k = \left[\frac{\partial L}{\partial \dot{q}_k} \delta q_k \right]_{t_1}^{t_2} - \int_{t_1}^{t_2} \frac{d}{dt} \frac{\partial L}{\partial \dot{q}_k} \delta q_k = -\int_{t_1}^{t_2} \frac{d}{dt} \frac{\partial L}{\partial \dot{q}_k} \delta q_k , \tag{3.68}$$

since the variation of generalized coordinates at points A and B is zero.

Returning to (3.63), based on (3.66)-(3.68) we can write

$$\int_{t_1}^{t_2} \sum_{i=1}^{n} \left(\frac{\partial L}{\partial q_k} - \frac{d}{dt} \frac{\partial L}{\partial \dot{q}_k} \right) \delta q_k dt = 0 . \tag{3.69}$$

Since the limits of integration were chosen arbitrarily and due to the arbitrariness of the variations of the generalized coordinates, we can write the desired equation of motion based on (3.69)

$$\frac{\partial L}{\partial q_k} - \frac{d}{dt} \frac{\partial L}{\partial \dot{q}_k} = 0, \qquad k = 1, 2, ..., n , \tag{3.70}$$

known as the Lagrange equation of the second kind for systems with a finite number of degrees of freedom.

3.4.3. Electric circuit equation. Let four ideal elements with lumped parameters be involved in the circuit: EMF – *e*, a coil with inductance *L*, a capacitor with capacity *C* and a resistor with resistance *R*. As a generalized coordinate, we will take the charge of the capacitor (*Q*). We will take the electric current (*i*) as the time derivative of the generalized coordinate. All the energies involved in (3.65) have the form

$$T = \frac{Li^2}{2}; \quad P = \frac{Q^2}{2C}; \quad \Phi = \int_0^t \frac{Ri^2}{2} dt; \quad D = \int_0^t eidt. \tag{3.71}$$

Substituting (3.71) into (3.70), we finally get

$$L\frac{di}{dt} = e - \frac{Q}{C} - Ri. \qquad \frac{dQ}{dt} = i. \tag{3.72}$$

In the case of a complex circuit, the energies of all elements should be involved in (3.71), and one or another method of analysis is obtained by choosing generalized coordinates, for example, contour charges.

3.4.4. The equation of a homogeneous line. Consider the equation of a two-wire homogeneous line as an element with distributed parameters. Linear parameters of the line: L_0 is inductance; C_0 is capacity; R_0 is resistance; G_0 is conductivity. As a generalized coordinate, we will accept the charge ($q = Q$). As the time derivative of the generalized coordinate, we will take the electric current ($\dot{q} = i$). But now we cannot use (3.70) as the equations of a system with a finite number of degrees of freedom. So it is necessary to turn directly to the expression (3.63), which takes the form

$$\delta\int_{t_1}^{t_2}\left(\int_l L dx\right)dt = 0. \tag{3.73}$$

where l is the length of the line.

In this case, the Lagrange function must satisfy the differential equation (we will give its derivation later in a more general statement of three-dimensional space)

$$\frac{\partial L}{\partial q} - \frac{\partial}{\partial x}\frac{\partial L}{\partial\left(\frac{\partial q}{\partial x}\right)} - \frac{\partial}{\partial t}\frac{\partial L}{\partial\left(\frac{\partial q}{\partial t}\right)} = 0. \tag{3.74}$$

All energies involved here will be [16, 18]

$$T = \frac{L_0 i^2}{2};\; P = \frac{1}{2C_0}\left(\frac{\partial Q}{\partial x}\right)^2;\; \Phi = \int_0^t \left(\frac{R_0 i^2}{2} - \frac{G_0}{2C_0^2}\left(\frac{\partial Q}{\partial x}\right)^2\right)dt;\; D = 0. \tag{3.75}$$

Substituting (3.75) into (3.60), and the obtained result into (3.74), and taking into account that

$$\frac{1}{C_0}\frac{\partial Q}{\partial x} = u; \quad -\frac{\partial u}{\partial x} = L_0\frac{\partial i}{\partial t} + R_0 i, \quad \int_0^t i dt = Q, \tag{3.76}$$

where u is the line voltage, we obtain the required equation

$$a^2\frac{\partial^2 Q}{\partial x^2} = \frac{\partial^2 Q}{\partial t^2} + \left(\frac{R_0}{L_0} + \frac{G_0}{C_0}\right)\frac{\partial Q}{\partial t} + \frac{R_0}{L_0}\frac{G_0}{C_0}Q; \quad \frac{\partial Q}{\partial t} = i, \tag{3.77}$$

where $a = 1/\sqrt{L_0 C_0}$ is the propagation speed of the electromagnetic wave.

The line equation (3.77) is obtained for the charge, but it is easily converted into the current equation by differentiating the left and right parts with time, and the voltage equation by differentiating the left and right parts with x while dividing by C_0. Into these operations, the form (3.77) will remain the same, only replaced accordingly $Q \to i \to u$.

3.4.5. Shaft equation. If we limit ourselves only to torsional vibrations in a circular shaft, then all energies involved in (3.60) can be written as [16,18]

$$T = \frac{\rho J_p \omega^2}{2};\ P = \frac{GJ_p}{2}\left(\frac{\partial \varphi}{\partial x}\right)^2;\ \Phi = \int_0^t \left(-\frac{\nu_e \omega^2}{2} + \frac{\nu_i}{2}\left(\frac{\partial^2 \varphi}{\partial x \partial t}\right)^2\right) dt;\ D = 0, \qquad (3.78)$$

where ρ is the mass density; G is shear modulus; J_p is the polar moment of inertia of the cross-section; ν_e, ν_i are coefficients of external and internal attenuation in the material, respectively; φ is the angle of rotation of the cross-section, and at the same time the generalized coordinate q ($q = \varphi$); ω is the angular velocity of the cross-section and at the same time the time derivative of the generalized coordinate ($\dot{q} = \omega$).

Since the dissipative function in (3.78) contains a mixed derivative, the expression (3.74) becomes even more complicated

$$\frac{\partial L}{\partial q} - \frac{\partial}{\partial x}\frac{\partial L}{\partial\left(\frac{\partial q}{\partial x}\right)} - \frac{\partial}{\partial t}\frac{\partial L}{\partial\left(\frac{\partial q}{\partial t}\right)} + \frac{\partial^2}{\partial x \partial t}\frac{\partial L}{\partial\left(\frac{\partial^2 q}{\partial x \partial t}\right)} = 0. \qquad (3.79)$$

Substituting (3.78) into (3.60), and the obtained result into (3.79) and taking into account that

$$GJ_p \frac{\partial \varphi}{\partial x} = M;\quad \frac{\partial M}{\partial x} = \rho J_p \frac{\partial \omega}{\partial t} + \nu_e \omega,\quad \int_0^t \omega dt = \varphi, \qquad (3.80)$$

we receive

$$a^2 \frac{\partial^2 \varphi}{\partial x^2} = \frac{\partial^2 \varphi}{\partial t^2} + \frac{\varepsilon_e}{\rho J_p}\frac{\partial \varphi}{\partial t} + \frac{\varepsilon_i}{\rho J_p}\frac{\partial^3 \varphi}{\partial x^2 \partial t};\qquad \frac{\partial \varphi}{\partial t} = \omega, \qquad (3.81)$$

where $a = \sqrt{G/\rho}$ is the propagation speed of the elastic wave.

3.5. Non-linear media

In isotropic media, the physical properties are independent of the spatial orientation of the field vectors. Therefore, the relationship between the action vectors **F** and the reaction **R** to this action from the environment is expressed by scalar dependencies. In anisotropic, the physical properties depend on the spatial orientation of the field vectors. Therefore, such environments are characterized by matrices of static specific electrical conductivities, and electrical and magnetic permeabilities. First, let's focus on the case of an isotropic medium, as it is simpler.

3.5.1. Nonlinear properties of an isotropic medium. They can be represented by the following scalar dependencies $\delta = \delta(E),\ E = E(D),\ H = H(B)$, or their inverses. The relationship between the vectors of the conductivity current density and the electric field strength is given in the form

$$\boldsymbol{\delta}_c = \gamma'(E)\mathbf{E}, \tag{3.82}$$

where γ' is the static specific electrical conductivity of the medium

$$\gamma'(E) = \delta(E)/E. \tag{3.83}$$

Vectors **E** and **D** are related by dependence

$$\mathbf{E} = \xi'(D)\mathbf{D}, \quad \text{або} \quad \mathbf{D} = \varepsilon'(E)\mathbf{E}, \tag{3.84}$$

where ξ', ε' are the static inverse and forward electrical permeabilities,,

$$\xi'(D) = E(D)/D; \quad \varepsilon'(E) = D(E)/E. \tag{3.85}$$

Vectors **H** and **B** are related similarly

$$\mathbf{H} = \nu'(B)\mathbf{B}, \tag{3.86}$$

where ν' is the static reluctivity of the medium

$$\nu'(B) = H(B)/B. \tag{3.87}$$

The moduli of the action vectors in (3.82)–(3.87) are usually found

$$h = \sqrt{h_x^2 + h_y^2 + H_z^2}, \quad h = E, D, B. \tag{3.88}$$

The corresponding dependencies (3.82), (3.84), (3.86) in the increments of the field vectors will be connected by differential dependencies, which can be easily obtained by the general formula of the transition from the matrices of static $S(x)$ and differential $D(x)$ parameters [18,29]

$$D(x) = \frac{dS(x)}{dx}x + S(x). \tag{3.89}$$

3.5.2. Nonlinear properties of anisotropic medium. Anisotropic properties of the medium are manifested in mutually perpendicular directions. Such an environment is called orthotropic. The problem boils down to revealing the dependence between the action vectors **F** and the reaction **R** to this action from the environment, as **R** = **R**(**F**). Since this function is a vector, the state of the environment is determined not only by the value of the vector modulus **F** (3.88), but also by its orientation in space, and the anisotropy of the environment determines the non-collinearity of action and reaction vectors. It is necessary to know in advance the characteristics of the environment in the main axes of anisotropy, that is, in a situation where the vector F is alternately oriented precisely in the direction of these axes. If there is a need to switch to coordinates of a different orientation, it is easy to do this with the help of trigonometric matrices of coordinate rotation. The named characteristics of environments can be presented in the form of functional dependencies:

$$R^i = f^i\left(F\right), \qquad i = x, y, z \tag{3.90}$$

Functions (3.90) in the case of hysteresis-free media are single-valued. Their ambiguity in hysteretic environments is due to the fact that the reaction of the environment at time t is determined not only by the vector of action **F**(t), but also by its prehistory – the value at the previous moment in time. Mathematics is still powerless in such cases, although this question requires an urgent solution.

Expressions (3.90) make it possible to use the static parameters of the environment in the directions of the main axes of orthotropy

$$s_i = f^i\left(F\right)/F, \quad i = x, y, z\ , \tag{3.91}$$

and this makes it possible to express the dependence $R = R(F)$ as:

$$\mathbf{R} = S\mathbf{F}\ , \tag{3.92}$$

where S is the matrix of static parameters

$$S = \mathrm{diag}\left(s_x, s_y, s_z\right). \tag{3.93}$$

Often there is a need to determine the relationship, not between action and reaction vectors, but their increments. Then, in contrast to (3.92), we write:

$$d\mathbf{R} = Dd\,\mathbf{F}\ , \tag{3.94}$$

where D is the matrix of differential parameters in the main axes of orthotropy. In contrast to S, the matrix D is filled. It is formally obtained from (3.93) according to (3.89). In the case of an isotropic medium according to (3.93), the matrix S degenerates into a scalar, which cannot be said about D.

In an orthotropic medium, expressions (3.82), (3.84), and (3.86) become more complicated. Expression (3.82) takes the form

$$\boldsymbol{\delta}_c = \Gamma'\mathbf{E}, \tag{3.95}$$

where Γ' is the matrix of static electrical conductivities. In the main axes of orthotropy, coinciding with Cartesian coordinates,

$$\Gamma' = \mathrm{diag}(\gamma'_x, \gamma'_y, \gamma'_z). \tag{3.96}$$

The elements of the matrix are determined by the characteristics of the conductor in the directions of the main axes of orthotropy

$$\delta^i = \delta^i(E),\ i = x, y, z, \tag{3.97}$$

as

$$\gamma'_i = \delta^i(E)/E = \gamma'_i(E), \tag{3.98}$$

moreover, E is found according to (3.88).

Equation (3.84) will be

$$\mathbf{E} = \Xi'\mathbf{D}; \qquad \mathbf{D} = \mathrm{E}'\mathbf{E}, \tag{3.99}$$

where E', Ξ' are the matrices of direct and inverse static permeability

$$\Xi' = \mathrm{diag}(\xi'_x, \xi'_y, \xi'_z); \qquad \mathrm{E}' = \mathrm{diag}(\varepsilon'_x, \varepsilon'_y, \varepsilon'_z). \tag{3.100}$$

The elements of the matrix (3.100) are found by the curves of the ferroelectric in the directions of the main axes of orthotropy

$$E^i = E^i(D),\ i = x, y, z, \tag{3.101}$$

and D is also determined according to (3.88), and the inverse permeabilities are as follows:

$$\xi'_i = E^i(D)/D = \xi'_i(D). \tag{3.102}$$

Equation (3.86) takes the form

$$\mathbf{H} = \mathrm{N}'\mathbf{B}, \tag{3.103}$$

where is the matrix of static reluctivities. In the main axes of orthotropy

$$N' = \mathrm{diag}(\nu'_x, \nu'_y, \nu'_z). \qquad (3.104)$$

The elements of the matrix (3.104) are found by the curves of the ferromagnet in the directions of the main axes of orthotropy

$$H^i = H^i(B),\ i = x, y, z, \qquad (3.105)$$

and B is determined according to (3.88), and reluctivities as follows:

$$\nu'_i = H^i(B)/B = \nu'_i(B). \qquad (3.106)$$

In an isotropic environment, characteristics (3.97), (3.101), (3.105) are the same in the directions of all three axes, and matrices (3.96), (3.100), (3.104) according to (3.98), (3.101), (3.106) degenerate into scalars (3.83), (3.85), (3.87).

For certainty, let us show the matrix of differential parameters D of an anisotropic medium based on the known matrix of static parameters S. For this, it is enough to substitute (3.93) into (3.89) and perform formal mathematical operations

$$D = \begin{array}{|c|c|c|} \hline (d_x - s_x)F_x^2/F^2 + s_x & (d_x - s_x)F_xF_y/F^2 & (d_x - s_x)F_xF_z/F^2 \\ \hline (d_y - s_y)F_yF_x/F^2 & (d_y - s_y)F_y^2/F^2 + s_y & (d_y - s_y)F_yF_z/F^2 \\ \hline (d_z - s_z)F_zF_x/F^2 & (d_z - s_z)F_zF_y/F^2 & (d_z - s_z)F_z^2/F^2 + s_z \\ \hline \end{array}, \qquad (3.107)$$

where d^i $(i = x, y, z)$ are differential parameters

$$d_i = \frac{df^i(F)}{dF},\ i = x, y, z\ . \qquad (3.108)$$

The elements of the matrix D can be calculated using the formula

$$d_{ik} = (d_i - s_i)F_iF_k/F^2 + \kappa_{ik}s_i, \quad i,k = x, y, z\ . \qquad (3.109)$$

In an isotropic medium, the characteristics (3.90) are the same along all axes. Then, according to (3.90), and (3.91), the matrix S (3.93) degenerates into a scalar. As for the matrix D, it will remain filled in the future, only the expression for its elements (3.109) will be simplified

$$d_{ik} = (d - s)F_iF_k/F^2 + \kappa_{ik}s, \quad i,k = x, y, z\ . \qquad (3.110)$$

In the linear environment, the obtained expressions undergo further simplifications.

As an example of a nonlinear physical system, let us describe the electromagnetic process in a nonlinear anisotropic medium. The main feature of the analysis is that the concept of kinetic energy cannot be used here. Kinetic co-energy appears in its place. In order to understand all the intricacies and possible side effects of mathematical support, we were forced to enter the territory of SRT, because it is almost the only decently processed field of nonlinearity, where analytical methods dominate. Analytical methods give us the opportunity to examine the entire studied space to the very horizon, while numerical methods examine it only one time step ahead. However, numerical methods step by step master the entire space of our interests, while analytical methods are assigned the role of an observer in this process.

Below we will solve the most difficult problem of variational methods of nonlinear environments.

3.6. The vector-potential equation of the electromagnetic field

We arrive at the equations of the vector potential of the electromagnetic field in a nonlinear anisotropic medium under the condition that the energy expressions must be given a different form with the simultaneous replacement of the expression of the specific kinetic energy by the expression of the specific kinetic co-energy. We can only be glad that this, perhaps the most difficult variational problem, was solved for the first time by my eldest son Andriy [16,17].

All previous examples of the energetic approach to the description of physical phenomena were based on the simplified expression of protoenergy (3.65). Here we are forced to turn to its full image (3.64). And to fill it with physical meaning, it is sufficient to use expressions (3.1)-(3.4), (3.7).

Provided that $D = 0$, (3.64) takes the form

$$L = \int_0^{\mathbf{E}} \mathrm{E}'(\mathbf{E})\mathbf{E}d\mathbf{E} - \int_0^{\mathbf{B}} \mathrm{N}'(\mathbf{B})\mathbf{B}d\mathbf{B} + \int_0^{t}\int_0^{\mathbf{E}} \Gamma'(\mathbf{E})\mathbf{E}d\mathbf{E}dt. \tag{3.111}$$

3According to (3.2), and (3.61), the protoenergy expression (3.111) can easily be translated into the space of the main vector $\mathbf{A}$

$$L = \int_0^{-\partial\mathbf{A}/\partial t} \mathrm{E}'(\mathbf{E})\left(-\frac{\partial\mathbf{A}}{\partial t}\right)d\left(-\frac{\partial\mathbf{A}}{\partial t}\right) - \int_0^{\nabla\times\mathbf{A}} \mathrm{N}'(\mathbf{B})(\nabla\times\mathbf{A})d(\nabla\times\mathbf{A}) +$$
$$+\int_0^{t}\int_0^{-\partial\mathbf{A}/\partial t} \Gamma'(\mathbf{E})\left(-\frac{\partial\mathbf{A}}{\partial t}\right)d\left(-\frac{\partial\mathbf{A}}{\partial t}\right)dt. \tag{3.112}$$

Let's form a functional of the vector-potential of the electromagnetic field with three independent variables

$$I = \int_V L\left(x, y, z, \mathbf{A}, \frac{\partial \mathbf{A}}{\partial x}, \frac{\partial \mathbf{A}}{\partial y}, \frac{\partial \mathbf{A}}{\partial z}, \frac{\partial \mathbf{A}}{\partial t} \right) dV, \tag{3.113}$$

where x, y, z are independent variables; $\mathbf{A}$ is a vector variable dependent on x, y, z. An arbitrary infinitesimal change $\mathbf{A}(x,y,z,t)$ corresponds to a variation of the functional

$$\delta I = \int_V \left(\frac{\partial L}{\partial \mathbf{A}} \delta \mathbf{A} + \frac{\partial L}{\partial \frac{\partial \mathbf{A}}{\partial x}} \delta \frac{\partial \mathbf{A}}{\partial x} + \frac{\partial L}{\partial \frac{\partial \mathbf{A}}{\partial y}} \delta \frac{\partial \mathbf{A}}{\partial y} + \frac{\partial L}{\partial \frac{\partial \mathbf{A}}{\partial z}} \delta \frac{\partial \mathbf{A}}{\partial z} + \frac{\partial L}{\partial \frac{\partial \mathbf{A}}{\partial t}} \delta \frac{\partial \mathbf{A}}{\partial t} \right) dV. \tag{3.114}$$

Here, the first of the derivatives should be understood as a set of derivatives on individual spatial projections onto the coordinate axes of vector A, and the rest as a set of derivative projections of the same vector on all possible derivatives of its projections on individual spatial coordinates of the vector functions $\nabla \times \mathbf{A}$, as well as on-based on-time t. As a result, there are many variables involved

$$\begin{gathered} I = I(x, y, z, A_x, A_y, A_z, \partial A_x / \partial y, \partial A_x / \partial z, \partial A_y / \partial x, \\ \partial A_y / \partial z, \partial A_z / \partial x, \partial A_z / \partial y, \partial A_x / \partial t, \partial A_y / \partial t, \partial A_z / \partial t). \end{gathered} \tag{3.115}$$

If we take into account that

$$\delta \frac{d\mathbf{F}}{ds} = \frac{d}{ds}(\delta \mathbf{F}), \quad s = x, y, z, t,$$

then we will get it

$$\delta I = \int_V \left(\frac{\partial L}{\partial \mathbf{A}}(\delta \mathbf{A}) + \frac{\partial L}{\partial \frac{\partial \mathbf{A}}{\partial x}} \frac{\partial}{\partial x}(\delta \mathbf{A}) + \frac{\partial L}{\partial \frac{\partial \mathbf{A}}{\partial y}} \frac{\partial}{\partial y}(\delta \mathbf{A}) + \frac{\partial L}{\partial \frac{\partial \mathbf{A}}{\partial z}} \frac{\partial}{\partial y}(\delta \mathbf{A}) + \frac{\partial L}{\partial \frac{\partial \mathbf{A}}{\partial t}} \frac{\partial}{\partial t}(\delta \mathbf{A}) \right) dV. \tag{3.116}$$

Differentiating the product and using Ostrogradsky's theorem

$$\int_V \nabla \cdot \mathbf{F} dV = \int_S \mathbf{F} dS \tag{3.117}$$

the expression (3.116) can be given the form

$$\delta I=\int_V\left[\frac{\partial L}{\partial \mathbf{A}}-\frac{\partial}{\partial x}\left(\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial x}}\right)-\frac{\partial}{\partial y}\left(\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial y}}\right)-\frac{\partial}{\partial z}\left(\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial z}}\right)-\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial t}}\right)\right]\delta\mathbf{A}dV+$$

$$+\int_S\left[l_x\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial x}}+l_y\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial y}}+l_z\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial z}}\right]\delta\mathbf{A}dS. \tag{3.118}$$

In (3.118), the time term is omitted in the surface integral as it has no physical contents.

Ratio (3.118) corresponds to the variational formulation of field theory problems. It establishes that the function that gives the minimum value to this functional must satisfy the differential equation

$$\frac{\partial L}{\partial \mathbf{A}}-\frac{\partial}{\partial x}\left(\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial x}}\right)-\frac{\partial}{\partial y}\left(\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial y}}\right)-\frac{\partial}{\partial z}\left(\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial z}}\right)-\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial\frac{\partial \mathbf{A}}{\partial t}}\right)=0. \tag{3.119}$$

It is not difficult to see that expressions (3.70) and (3.74) are special cases of (3.119). The derivation (3.74) was promised earlier (p. 89).

We write the potential energy under the condition (3.111) as

$$P=\int_0^{\mathbf{B}}\mathbf{H}d\mathbf{B}=\int_0^{B_x}\nu_x B_x dB_x+\int_0^{B_y}\nu_y B_y dB_y+\int_0^{B_z}\nu_z B_z dB_z. \tag{3.120}$$

Based on (3.60), and (3.64), for the first term of (3.119), we have

$$\partial L/\partial\mathbf{A}=0. \tag{3.121}$$

Let's write the next three terms (3.119) under condition (3.2))

$$\frac{\partial}{\partial x}\frac{\partial L}{\frac{\partial \mathbf{A}}{\partial x}}=\frac{\partial}{\partial x}\frac{\partial}{\frac{\partial \mathbf{A}}{\partial x}}\left(\int_0^{B_x}\nu_x B_x dB_x+\int_0^{B_y}\nu_y B_y dB_y+\int_0^{B_z}\nu_z B_z dB_z\right)= \tag{3.122}$$

$$= -\mathbf{y_0}\frac{\partial}{\partial x}\frac{\partial}{\dfrac{\partial A_y}{\partial x}}\int_0^{B_z}\nu_z B_z dB_z + \mathbf{z_0}\frac{\partial}{\partial x}\frac{\partial}{\partial A_z/\partial x}\int_0^{B_z}\nu_y B_y dB_y =$$

$$= \frac{\partial}{\partial x}\left(-\nu_z\left(\frac{\partial A_y}{\partial x}-\frac{\partial A_x}{\partial y}\right)\mathbf{y_0}+\nu_y\left(\frac{\partial A_x}{\partial z}-\frac{\partial A_z}{\partial x}\right)\mathbf{z_0}\right); \tag{3.122}$$

$$\frac{\partial}{\partial y}\frac{\partial L}{\partial(\partial \mathbf{A}/\partial y)} = \frac{\partial}{\partial y}\left(-\nu_x\left(\frac{\partial A_z}{\partial y}-\frac{\partial A_y}{\partial z}\right)\mathbf{z_0}+\nu_z\left(\frac{\partial A_y}{\partial x}-\frac{\partial A_x}{\partial y}\right)\mathbf{x_0}\right); \tag{3.123}$$

$$\frac{\partial}{\partial z}\frac{\partial L}{\partial(\partial \mathbf{A}/\partial z)} = \frac{\partial}{\partial z}\left(-\nu_y\left(\frac{\partial A_x}{\partial z}-\frac{\partial A_z}{\partial x}\right)\mathbf{x_0}+\nu_x\left(\frac{\partial A_z}{\partial y}-\frac{\partial A_y}{\partial z}\right)\mathbf{y_0}\right). \tag{3.124}$$

Finally, we write the last term (3.119)

$$\frac{\partial}{\partial t}\frac{\partial L}{\partial(-\partial \mathbf{A}/\partial t)} = \frac{\partial}{\partial t}\frac{\partial}{\partial(-\partial \mathbf{A}/\partial t)}\left(\int_0^{-\partial \mathbf{A}/\partial t}\mathrm{E}'(\mathbf{E})\left(-\frac{\partial \mathbf{A}}{\partial t}\right)d\left(-\frac{\partial \mathbf{A}}{\partial t}\right)+\right.$$

$$\left.+\int_0^t\int_0^{-\partial \mathbf{A}/\partial t}\Gamma'(\mathbf{E})\left(-\frac{\partial \mathbf{A}}{\partial t}\right)d\left(-\frac{\partial \mathbf{A}}{\partial t}\right)dt\right) = -\frac{\partial}{\partial t}\left(\mathrm{E}'\frac{\partial \mathbf{A}}{\partial t}\right)-\Gamma'\frac{\partial \mathbf{A}}{\partial t}. \tag{3.125}$$

Combining the results of transformations (3.119)–(3.125), we obtain that the function that minimizes the functional (3.111) must satisfy the differential equation of the electromagnetic field theory in a nonlinear anisotropic medium (provided there are no extraneous sources)

$$\mathrm{E}''\frac{\partial^2 \mathbf{A}}{\partial t^2}+\Gamma'\frac{\partial \mathbf{A}}{\partial t} = -\left(\nabla\times \mathrm{N}'\nabla\times\mathbf{A}\right). \tag{3.126}$$

The second time derivative in (3.126) is obtained from (3.125) according to the theorem on the connection of static $S(x)$ and differential $D(x)$ parameter matrices (3.89).

Equation (3.126) is the most profound achievement of electromagnetism of stationary nonlinear media. It is clear that it itself absorbs (3.62) as a special case of linearity under the condition $\mathrm{E}'' \to \varepsilon$; $\Gamma \to \gamma$; $\mathrm{N}' \to \nu$. It can only be reduced to the case of motion. But since this action is not fundamental for us, we will use the ready-made result from [18, 21] for a practical case – quasi-stationarity

$$\frac{\partial \mathbf{A}}{\partial t} = -\mathrm{P}'\boldsymbol{\nabla} \times \mathrm{N}'\boldsymbol{\nabla} \times \mathbf{A} - (\mathbf{v} \cdot \nabla)\mathbf{A}. \tag{3.127}$$

We can only be glad that the priority of solving the most complex variational problem of theoretical electricity belongs to Ukraine [16]!

3.5.2. Maxwell's equations. It is interesting that it is not possible to obtain Maxwell's equations from the energy functional. This confirms once again that only the vector potential is the real basis of electromagnetism, and the field vectors are only its derivatives – temporal and spatial (3.2). And it is through these derivatives that we can arrive at the mentioned equations. Although historically everything happened the other way around.

If we take into account (3.2), (3.82), (3.84), (3.86), the expression (3.126) degenerates into Maxwell's first equation

$$\mathrm{E}\frac{\partial \mathbf{E}}{\partial t} = \nabla \times \mathbf{H} - \Gamma\mathbf{E}. \tag{3.128}$$

We arrive at Maxwell's second equation based on expressions (3.2). Differentiating the second of them by time and substituting the first in the obtained result, we obtain

$$\frac{\partial \mathbf{B}}{\partial t} = -\nabla \times \mathbf{E}. \tag{3.129}$$

Maxwell's equations are increasingly being squeezed out of practical use by equations of the vector-potential A. This especially applies to theoretical physics and the construction of modern field mathematical models of electrical and electromechanical devices.

Therefore, according to (3.128), a time-varying electric field generates a magnetic field, and according to (3.129), a time-varying magnetic field generates an electric field. From this follows the possibility of the existence of electromagnetic waves in a vacuum at a considerable distance from current-carrying conductors. Electric and magnetic fields can exist, mutually exciting each other. It is now clear that electromagnetic waves exist due to bias currents.

Maxwell's basic equations (3.128), and (3.129) should be supplemented with two additional ones that ensure the unambiguity of the solution under the given initial and boundary conditions. These include Maxwell's postulate and the equation of continuity of the magnetic field, the latter of which is sometimes called Maxwell's third equation

.

$$\nabla \cdot \mathbf{D} = \rho. \qquad \nabla \cdot \mathbf{B} = 0. \tag{3.130}$$

According to (3.130), the electric field lines can be broken, starting and ending at the electric charges that generate them. Whereas magnetic field lines are always closed on themselves. That is, there are no natural sources of the magnetic field. This has a deep physical meaning, but more on that later.

Maxwell's equations (3.128), (3.129) form the complete system of electromagnetic field equations, and (3.130) express only limitations on the possible distribution of this field in space. And commutation states often arise in electrodynamics problems. Knowledge of commutation laws is necessary to determine the initial conditions. They are easy to obtain according to Maxwell's laws

$$\mathbf{D}(+0) = \mathbf{D}(-0); \tag{3.131}$$

$$\mathbf{B}(+0) = \mathbf{B}(-0) \tag{3.132}$$

That is, vectors of electric and magnetic induction are functions that are continuous in time. If this were not so, then their corresponding time derivatives would reach infinity, which is impossible due to energetic considerations.

3.5.2. Unified equations of linear media. It is clear that in an isotropic medium, and even more so in a linear equation (3.126), undergoes simplification according to the simplification of the parameters of the medium:

$$\mathrm{E}'' \to \mathrm{E}''_{iz} \to \varepsilon; \quad \Gamma' \to \gamma' \to \gamma; \quad \mathrm{N}' \to \nu' \to \nu. \tag{3.133}$$

It is quite obvious that in a linear medium under the condition (3.133), the vector-potential equation (3.126) is simplified

$$\frac{\varepsilon}{\nu}\frac{\partial^2 \mathbf{A}}{\partial t^2} + \frac{\gamma}{\nu}\frac{\partial \mathbf{A}}{\partial t} = -\nabla \times \nabla \times \mathbf{A}. \tag{3.134}$$

Moreover, by excluding all vectors from the system (3.128), (3.129) in turn, except for one in the case of a linear medium, the calculation equations of the electromagnetic field can be unified like (3.134)

$$\frac{\varepsilon}{\nu}\frac{\partial^2 \mathbf{U}}{\partial t^2} + \frac{\gamma}{\nu}\frac{\partial \mathbf{U}}{\partial t} = -\nabla \times \nabla \times \mathbf{U}, \quad \mathbf{U} = \mathbf{A}, \mathbf{B}, \mathbf{E}, \mathbf{H}, \mathbf{D}. \tag{3.135}$$

One could succumb to the temptation to look for a physical interpretation for the vector **U**, but such unification does not always take place, for example, in nonlinear environments.

We will consider equation (3.135) as the basic calculation equation of the electromagnetic field in a stationary linear isotropic medium. We animate it in relation to this or that vector, based on the following considerations:

- from the number of spatial components of this or that vector in the given coordinate system;
- from the method of obtaining boundary conditions.

In the case of a lossless medium (vacuum) (3.135) will be

$$\frac{1}{c^2}\frac{\partial^2\mathbf{U}}{\partial t^2} = -\nabla\times\nabla\times\mathbf{U}, \quad \mathbf{U} = \mathbf{A}, \mathbf{B}, \mathbf{H}, \mathbf{D}, \mathbf{E}. \tag{3.136}$$

The result (3.136) leads to the classical wave equation, but this will be discussed later.

3.7. Equation of non-stationary thermal conductivity.

Equations of non-stationary thermal conductivity interest us not only from the point of view that electromagnetic processes in dissipative media are always accompanied by heat losses but also from the point of view of extending the properties of the universal protoenergy formula (3.64). The fact is that the concept of energy in relation to heat loses its real meaning and gains a virtual one. Still, formula (3.64) works in this case as well. What is the secret here, nowadays it is difficult to answer. Because theoretical physics still does not have a comprehensive answer to the question of the physical essence of energy.

The protoenergy equation (3.64) in the case of constructing the unsteady thermal conductivity equation under the condition $T = 0,\ D = 0$ looks like this

$$L = -\int_0^q \Lambda'(q)\mathbf{q}d\mathbf{q} + \int_0^t \int_0^{\partial\Theta/\partial t} C'\left(\frac{\partial\Theta}{\partial t}\right)\rho\frac{\partial\Theta}{\partial t}d\frac{\partial\Theta}{\partial t}dt, \tag{3.137}$$

where $\Lambda'(q) = diag(\lambda_x, \lambda_y, \lambda_z)$ is the matrix of static thermal conductivities; $C'(\partial\Theta/\partial t)$ is static heat capacity; ρ is specific weight; $\mathbf{q}$ is the heat flow

$$\mathbf{q} = \nabla\Theta = \mathbf{x_0}\frac{\partial\Theta}{\partial x} + \mathbf{y_0}\frac{\partial\Theta}{\partial x} + \mathbf{z_0}\frac{\partial\Theta}{\partial x}. \tag{3.138}$$

Due to the scalar nature of temperature, equation (3.119) is significantly simplified

$$\frac{\partial L}{\partial \Theta}-\frac{\partial}{\partial x}\left(\frac{\partial L}{\partial \frac{\partial \Theta}{\partial x}}\right)-\frac{\partial}{\partial y}\left(\frac{\partial L}{\partial \frac{\partial \Theta}{\partial y}}\right)-\frac{\partial}{\partial z}\left(\frac{\partial L}{\partial \frac{\partial \Theta}{\partial z}}\right)-\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \frac{\partial \Theta}{\partial t}}\right)=0. \qquad (3.139)$$

Based on (3.60), (3.137), (3.138) for the first term (3.139), we have that $\partial L/\partial \Theta = 0$. The following will be

$$\frac{\partial}{\partial x}\frac{\partial L}{\partial \frac{\partial \Theta}{\partial x}}=-\frac{\partial}{\partial x}\frac{\partial}{\partial \frac{\partial \Theta}{\partial x}}\left(\int_0^{\frac{\partial \Theta}{\partial x}}\lambda_x \mathbf{x_0}\frac{\partial \Theta}{\partial x}d\frac{\partial \Theta}{\partial x}+\int_0^{\frac{\partial \Theta}{\partial y}}\lambda_y \mathbf{y_0}\frac{\partial \Theta}{\partial y}d\frac{\partial \Theta}{\partial y}+\int_0^{\frac{\partial \Theta}{\partial x}}\lambda_z \mathbf{z_0}\frac{\partial \Theta}{\partial z}d\frac{\partial \Theta}{\partial z}\right)=$$

$$=-\frac{\partial}{\partial x}\left(\lambda_x \mathbf{x_0}\frac{\partial \Theta}{\partial x}\right);\ \ \frac{\partial}{\partial y}\frac{\partial L}{\partial \frac{\partial \Theta}{\partial y}}=-\frac{\partial}{\partial y}\left(\lambda_y \mathbf{y_0}\frac{\partial \Theta}{\partial y}\right);\ \ \frac{\partial}{\partial z}\frac{\partial L}{\partial \frac{\partial \Theta}{\partial z}}=-\frac{\partial}{\partial z}\left(\lambda_z \mathbf{z_0}\frac{\partial \Theta}{\partial z}\right); \qquad (3.140)$$

$$\frac{\partial}{\partial t}\frac{\partial L}{\partial \frac{\partial \Theta}{\partial t}}=\frac{\partial}{\partial t}\frac{\partial}{\partial \frac{\partial \Theta}{\partial t}}\int_0^t\int_0^{\frac{\partial \Theta}{\partial t}} C'\rho\frac{\partial \Theta}{\partial t}d\frac{\partial \Theta}{\partial t}dt=C'\rho\frac{\partial \Theta}{\partial t}.$$

Substituting (3.140) into (3.139), we obtain the equation of unsteady thermal conductivity in a nonlinear anisotropic medium without a free term p of extraneous origin

$$\frac{\partial \Theta}{\partial t}=\nabla\cdot\Lambda'\nabla\Theta / C'\rho. \qquad (3.141)$$

The extraneous term p for the case of electromagnetic losses in a conductive medium looks familiar

$$p=\gamma E^2. \qquad (3.142)$$

Combining (3.141), and (3.142), we obtain

$$\frac{\partial \Theta}{\partial t}=\frac{\nabla\cdot\Lambda'\nabla\Theta+p}{C'\rho}. \qquad (3.143)$$

The formal transition from (3.137) to (3.139) forces us to revise the traditional dependencies $\Lambda'=\Lambda'(\Theta); C'=C'(\Theta)$ in favor of $\Lambda'=\Lambda'(q); C'=$

$= C'(\partial\Theta / \partial t)$, because otherwise $\partial L / \partial\Theta \neq 0$ the result (3.141) will turn out to be completely distorted. But the last word here belongs to heating specialists.

In the case of a linear medium when $C' = C = const$, equation (3.141) is significantly simplified

$$\frac{\partial\Theta}{\partial t} = \frac{\lambda}{C\rho}\nabla^2\Theta. \tag{3.144}$$

The material of this section does not claim to replace deeply developed methods of electricity, mechanics, and thermodynamics. Its role is much more modest – to show the deep processes that unite the methods of separate sciences and contribute to a significant saving of brain activity of the researcher, especially the one who works at their interface. It is no accident that processes of different physical origins are described by a common mathematical apparatus. The deep mystery of space-time is hidden behind this phenomenon. This material cannot be indifferent to inquisitive minds that seek to learn more deeply not only about their profession, but also about neighboring ones. It greatly expands the horizon of knowledge and awakens the creative process. And in our specific case, it opens new horizons of the mechanical field theory.

4. COMBINED EQUATIONS OF ELECTRICITY AND GRAVITY

4.1. Basic equations

The previous third section pursued two main goals:

1. To show the enormous possibilities of variational methods of analysis of physical systems, in order to strengthen confidence in their final results, regardless of the field of practical interests. This is very important because the course of our main thoughts was interrupted in the second section by the expression (2.90), which is essentially a sub integral function of the action according to Hamilton (3.59), and at the same time, the expression of the protoenergy of non-linear media (3.64). And this means only one thing – the further burden of the ultimate goal of unifying the equations of electricity and gravity will be transferred to the shoulders of the variational principle of Hamilton-Ostrogradsky.

2. Show the latest achievements of the theory of the electromagnetic field of nonlinear media. This is also very important because the course of our main thoughts was interrupted in the same second section at expressions (2.27), (2.39), (2.42), (2.44), (2.45), (2.84)-(2.90), which subconsciously parallelized electricity and mechanics. And this means that we can painlessly direct the theory of mechanics in the direction of the achievements of the theory of electricity!

Thus, under the action of (2.78) based on of the variational principle of Hamilton-Ostrogradskyi [16-18], [20-23] we arrive at the equations of vector potentials of electric and mechanical fields.

As a result, the basic equation of vector potentials of electric and mechanical fields takes the form [21]

$$\frac{\varepsilon_{0k}}{\nu_{0k}}\frac{\partial^2 \mathbf{A}_k}{\partial t^2}+\frac{\gamma_k}{\nu_{0k}}\frac{\partial \mathbf{A}_k}{\partial t}=-\nabla\times\left(\nabla\times\mathbf{A}_k\right),\ k=q,\ m, \tag{4.1}$$

The current density vector is hidden in equation (4.1)

$$\boldsymbol{\delta}_k=\gamma_k\mathbf{E}_k+\frac{\partial \mathbf{D}_k}{\partial t},\quad k=q,\ m. \tag{4.2}$$

If losses are omitted in (4.1): then we get the equation of the lossless electric and gravitational fields (3.136)

$$\frac{1}{c^2}\frac{\partial^2 \mathbf{A}_k}{\partial t^2}=-\nabla\times\left(\nabla\times\mathbf{A}_k\right),\quad k=q,\ m. \tag{4.3}$$

If the sub integral function in (4.1) is complicated to the expression of protoenergy (3.64), then based on the mentioned variational principle we arrive at the equations of electric and mechanical fields in a nonlinear anisotropic dissipative medium. Such equations testify to the highest triumph of variational approaches in the theoretical physics of nonlinear media. For this reason (although we are talking about a strong interaction that leads to asymptotic freedom), it is worth quoting [4], which sheds light on political ideology in science: "Landau decided: "We concluded that Hamilton's method for strong interactions is dead and should be buried, although with due honors". As we can see, in the USSR, not only the famous genetics fell, but partly also physics. Let's not forget that many physicists at that difficult time of the world's most advanced social system paid with their heads for criticizing relativism.

In this research, we do not aim to direct the entire theory of mechanics in the direction of electricity, although it is possible to do this based on electromechanical analogies. The simplest example of such a possibility can be the well-known equations of a homogeneous line with distributed parameters (3.77) from the electrical side and the equation of a shaft conduit with distributed parameters (3.81) from the mechanical side.

Since our idea of combining the theories of both physical fields takes only the first step, and even then at the level of a hypothesis, we will significantly narrow the further task to electric and gravitational fields in open, lossless space. And this is equivalent to restricting ourselves to the main equation in terms of (4.3) with its global constants ε_0, G, c . As for the fourth constant present in (4.1), it is a derivative of the previous ones (2.36)

$$\nu_{0k} = \varepsilon_{0k} c^2, \quad k = q,\, m. \tag{4.4}$$

4.2. Dimensionality of electrical and mechanical quantities

Since all involved equations of combined electricity and mechanics operate in parallel with the physical vectors of electricity and mechanics, the very important question of unification of the physical dimensionalities of the quantities involved arises. But, it turns out, there is a strict proportionality between all of them (electrical and mechanical). Since, according to the design of this study, the theory of mechanics is adapted to the theory of electricity, and not vice versa, it is reasonable to express the mechanical dimensions through the known electrical

$$\lambda_m = \xi \lambda_q, \qquad \xi = \mathrm{kg\,s^{-1}A^{-1}}\ (\mathrm{kg/C}), \tag{4.5}$$

де λ – відповідна розмірність; ξ – коефіцієнт пропорційности.

where is the corresponding dimensionality; is the proportionality factor.

For orientation convenience, we will summarize the comparative results in a table

Value	Dim.mech.	Dim.elec.	Coef.
q	kg	s A (C)	ξ
A	$\mathrm{m\,s^{-1}}$	$\mathrm{kg\,m\,s^{-2}A^{-1}}$ (Vs/m)	ξ^{-1}
E	$\mathrm{m\,s^{-2}}$	$\mathrm{kg\,m\,s^{-3}A^{-1}}$ (V/m)	ξ^{-1}
D	$\mathrm{kg\,m^{-2}}$	$\mathrm{m^{-2}s\,A}$ ($\mathrm{C/m^2}$)	ξ
δ	$\mathrm{kg\,m^{-2}\,s^{-1}}$	$\mathrm{m^{-2}A}$ ($\mathrm{A/m^2}$)	ξ
B	$\mathrm{s^{-1}}$	$\mathrm{kg\;s^{-2}A^{-1}}$ (T)	ξ^{-1}
H	$\mathrm{kg\,m^{-1}s^{-1}}$	$\mathrm{Am^{-1}}$ (A/m)	ξ
A	$\mathrm{kg\,m^2s^{-2}}$ (J)	$\mathrm{kg\,m^2s^{-2}}$ (J)	1
p	$\mathrm{kg\,m^2s^{-3}}$ (W)	$\mathrm{kg\,m^2s^{-3}}$ (W)	1
F	$\mathrm{kg\,m\,s^{-2}}$ (N)	$\mathrm{kg\,m\,s^{-2}}$ (N)	1
ε	$\mathrm{kg\,m^{-3}s^2}$	$\mathrm{kg^{-1}m^{-3}s^4A^2}$ (F/m)	ξ^2
ν	$\mathrm{kg\,m^{-1}}$	$\mathrm{kg^{-1}m^{-1}s^2A^2}$ (m/H)	ξ^2
γ	$\mathrm{kg\,m^{-3}s}$	$\mathrm{kg^{-1}m^{-3}s^3A^2}$ (S/m)	ξ^2

If necessary, you can enter integral values

$$i_k = \int_S \boldsymbol{\delta}_k dS; \quad u_k = \int_l \mathbf{E}_k dl;$$

$$\Phi_k = \int_S \mathrm{B}_k dS; \quad V_k = \int_l \mathbf{H}_k dl, \quad k = q, m, \tag{4.6}$$

where i_k, u_k, Φ_k, V_k are current, voltage, eddy current, and eddy voltage, respectively. Their dimensionalities:

Value	Dim.mech.	Dim. elect.	Coef.
i	$\mathrm{kg\;s^{-1}}$	A	ξ
u	$\mathrm{m^2\,s^{-2}}$	$\mathrm{kg\,m^2\,s^{-3}A^{-1}}$ (V)	ξ^{-1}
Φ	$\mathrm{m^2\,s^{-1}}$	$\mathrm{kg\,m^2\,s^{-2}A^{-1}}$ (Wb)	ξ^{-1}
V	$\mathrm{kg\;s^{-1}}$	A	ξ

If we introduce the concept of the rate of loss of mass and mass

$$i = \frac{\partial q}{\partial t}; \qquad i_m = \frac{\partial m}{\partial t}, \tag{4.7}$$

which we will call electric and mechanical currents, then the dimensionalities of the coefficient (4.5) is also the ratio of the dimensionalities of the mechanical and electric currents (4.7).

Judging by the complexity of the dimensions of vector and scalar quantities, we can say that the equations of the unified field are much more transparent in the mechanical version than in the electrical version, although in fact, they appeared as electromagnetic ones. First of all, we are talking about the basic vector-potential $\mathbf{A}$ (2.90), the dimension of which appeared in the gravitational field as the dimension of the velocity vector **V**, and its first derivatives (2.74) as the dimensions of the vectors: acceleration ($\mathbf{E}_m = \mathbf{\Gamma}$) and angular velocity ($\mathbf{B}_m = \mathbf{\Omega}$), which fully corresponds to the energy processes (2.89), (2.90).

The total energy of the gravitational field is divided into the sum of the linear and vortex components. We will conventionally consider the linear component as kinetic, and the vortex as potential (gravitational). This is done only in order to be able to use the universal formulas (2.89) for their calculation. The specific densities of these energies in the usual mechanical notation will be

$$w_k = \frac{\varepsilon_{0m} a^2}{2}; \quad w_p = \frac{\nu_{0m} \omega^2}{2} \tag{4.8}$$

where a, ω are the modules of the vectors of linear acceleration $\mathbf{\Gamma}$ and angular velocity of the vortex.

Despite the similarity of the basic equations (4.1) and (4.3) for electric and gravitational fields, there is still a stumbling block between the processes described by it. Because the charge q has two signs, and the mass m has only one. So, the force of electrical interaction manifests itself in attraction and repulsion, and mechanical interaction - only in attraction. But in scientific circles, the idea of antimatter with antigravitational action is becoming more and more pressing. If this fact is confirmed, then we will have complete symmetry of electrical and mechanical interaction. But the asymmetry of matter and antimatter in the Universe is still one of the biggest unsolved problems of physics!

The material of our research illustrates how physics works its way into our consciousness through the labyrinths of mathematics. And this is already a question of epistemology – knowledge as a form of connection between consciousness and being. Because the vector **A** has not only the physical dimension of speed (ms^{-1}) but also the philosophical one – *the measure of the All-Encompassing Movement,* "in Greek they say Panta Rhei". It can be seen that Heraclitus of Ephesus (535-475 BC) addressed these two winged words to us over the centuries for a reason. And so that we finally understand their greatness.

4.3. Poiting vector

We arrive at the Poiting vector in the electric field based on the power balance. Since it is a classical material, it is possible to write down the ready-made expression of the corresponding component of this balance as the flow of radiation power p through a given surface S

$$p = \int_S \mathbf{\Pi}\, d\mathbf{S}, \tag{4.9}$$

where $\mathbf{\Pi}$ is the actual Poiting vector

$$\mathbf{\Pi}_k = \mathbf{E}_k \times \mathbf{H}_k = \nu_{0k}(\mathbf{E}_k \times \mathbf{B}_k), \quad k = q, m, \tag{4.10}$$

причому розмірність вектора Пойтинґа в обох випадках одна й та ж – kg s^{-3} (W m^{-2}).

Based on analogies of electric and mechanical fields, vector (4.10) can be written in the usual mechanical notation

$$\mathbf{\Pi}_m = \frac{c^2}{4\pi G}(\mathbf{\Gamma} \times \mathbf{\Omega}). \tag{4.11}$$

Integral (4.9) presents the component of the power of the gravitational or electric field that is spent on cosmic radiation.

4.4. Lorentz force

On page 37, it was promised that, after obtaining the necessary theoretical material, the Lorentz force formula (2.43) would be substantiated in the gravitational field, since this important expression was introduced purely formally. Following the promise, we will give it greater transparency from the point of view of mechanics.

Based on electro-mechanical analogies of expression (2.43), it is possible to give a form in mechanical notation

$$\mathbf{F} = m(\mathbf{\Gamma} + \mathbf{v} \times \mathbf{\Omega}), \tag{4.12}$$

as Newton's second law $\mathbf{F} = m\mathbf{a}$ in the field of mutually orthogonal accelerations of the gravitational vortex.

4.5. Laws of gravity

The first law. The first law of gravity can be called a mechanical analog of Maxwell's first law of electricity (3.128), which for a lossless medium in the universal representation according to (4.4) will take the form

$$\frac{\partial \mathbf{E}_k}{\partial t} = c^2 \nabla \times \mathbf{B}_k, \quad k = q, m, \tag{4.13}$$

where c is the speed of electric and gravitational field propagation in the vacuum.

If we use electro-mechanical analogies, then in the gravity field expression (4.13) will take the form

$$\frac{\partial \mathbf{\Gamma}}{\partial t} = c^2 \nabla \times \mathbf{\Omega}. \tag{4.14}$$

The second law. The second law of gravitation or the law of vortex gravitational induction will be interpreted as an analog of Faraday's experimental law of electric induction (1831), which conditionally started the second technical revolution. It will be recalled that the first was initiated by the invention of the steam engine by Watt (1769).

The vortices of electric and gravitational induction can be formally arrived at based on (2.85). To do this, it is enough to take the vector operation $\nabla \times$ from the first expression and substitute the second expression into the obtained result, as a result of which we will have

$$\frac{\partial \mathbf{B}_k}{\partial t} = -\nabla \times \mathbf{E}_k, \quad k = q,\ m. \tag{4.15}$$

In the electrical version, the form of the law (4.15) is known as Maxwell's second law (3.129).

In the case of a gravitational field in the usual notation, expression (4.15), based on the analogies of both fields, will have the form

$$\frac{\partial \mathbf{\Omega}}{\partial t} = -\nabla \times \mathbf{\Gamma}. \tag{4.16}$$

For the sake of certainty, (4.16) can be arrived at as usual if the motion vectors are expressed based on the laws of classical mechanics. For that, we write down the definition

$$\mathbf{\Gamma} = \frac{\partial \mathbf{V}}{\partial t}. \tag{4.17}$$

If we take the vector operation $\nabla\times$ from the left and right parts of (4.17), then we can get

$$\nabla\times\mathbf{\Gamma} = \frac{\partial}{\partial t}\nabla\times\mathbf{V}. \tag{4.18}$$

If we take into account that the angular velocity vector $\mathbf{\Omega}$ is the vortex component of the linear velocity vector $\mathbf{V}$, then equation (4.18) turns into (4.16) by itself. The "-" sign in (4.16) is introduced by matching the vector orientation according to the right-hand screw rule.

Theoretical pause. Equation (4.18) requires more careful attention. The point is that by definition

$$\nabla\times\mathbf{V} = 2\mathbf{\Omega}. \tag{4.19}$$

To understand the physical connection of the vectors in (4.19) and not to describe it by all projections, let's focus on the classical case of cylindrical symmetry: $\mathbf{V} = \boldsymbol{\alpha}_0 v; \mathbf{\Omega}' = \mathbf{z}_0\omega$, where $\boldsymbol{\alpha}_0, \mathbf{z}_0$ are orthogonal. Then (4.19) is significantly simplified

$$\frac{v}{r} + \frac{\partial v}{\partial r} = 2\omega. \tag{4.20}$$

From its obvious solution, we obtain the classical expressions of linear velocity and acceleration

$$v = \omega r; \quad a = \omega^2 r. \tag{4.21}$$

Therefore, in the right part of (4.16) according to (4.15)-(4.17), coefficient 2 should appear at $\mathbf{\Omega}$, but this will violate the external similarity of the laws of gravity and electricity. To prevent this from happening, we will leave it in its previous form, remembering that we are not operating with a real, but for the time being, with a double angular velocity: $\mathbf{\Omega}' = 2\mathbf{\Omega}$. This is how this problem was solved in gravitomagnetism, and besides, the appearance of 2 by $\mathbf{\Omega}$ is explained there not by the definition of the vector operator (4.19), and in his own way: "the gravitational field is described by a tensor of the second rank, in contrast to the electromagnetic field, which is described by a tensor of the first rank (vector)". But none of the creators of gravitomagnetism thought that the rest of the rotor operations (4.13)-(4.15) in the original Maxwell equations were put in a difficult position. Below we will explain what is actually happening here.

Let us start from two experimental facts: electric and gravitational waves are transverse ($\mathbf{E} \perp \mathbf{B}$; $\mathbf{V} \perp \mathbf{\Omega}$) and propagate at a speed $v = c$. These conditions are quite sufficient to write down an expression very important for field theory according to (1.5), (2.39)

$$\mathbf{E}'_k = E_k \left(1 + \frac{c^2}{c^2}\right)\mathbf{r}_0 = 2\mathbf{E}_k, \quad k = q, m. \tag{4.22}$$

If now in (4.13)-(4.16) we replace the vector notations with the corresponding hatched ones, then everything will remain unchanged because factors 2 will be reduced. And this indicates that we operate with real physical quantities, electrical and mechanical! One can only marvel at the genius of Maxwell, who, at the dawn of developing electrodynamics, did not fall into the same trap that the prolongers of his equations on gravity fell into.

Formula (4.22) is a guarantee that the third force component (2.45) does not affect the classical equations of electricity and gravity of stationary media with their transverse motion.

Gravitomagnetism. By design, gravitomagnetism (gravitoelectromagnetism) is an adjunct to GRT, which makes it possible to take into account in the theory of gravitation the forces of rotation of gravitating masses, similar to magnetic forces in electricity [28]. According to the GRT theory: "the gravitational field generated by a rotating object, in some limiting case (we are talking about weak gravitational fields) can be described by equations that have the same form as Maxwell's equations in the SI system." And then, in order not to lose face, "wisdom" is added: "In the case of strong fields and relativistic velocities, the gravitomagnetic field cannot be considered separately from the gravitational one, just as in electromagnetism, electric and magnetic fields can be separated only in non-relativistic limits in static and stationary cases". With the above, we only warn against forming a formal opinion that vector equations (4.9)-(4.18) also appeared in the field of gravitomagnetism of weak fields and prerelativistic velocities. On the contrary, our expressions present real fields and velocities within the limits of their physical existence. This is the fundamental difference between electro-gravity and gravitomagnetism!

Finally, note *that the intensity (tension) vectors of both force fields* $\mathbf{E}_q, \mathbf{E}_m$ *are actually a conveniently veiled interaction of the corresponding masses (2.39)!*

In the next two subsections, we will consider two important theoretical problems of gravity – the direct interaction of electric and gravitational fields and, what is very important, the reality of the existence of gravitational waves. There have been discussions about the existence of gravitational waves for a long time, but there was no luck with observations for a long time. But now, as we learn, that is already in the past. Although you can come across publications that question the last statement.

4.6. Gravitational lens

A gravitational lens is a massive body (star, planet) or a system of bodies (galaxy, cluster of galaxies) that bends the direction of propagation of electric radiation with its gravitational field, in the same way as an ordinary lens bends a light beam. Among the observed cosmic effects of this phenomenon, such as Einstein's rings and cross are known. Einstein rings occur when the observer is in the same line with the source of the gravitational field and the source of light behind it. Einstein's cross is a gravitational lensing image of a quasar located along the line of sight behind the galaxy 2W2237+030. This enlarged quadruple image forms a cross with a lens galaxy in the center.

If we talk more broadly about the celestial phenomenon, then we are talking about the direct influence of the gravitational field on the electric field. A meticulous theoretical approach to the study of this phenomenon shows that the principle of the constancy of the speed of light in a vacuum appears as an obstacle here. The mass of the signal carrier can be found using the formula $m = E/c^2$. And if such a mass is present, then entering into gravitational processes, its movement must undergo not only a distortion of the trajectory but also acceleration and braking effects! But in this case, the constancy of the speed of light (c = 299792458 ms^{-1}) has to be somewhat compromised in a small neighborhood, otherwise, the fact of the existence of a gravitational lens loses its physical meaning, and this contradicts the practice of observations. With this understanding, we can use the differential equations of motion (2.50). If within the limits of the accepted compromise, their adaptation to the solution to the given problem is carried out, then we will obtain

$$\begin{aligned}
&\frac{dv_x}{dt} = -2\frac{GM\,r_x}{r^3}\left(1+\frac{r_x v_x + r_y v_y}{rv}\right); \quad \frac{dr_x}{dt} = v_x; \\
&\frac{dv_y}{dt} = -2\frac{GM\,r_y}{r^3}\left(1+\frac{r_x v_x + r_y v_y}{rv}\right); \quad \frac{dr_y}{dt} = v_y.
\end{aligned} \tag{4.23}$$

Based on (4.23), we simulate the distortion of the trajectory of the electric signal under the influence of the star's gravitational field. At the same time, we will discuss the inconsistency of the obtained results from the point of view of observations.

Example 4.1. We simulate the correction of the trajectory of the light beam in the gravitational field of the Sun at a maximum approach of $0.5 \cdot 10^8$ m with its calculated surface.

The results of the numerical integration of equations (4.23) are shown in Fig. 4.1 – fig. 4.3) with constant parameters $GM = 13,27128 \cdot 10^{19}$ $\mathrm{m^3 s^{-2}}$ corresponding to the Sun and initial conditions:

$$r_x(0) = -12.0 \cdot 10^8;\ r_y(0) = 7.5 \cdot 10^8;\ v_x(0) = c;\ v_y(0) = 0.$$

In fig. 4.1 shows the curvature of the trajectory of the light beam in the gravitational field of the Sun. Analysis of the numerical data of the computer simulation showed that the beam was deflected by a very small angle, which is only 0.857503" of angular arc. In calculations based on classical equations (under the action of Newton's force only), this angle turned out to be significantly smaller than 0.468197" of an angular arc. Calculations performed by various methods only reinforce the real presence of a physical effect.

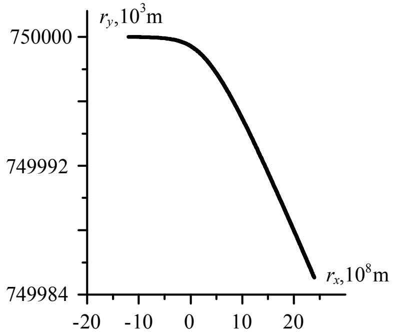


Fig. 4.1. Distortion of the trajectory of a light signal $r_y = r_y(r_x)$ flying near the Sun at a distance of 750,000 km from its center

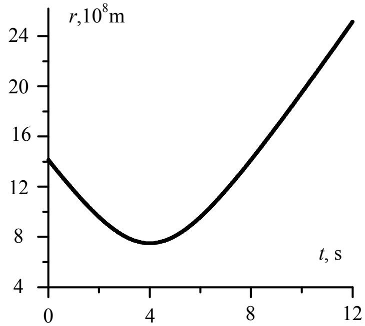


Fig. 4.2. The time dependence of the distance $r = r(t)$ between the gravitated signal and the center of the star in the transient process corresponding to fig. 4.1

Fig. 4.2 illustrates the time dependence of the distance between interacting masses.

The further train of thought will be chained to the time dependence of the speed of signal propagation. Its course is the fundamental problem of theoretical physics – is the speed of light constant [34]? The positive answer to this question is not only known but also endowed with the face of holiness. While in our numerical experiment, under the influence of the Sun's gravity, it exceeded c (299792 458) by 213 ms^{-1} (299792671) at the stage of convergence with the luminary and decreased from c at the stage of departure by 1616 ms^{-1} (299790842). It is for the sake of this important information that the duration of the transition process has been increased from 12 s to 25 s.

Based on the dependence $c = c(t)$ (fig. 4.3), obtained according to the

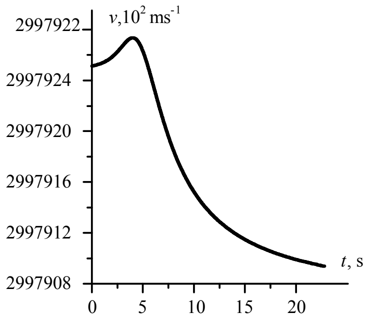


Fig. 4.3. The time dependence of the signal speed $c = c(t)$ in the transient process corresponding to fig. 4.1

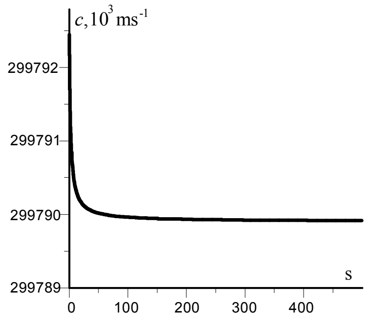


Fig. 4.4. The speed of light $c = c(t)$ its path from the Sun to the Earth

fundamental laws of physics, *the speed of light in a vacuum c, as a physical constant, can be safely translated into the form of a quasi-constant*, especially since this phenomenon is confirmed by observations [39], including the effect of gravitational delay signal, or the Shapiro effect, and data from observations of the supernova SN1987A, which exploded in 1987 50,000 ps from the Sun. As a result, a flux of photons and neutrinos was recorded, but the photons appeared at 4.7 h. later than expected.

Unfortunately, in our opinion, the explanation of both observations is unsuccessful. One of them was hindered by relativistic thinking, the other by quantum thinking.

The Shapiro effect in the GRT is calculated not based on the basic differential equations of this theory, but traditionally by finding a convenient approximation expression for the experimental data, as was done in the case of calculating the precession of the Mercury orbit (2.52) - (2.56)

$$\Delta t = -R_g \log(1 - \mathbf{r}_0 \cdot \mathbf{x}_0), \tag{4.24}$$

where Δt is gravitational time delay; R_g is gravitational radius of the gravitating body (2.9); $\mathbf{r}_0, \mathbf{x}_0$ are unit vectors directed from the observer to the source and the gravitational mass. This delay of time corresponds to the deformation of space $\Delta x = c\Delta t$ at $c = const$. The question is, isn't it more natural to allow c = var and leave the long-suffering both time and space alone?

J. Franson from the USA, a supporter of the change in the speed of light in a vacuum, justifies the phenomenon from a quantum standpoint: "A photon spontaneously splits into a positron and an electron, and then quickly recombines into a photon again, and this can a little delay the photon's movement."

So, we are not alone on the way to the truth, and this is the most important thing.

From this point of view, the speed characteristic of the sun's rays (fig. 4.4), which reaches our eye, obtained as a result of the integration of equations (2.17) for the value of GM =13,27128·10^{19} and the initial conditions: $v_0 = c$; h_0 = 6,934·10^8. The signal lost 2542 ms^{-1} of speed during the flight, with a third of this loss occurring in the first second. Time delay according to (4.24) $\Delta t \approx 0.004$ s. If only Newton's force (2.42) is used in the calculations, then this delay will decrease four times by $\Delta t \approx 0.001$ s. By the way, formula (4.24) is not applicable here.

4.7. Gravitational waves

On February 11, 2016, the LIGO and VIRGO collaborations announced the experimental discovery of gravitational waves resulting from the merger of two black holes with masses of 36 and 29 solar masses into one with a mass of 62 solar masses (Observation of Gravitational Waves from a Binary Black Hole Merger B.P. Abbottetal. (LIGO Scientific Collaboration and Virgo Collaboration) Phys. Rev. Lett. 116, 061102 – Published 11. February 2016.). Thus, the energy released in a tenth of a second in the merger is equivalent to about 3 masses of the Sun. The distance to the source is about 1.3 billion St. r. Gravitational waves were predicted by many theories of gravity. But to detect them, a surprisingly sensitive detector was needed. When such oscillations reach the Earth, they have a very small amplitude – thousands of times smaller than the atomic nucleus.

In this regard, we read on the International Web: "The existence of gravitational waves can change our perception of the universe. Scientists will be able to investigate the consequences of the biggest event in the history of the universe – the Big Bang. It will be possible to look into the most distant corners of the cosmos because such waves propagate through the universe absolutely unhindered. It doesn't matter what happens on their way. This is how they differ from light or sound waves. Thanks to gravitational waves, there is hope to solve some of the biggest mysteries in science, for example, what makes up a large part of the universe. After all, only 5% of the universe is ordinary matter, 27% is dark matter, and the other 68% is dark energy. They are called dark because it is not known what they are [33]". We also gain denial of the possibility of the existence of dark matter and dark energy [38] and at the same time the existence of gravitational waves themselves, especially modern technical means of their registration [2].

Gravitational waves are emitted by any massive body moving with acceleration. However, for the generation of a wave of significant amplitude, an extremely large emitter mass and/or huge accelerations are required. If a certain object is moving at an accelerated rate, it means that some force is acting on it from the side of another object. In turn, this other object feels the opposite action. It turns out that two objects emit gravitational waves only in pairs. For the Solar System, for example, the largest gravitational radiation is caused by the subsystem of the Sun and Jupiter. The power of this radiation is small - approximately 5 kW. The most powerful sources of gravitational waves are colliding galaxies and the gravitational collapse of a binary system of compact objects with huge accelerations and huge masses.

It seems that there is no need to manipulate the warnings that "gravitational waves compress and stretch space, distort it, change the structure of space-time", because electric waves parallel to them have not yet done anything of the kind. And without them, we cannot imagine the existence of civilization. Examples of electric waves are light, radio waves, X-rays, gamma rays, etc. They are described by Maxwell's equations (3.128), and (3.129) common to electrical phenomena. Even in the absence of electric charges and currents in space, Maxwell's equations have non-zero solutions. They describe electric waves (3.136).

In a vacuum, the intensity vectors of the stationary and vortex components of an electric wave are necessarily perpendicular to the direction of wave propagation. Such waves are called transverse, in addition, the intensities of the stationary and vortex components of the field are perpendicular to each other. If you choose a coordinate system so that the z-axis coincides with the direction of propagation of the electric wave, there will be two different possibilities for the directions of the electric field strength vectors. If the stationary field is directed along the x-axis, then the eddy field will be directed along the y-axis, and vice versa. These two different possibilities are not mutually exclusive and correspond to two different polarizations.

In the absence of masses and their temporal changes, the expressions (4.14), (4.16) correspond to Maxwell's equations (3.128), (3.129) will be expressions (4.14), and (4.16)

$$\frac{\partial \mathbf{\Gamma}}{\partial t} = c^2 \nabla \times \mathbf{\Omega}; \qquad \frac{\partial \mathbf{\Omega}}{\partial t} = -\nabla \times \mathbf{\Gamma}, \tag{4.25}$$

and the continuity equations (3.130) are similar

$$\nabla \cdot \mathbf{\Omega} = 0; \quad \nabla \cdot \mathbf{\Gamma} = 0. \tag{4.26}$$

Equation (4.25) is analogous to the corresponding electrical equations (3.136)

$$\frac{1}{c^2}\frac{\partial^2 \mathbf{U}}{\partial t^2} = -\nabla \times \nabla \times \mathbf{U}, \quad \mathbf{U} = \mathbf{\Gamma}, \mathbf{\Omega}. \tag{4.27}$$

If we use the theorem $\nabla \times (\nabla \times \mathbf{F}) = \nabla(\nabla \cdot \mathbf{F}) - \nabla^2 \mathbf{F}$, based on (4.26), we obtain the classical equations of gravitational transverse waves

$$\frac{1}{c^2}\frac{\partial^2 \mathbf{U}}{\partial t^2} = \nabla^2 \mathbf{U}, \quad \mathbf{U} = \mathbf{\Gamma}, \mathbf{\Omega}. \tag{4.28}$$

What had to be shown. Equations (4.28) are vectors. If necessary, they can be written down as coordinately. Yes, in Cartesians coordinates we will have

$$\frac{1}{c^2}\frac{\partial^2 U_r}{\partial t^2} = \frac{\partial^2 U_r}{\partial x^2} + \frac{\partial^2 U_r}{\partial y^2} + \frac{\partial^2 U_r}{\partial z^2}, \quad U = \Gamma, \Omega.; \quad r = x, y, z. \tag{4.29}$$

In the case of a symmetric spherical wave in spherical coordinates (radius r), expression (4.29) simplifies to the classical

$$\frac{1}{c^2}\frac{\partial^2 U}{\partial t^2} = \frac{\partial^2 U}{\partial r^2}, \quad U = \Gamma, \Omega. \tag{4.30}$$

The specific energies of gravitational waves are calculated based on the results of solving the corresponding differential equations according to expressions (4.8).

4.8. Spatial protovector-potential

From a mathematical point of view, there is no need for a deeper unification of electricity and gravity to the level of the spatial protovector potential $\mathbf{P}$ (Greek letter *ro*). But as a form of connection between consciousness and existence, it deserves attention, since here, based on philosophical irresponsibility, a lot can be said with benefit for the activation of thought. In addition, for the human perception of the universe, nature itself made this association a long time ago, as evidenced by the table of dimensionalities (see p. 99). Each of the values of a separate field has its own dimensionality. But as for the energy characteristics

$(p, A, \mathbf{F})$ necessary for the contact of the field with a person, the dimensionalities are the same - combined

We enter the protovector through the open door

$$\mathbf{A}_k = \frac{\partial \mathbf{P}_k}{\partial t}, \quad k = q, m. \tag{4.31}$$

The protovector-potential $\mathbf{P}$ in the mechanical interpretation is a spatial radius vector, in the electrical interpretation it is the same vector, only in deformed space by the coefficient (4.5): m / q. Therefore, we will conditionally assume that the space is dual – the space of gravity (mass) and the space of electricity (charge), and the coefficient is a flipping from one to another, which reduces either the mass or the charge in favor of the opposite field. At the same time, one should not forget that the corresponding global constants ($k \rightleftarrows G$) must be exchanged.

Based on such total symmetry of the World, one can express a bold opinion: "*Since the total charge of our Universe is zero*, then this necessary condition of stability must also be inherent in the mass – *the total mass of our Universe must also be zero!*" And if so, then the existence of antimatter with antigravitational action can be brought closer to reality from the level of a hypothesis, because there is simply no other way to ensure this condition than ensuring this condition, than the inherently to the mass $\pm m$, as well as to the charge $\pm q$, simply does not exist

Thoughts.

1. At one time, two fundamental forces of interaction of immovable bodies were known experimentally - Newton's force of gravity in mechanics and Coulomb's force in electricity. Then one more was added to them, caused by the movement of these bodies – Lorentz's magnetic force in electricity and its extension to mechanics – the gravitomagnetic force. We discovered and added one more to the existing ones (2.45), which are more strongly dependent on speed than the previous ones. In this way, we closed the trinity of physical force interactions in both mechanics and electricity. The integrity of the new theory was tested in the problems of the dynamics of the mega-, macro-, and microworld. Interestingly, that the new force component does not affect the classical equations of electricity and gravity of stationary media with their inherent transverse motion.

2. The common theory of separate electric and gravitational fields should be interpreted as a bold hypothesis, implemented thanks to the rejection of magnetism in favor of the vortex effect of motion, and the finite speed of propagation (even in the microcosm!) of electric and gravitational fields in physical space and time.

3. The dimensionality of the vector potential of gravity turned out to be the

dimensionality of speed, which gave it not only physical but also philosophical transparency – as an All-Encompassing Movement, promoted since ancient times. The truth of certain theoretical results of gravitation, likened to the results of electricity, was confirmed by obtaining them using traditional approaches adopted in mechanics.

4. If we deepen the process of conditional unification of gravity and electricity to the level of the protovector of the spatial radius, then it is possible to reach the duality of electric and gravitational space, provided that there is an anti-mass with antigravitational action in order to ensure the stability of the Universe. It is possible to express the opinion that on the path of further convergence of the theories of electricity and gravity, there are world constants, which primarily belong to *k, G*, each with a field of existence subordinate to it. The union of these fields is equivalent to the union of world constants, which are determined experimentally and characterize not individual bodies, but the physical properties of our World as a whole. Therefore, such an association would contradict the currently recognized anthropic principle. Although there is a caveat. Recently, more and more often physicists encroach on constants, and, first of all, on the speed of light in a vacuum c, hastily included in the world constants. Interestingly, that the first speaker on the subject of possible impermanence came at the beginning of the 20th century. none other than Poincare himself. And the warnings of geniuses, as they say, must be treated appropriately. It was also possible to pay attention to the fact that in our formulas (2.39), reflecting the effects of motion, there are also no restrictions on the constant c, like the Lorentz coefficient in (2.18), (2.30).

5. The equations of the wave processes of gravity fit into the classical equations of electric transverse waves that propagate in a vacuum with the speed of light. Light rays, interacting with gravitational fields, inevitably enter into inertial processes. And this gives the physical constant c the status of a quasi-constant with observed minor fluctuations in the vicinity of c.

6. It is impossible not to pay attention to the fact that for human perception of the universe, the combination of electricity and gravity is made by nature itself. All energy characteristics – force, work, power – necessary for the contact of the field with a person are common and have the same dimensionality.

7. The proposed general equation of electric and mechanical fields (4.1) compatible with the proto-energy formula (3.64) can be extended to nonlinear media, electric, and mechanical (3.126).

8. Based on the coincidence of the Hamiltonian action expressions for the electric and gravitational fields (2.90), (3.59)–(3.61), under the condition of the existence of antimatter, there are no fundamental reservations regarding the adaptation of the main achievements of quantum electrodynamics to the future quantum gravity dynamics with its still hypothetical massless quantum - graviton.

9. Nowadays, no one should be surprised by the presence of black holes in the sky. But we also encountered them in the depths of matter. All of them are united by the fact that on the other side of their spheres, the laws of our universe collapse into a singularity of energy. And this is not permissible. Therefore, it remains to assume that other physical laws apply there. And other physical laws can belong only to other universes. So, following Gedel's theorem about the incompleteness of our knowledge, we mentally come to the cosmological concept of parallel universes. And the fact that they cannot be detected only strengthens the hypothesis that the total sources of force fields in each of them – like our charges and masses – must be zero in order to be invisible from the side. But the last mentioned belongs to the surreal simulation, which will be discussed further.

10. You are surprised: portions of knowledge are given to humanity on demand. Ampere, Faraday, Maxwell, and Lorentz discovered and worked out the force effect of the transverse component of the speed of movement of a charged body in an electric field at the dawn of the electrification of mankind. I did the same with the longitudinal component (though first in the gravitational field) at the dawn of the astronautics of mankind! So all time gaps between these events are completely logical and justified.

11. The harmony of the presented results of the simulation of terrestrial and cosmic transient processes gives us a certain moral and aesthetic right to consider them as corresponding to objective reality according to H. Poincare.

5. SURREALITY IN SCIENCE

So that the appearance of the term surrealism in this real scientific study does not seem strange, let us say in advance that it will be about the physical effects of movement, which have excited human minds for more than a hundred years. It was the theory of these effects that caused a stir, like no other physical theory of the universe, due to its indescribable beauty and flight of fantasy. It is clear that we are talking about the theory of relativism in two guises – SRT and GRT, and our relations to it. But we will talk about all that later, and first let's skip the previous material so that we can talk more clearly about the main thing.

It is about one side of science, known to everyone, but silenced - about the elements of surreality, which are used in theoretical exercises. This is mostly done to the benefit, but sometimes to the detriment of science itself. Such a warning is since the methods of super-reality must be used carefully, relying on reason and intuition, so as not to become a victim of one's own subconscious, which is not guided by the same own consciousness.

The world of art long ago mastered this and achieved great success in revealing the idea. The surreal approach, known as surrealism, creates wonders in painting, plastic arts, literature, and music. And why does the world of science have to stand aside? After all, the world of art and science is an inseparable field of activity of the human spirit. On this occasion, I wrote about my own surreal literary exercises: "Music, literature, and painting are the factors that support the activity of those brain cells that are connected with the perception of higher aesthetic tastes. They strengthen the emotional side of our activity... The loss of these tastes is equivalent to the loss of happiness. Reason and intuition are the wings of a scientist. And literature is one field of flight yet. The wonderworld of science is not inferior to the wonderworld of art. In science, a person is closer to the harmony of beauty, because beauty here is perceived by the brain directly, and not through translators – the organs of sight, hearing, etc., as in art."

To be honest, science has long used the elements of surrealism on a subconscious level, without thinking about it. Let's name at least a widely used one with a claim to the reality of the decomposition of a periodic function into a Fourier series. Most even believe in the existence of real harmonics in this series. And on objections about the possibility of decomposing this same function into another series, for example, Walsh puts them at a dead end because the division of reality into harmonics or rectangular formations appears. And who would deny that the world of complex variables, one of the cornerstones of mathematics, does not belong to this group? Examples can be given endlessly, but it is so clear what is being said.

Frankly speaking, all mathematics, as a science, gravitates towards the surreal but serves this reality more sincerely than all other known realities. When raising the question of the surreality of mathematics, one cannot bypass the meaningful surreal exercises of its best representative, Henry Poincare, at least in his "Non-Euclidean World".

But Poincare's surreal model of the non-Euclidean world is not an exercise for the sophisticated brain. It pursues the pragmatic goal of simplifying the perception of non-Euclidean geometry, to which he made a significant contribution. Everything written by Poincare is captivating. According to his scientific-philosophical reflections on the "spirituality of nature", the "non-Euclidean world" makes it possible to rise to the heavens and look into the state of the creator, who builds a new world, which is perceived as boundless with heart, and as closed with his mind. It is also a miracle that my first International Conference was held in Nancy, and on September 18, 1990, I set foot on the land of the prophet of science. The meeting with Poincare offered below, sheds light on the wonderland of his creative spirit. But this in no way reveals the worldview of the great Scientist, it is simply a philosophical touch to his creative style. The original text, translated from French, follows.

5.1. The non-Euclidean world

Let's imagine the world enclosed within a large sphere and subject to such laws. The temperature here is not uniform; it has the greatest value in the center and decreases with distance from it, reaching absolute zero on the spherical surface, which is the limit of this world. I will determine precisely even the law according to which this temperature changes. Let R be the radius of the boundary surface, r is the distance of this point from the center of the sphere. Let the absolute temperature be proportional to R^2-r^2. I will assume further that in this world all bodies have the same coefficient of expansion, precisely such that the length of any ruler is proportional to the absolute temperature. Finally, I will assume that an object transferred from one point to another, where the temperature is different, immediately enters a state of thermal equilibrium with its new environment. There is nothing contradictory or unthinkable in these assumptions.

In this case, the moving object will decrease as it approaches the limit sphere. Now note that although this world is limited from the point of view of our ordinary geometry, it will appear infinite to its inhabitants. Indeed, when they wished to approach the limit sphere, they would cool and become smaller and smaller. Therefore, their steps would be constantly shortened, and they would never be able to reach the limit sphere. If to us geometry is nothing else but the study of the laws by which solid bodies remain unchanged, to these imaginary beings it would be the study of the laws by which solid bodies change in consequence of those differences of the temperature of which I have just spoken.

Undoubtedly, in our world, real solid bodies also undergo changes in shape and volume due to heating and cooling. But in establishing the foundations of geometry, we neglect these changes, since, in addition to being extremely insignificant, they are also disorderly and, therefore, seem to us accidental. In the world we imagine, this would no longer be the case; these changes would obey correct and very simple laws. On the other hand, the various solid components of the body of the inhabitants of this world would experience the same changes in shape and volume.

I will make another assumption that the light here passes through media of different refractive power, precisely such that the index of refraction is inversely proportional to R^2-r^2. It is easy to see that under these conditions the light rays would not be rectilinear, but circular. To justify all the foregoing, it remains for me to show that certain changes occurring in the position of external objects may be compensated for by the correlative motions of the sentient beings which inhabit this imaginary world; thus, the original set of impressions experienced by these beings can be restored. Let's really assume that the object moves, deforming: not as an unchanging solid body, but as a solid body that experiences uneven expansions, exactly corresponding to the law of temperature changes assumed above. For the sake of brevity, I will allow myself to call such a movement a non-Euclidean movement.

If a sentient creature is nearby, its impressions will be altered by the movement of the object, but it will be able to restore them to tneir former form by moving just the right way. It is enough that, as a result, a system consisting of an object and a sentient being, considered as one body, experiences one of those special displacements which I have called non-Euclidean. This is possible if we assume that the members of these creatures expand according to the same law as other bodies of the world inhabited by them. Although, from the point of view of our ordinary geometry, the bodies will appear deformed after such a movement, and their various parts will by no means return to their former relative position, we shall see that the impressions of the sentient being will the same.

Indeed, if the mutual distances of the different parts could change, the parts that were once in the collision will again be in a collision. Therefore, tactile impressions will not change. On the other hand, if we take into account the hypothesis about the refraction and curvature of light rays, we will be sure that visual impressions will remain the same. Therefore, our imaginary creatures will have to, like us, classify the phenomena they observe and distinguish from them "changes in position", which can be compensated by the appropriate volitional movement. If they create geometry, it will not be, like ours, the study of the motions of our immutable solid bodies; it will be the science of changes in position, changes which they will single out in a special group and which will represent nothing but "non-Euclidean displacements". This will be a non-Euclidean geometry.

Thus, creatures like us, raised in a similar world, would have a geometry different from ours.

The appearance here of the surreal non-Euclidean world of H. Poincare is not accidental. This world is a vivid example of a surreal mathematical model. But Poincare's model gravitates towards the fantastic, and we propose the use of surreality to more effectively reveal certain aspects of reality itself, or perhaps the same surreality in surreality. To be more specific, at least one of the projections of such a model should lead to the desired result. As an example of such an unusual mathematical model, a model of a surreal light sphere of limiting velocities and energies is proposed.

5.2. The world of extreme speeds

Similar to the surreal mathematical model of the spherical non-Euclidean world of G. Poincare, which confirms the possibility of wedging surreality into the real world of physical structures, we offer our own surreal mathematical model of the light sphere in the space of the limiting speeds of light in a vacuum. But there is a fundamental difference between these two models. If the model of the non-Euclidean world distances us from the real, then the light sphere model is projected onto the real (quasi-real) world. Here, the real velocities are interpreted as components of the limit in a certain coordinate system. The kinematics and dynamics of the projections of the velocity vectors of such a surreal sphere completely coincide with the real relativistic theory (SRT). In this way, we further develop the surreal world of mathematical models.

First of all, let us note that the geometric construction of such a sphere is not carried out in spatial coordinates, but in the space of velocities. It has a constant radius equal to the speed of light in vacuum $c = 2{,}9979 \cdot 10^8$ ms^{-1}. In the field of this sphere, there are no velocity vectors whose modules are different from *c*. Thus, the hodographs of all velocity vectors lie on the sphere, creating a surreal world of extreme velocities. In such a world, the velocity vectors do not differ in terms of their magnitudes, but only in their quasi-spatial orientation to the coordinate of the observer or participant in the experiment. Due to the constancy of the radius, the sphere is called a light sphere. Of course, if certain bodies with non-zero rest mass move inside such a sphere at the maximum possible speed, then we will be dealing with the world of super-energy.

Any real speed v inside the light sphere should be interpreted as a projection of the speed of the light radius onto a real coordinate system, for example, Cartesian (fig. 5.1). In this case, the longitudinal v_x and transverse v_y components of the velocity will be defined as

$$v_x = c\cos\alpha, \quad v_y = c\sin\alpha, \tag{5.1}$$

where α is the defining projection angle. It is clear that in the case of a stationary state $\alpha = \pi/2$. Thus, we freely possess all possible real velocities $0 \le v \le c$ inside the sphere, but in the field of individual components (projections) of this or that light velocity vector **v**.

Based on (5.1), we give the transverse component of the velocity as

$$v_y = c\sin\alpha = c\sqrt{1-\cos^2\alpha} = c\sqrt{1-\frac{v_x^2}{c^2}}. \tag{5.2}$$

The appearance of the Lorentz coefficient in the transverse component of the velocity is fully consistent with the relativistic theory. And this is not accidental, because the conditions of relativism are laid down in advance in the sphere itself since its radius is constant. And this means that no matter what combinations we do with individual components of velocities, their sum cannot cross the boundary of the sphere. Thus, we completely geometrize the kinematics of velocities inside the light sphere according to the theory of relativism.

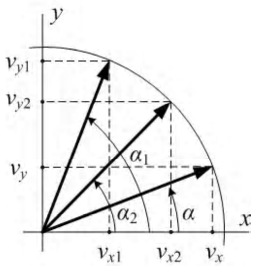


Fig. 5.1. Fragment of the cross-section of the light sphere of the limiting velocities in the plane of Cartesian coordinates

We will show how to add velocity components inside the light sphere using the simplest example – their algebraic addition. Because we are not interested in the subtleties of the relativistic transformation of velocities, but in the possibilities of the sphere itself. In this case, we will deal with planar angles in the cross-section of the sphere by the plane of Cartesian coordinates $x,0,y$ (fig. 5.1).

Two light vectors are shown here, the projections of which determine the real speeds v_{x1}, v_{x2}. According to the accepted rules, the total speed of both of them must be determined by the projection of some other light vector, which will also have a different quasi-spatial orientation. And this means that the task is reduced to determining a new defining angle by a combination of defining angles of individual terms.

First of all, let's select the optimal formula for the relativistic addition of the cosines of individual defining angles, as the closest to their usual addition

$$\cos\alpha = \frac{\cos\alpha_1 + \cos\alpha_2}{1+m}, \tag{5.3}$$

where m is the correction coefficient, of course, if $m = 0$, then (5.3) degenerates into the usual sum of two terms.

This coefficient can be determined from the boundary conditions.

First, it must be zero if one of the two terms in the numerator of the expression (5.3) is zero: $\cos\alpha_1 = 0$, otherwise $\cos\alpha_2 = 0$, the addition itself is degenerate. In addition, these two conditions must be embodied in the simplest form, and this is the case

$$m = k\cos\alpha_1\cos\alpha_2, \tag{5.4}$$

where k is some still unknown coefficient.

Secondly, under the condition of maximum values of both terms in the numerator (5.3) ($\cos\alpha_1 = 1$ and $\cos\alpha_2 = 1$) in (5.3), the trigonometric maximum condition must be fulfilled: $\cos\alpha = 1$. And this is possible only under one condition: $k = 1$.

Now, substituting (5.4) for the second boundary condition in (5.3), we obtain the final formula for the relativistic addition of velocities

$$\cos\alpha = \frac{\cos\alpha_1 + \cos\alpha_2}{1 + \cos\alpha_1\cos\alpha_2}. \tag{5.5}$$

Example. Let the velocity components be $v_{x1} = v_{x2} = 0{,}5c$. And this, according to (5.1), determines: $\cos\alpha_1 = \cos\alpha_2 = 0{,}5\ (\alpha_1 = \alpha_2 = 60^0)$. Substituting these values in (5.6), we obtain: $\cos\alpha = 0{,}8;\ \alpha = 36{,}87^0$. So, the total speed is only 0.8 *c*.

The static mass m' can be found from the increments of energy and momentum

$$\frac{d(m'(v)c^2)}{dt} = c\cos\alpha\frac{d(m'(v)c\cos\alpha)}{dt}. \tag{5.6.}$$

Integrating under the condition $m'(v) = m_0$ that at $\cos\alpha = 0$, we will have

$$m'(v) = \frac{m_0}{\sin\alpha}. \tag{5.7}$$

The energy of movement is interpreted as the difference between full and rest energies (3.46), (3.47)

$$w_k = (m'(v) - m_0)c^2. \tag{5.8}$$

Then according to (5.7) we have

$$w_k = \frac{m_0 c^2}{\sin\alpha}(1-\sin\alpha). \tag{5.9}$$

As for the co-energy of motion, it is found similarly to (5.8), (5.9)

$$w_{kc} = w_k \sin\alpha = m_0 c^2 (1-\sin\alpha). \tag{5.10}$$

Formulas (5.7), (5.9), and (5.10) are essentially the same as expressions (3.33), (3.34), and (3.39).

We look for the force action by the kinetic energy gradient according to (3.41), (5.9)

$$F_k = \frac{\partial w_k}{\partial x} = m_0 c^2 \frac{\partial}{\partial \sin\alpha}\left(\frac{1}{\sin\alpha} - 1\right)\frac{\partial \sin\alpha}{\partial x} = \frac{m_0}{\sin^3\alpha} a, \tag{5.11}$$

where $a = dv/dt$ is the acceleration.

To (5.11) can be arrived at through mechanical impulse

$$p = m_0 c \cdot \mathrm{ctg}\alpha. \tag{5.12}$$

Differentiating (5.12) with respect to time, we obtain

$$F_k = m_0 c \frac{\partial \mathrm{ctg}\alpha}{\partial t} = m_0 c \frac{\partial \mathrm{ctg}\alpha}{\partial v} a = \frac{m_0}{\sin^3\alpha} a. \tag{5.13}$$

Expressions (5.11), and (5.13) completely coincide with (3.44). Thus, in the world of limiting speeds, with a known value of rest mass m_0, the motion is described in detail by the defining coefficient α.

It is interesting that for velocities $v \ll c$, the kinetic energy expression (5.9) on the basis of the binomial theorem (3.40) can be given the form of the surplus of the mass of motion

$$w_k = m_0 c^2 \left(\frac{1}{\sqrt{1-\cos^2\alpha}} - 1\right) = m_0 c^2 \left(1 + \frac{1}{2}\cos^2\alpha - 1\right) = \frac{1}{2} m_0 c^2 \cos^2\alpha. \tag{5.14}$$

The existence of a light sphere, in reality is unlikely (although there are no caveats from the side of philosophy). It is, as it were, a targeted wedge of surreality into reality in order to geometrize the kinematics and dynamics of real speeds. The subjective idea was precise to show that surreality is capable of contributing to the discovery of the harmony of rational unambiguity. At the same time, the layers raised here lead us directly to the original concept of philosophy – being, which has the broadest generalization and therefore appears as a cornerstone worldview reference point.

Thus, kinetic energy w_k (5.9), (3.39), and co-energy w_{kc} (5.10), (3.34) at real speeds v are determined primarily by the speed of light c. And this in advance brings us closer to the surreal world of extreme speeds, making it more and more real in the light of modern philosophical teaching [10] about the levels and forms of the manifestation of being. These levels and forms are the most complex and contradictory in the theory of knowledge. We will talk about this in more detail below in the philosophical digression.

Philosophical digression. Interestingly, that the essence of the mathematical surreal exercises proposed above fits into one of the sides of the modern dualistic perception of the world. Poincare once wrote (it is unlikely that the greatest mind on the planet could be wrong): "*The harmony which the human mind hopes to discover in nature, does it exist outside the human mind? Without a doubt, no; an impossible reality that would be completely independent of the mind that grasps it, sees it, feels it. Such an external world, if it even existed, would never be accessible to us. But what we call objective reality is ultimately what is common to several thinking beings and could be common to all. This common side can only be harmony expressed by mathematical laws. Therefore, it is precisely this harmony that is the only objective reality, the only truth that we can achieve; and if I add that the universal harmony of the world is the source of all beauty, then it will be clear how we should value those slow and difficult steps forward that little by little reveal it to us.*"

Non-classical philosophy echoes the same: "There is no being outside of consciousness; at least, we don't know anything about it." And the current one [10] is close to that: "*Existence encompasses the very foundations of the subjective-objective relationship and at the same time inscribes a person into the structure of the universe, making his consciousness a fundamental condition for the discovery of forms of existence... On the other hand, existence seems to be behind us and a priori given to us as a total quality.*"

In this way, the modern dualistic interpretation of existence is far from the orthodox metaphysical one taught to us by faithful Leninists at the student desk, and it does not contradict the bright mind of Poincare. Although Poincare himself was reprimanded for these words directly by Lenin himself in his infamous "Philosophical Notebooks".

Having come across a such scientific curiosity in the labyrinths of my own subconscious, I was stunned. But to approach people with such a "World", I confess sincerely, I was afraid, knowing that the subjects of the actions of creative collectives are not themselves, but the laws and imperatives of nature, which resolutely opposes human creativity. This wisdom was inspired by the negative reviews of a local magazine on my "Conflict-free electron model" (1.20), (1.22), which was later published in one of the most prestigious magazines [40]. So, for advice, I went to V. Petrushenko, a tireless worker of philosophical thought in Ukraine. After hearing the essence of the matter, he, without thinking, says: "Since you discovered such a world and described it mathematically, then it exists." And here is Prof. J. Bujak unexpectedly offers to compose a joint monograph. I already took this as a sign of Heaven. This is how our "sinful world" saw "The World of Limiting Speeds" on its pages [1].

Creative surreality is directly related to the unconscious. In the USSR, it was declared the most reactionary bourgeois trend. The communists couldn't detect its presence in science, so the punitive apparatus carefully monitored the purity of socialist realism in art. But at the same time, the KGB suffered a fiasco, seeing through the purity of the surrealistic style of its own shy "chastushka". To dispel the remnants of that drug, let's look at the problem of the unconscious from the perspective of modern philosophical knowledge [10]: "In our time, intuition is combined with manifestations of the unconscious, as well as with the phenomenon of so-called "background knowledge", that is, it is assumed that intuition activates hidden depths background knowledge is that implicit knowledge that is involved in scientific discourse, but is not realized; it is present in scientific constructions, only later, in their further careful analysis... The images of intuitive solutions and insights must be further developed in order to acquire the status of scientifically reliable. Intuition is given great importance, but its role is not exaggerated, because it is not a simple and random gift to a person, but only a reward for long and persistent intellectual searches.

In the next subsection, we will share thoughts about relativism.

5.3. Relativism

The very fact that such a prestigious piece of science as relativism is placed in the section devoted to surrealism can be alarming. But let's not rush to conclusions. About everything in order.

SRT. The SRT is based on two postulates:

1. The principle of relativity - all physical phenomena in all inertial frames of reference (IFR) with the same initial conditions proceed in the same way. So, the equations that describe physical phenomena of any nature are the same in all IFRs.

2. The principle of the constancy of the speed of light c in a vacuum.

It is customary to express the laws of nature in SRT in such a way that they remain unchanged when moving from one inertial coordinate system to another. A coordinate transformation satisfying these requirements is associated with the Lorentz name. If we assume that the coordinate system moves along the x-axis with a speed *of* v, then the direct Lorentz transformation has the form

$$x' = \vartheta(x - vt)); \; y' = y; \; z' = z; \; t' = \vartheta\left(t - \frac{v}{c^2}x\right), \tag{5.15}$$

$$\vartheta = \left(\sqrt{1 - \frac{v^2}{c^2}}\right)^{-1}. \tag{5.16}$$

The inverse transformation is similar

$$x = \vartheta(x' + vt')); \; y = y'; \; z = z'; \; t = \vartheta\left(t' + \frac{v}{c^2}x'\right). \tag{5.17}$$

The Lorentz transformation, as the simplest, is reached when looking for a transformation that leaves the propagation of a spherical wave or the speed of a light signal unchanged. The equation of a spherical light wave emanating at time $t = 0$ from the origin of coordinates in the K system has the form

$$x^2 + y^2 + z^2 - c^2t^2 = 0. \tag{5.18}$$

At the moment $t = 0$, the system K' moving along the x-axis at a constant speed must coincide with the system K. If we substitute the value x, y, z, t from formula (5.17) into equation (5.18), then we easily obtain the equation

$$x'^2 + y'^2 + z'^2 - c^2t'^2 = 0. \tag{5.19}$$

This means that the observer, who is in the system K', will also detect the spherical surface of the wave propagating at the speed c.

It is important for us that the vector-potential equations and Maxwell's equations are invariant when moving to a moving coordinate system in the world of Lorentz transformations, as they are involved in the combined description of electricity and gravity. We can only be glad that Maxwell did his work in good faith, and we will try to transfer his possessions to gravity in the same way.

On the basis of (5.16)–(5.20) in the field of capture of IFR was built the world of SRT with its kinematics and dynamics, along with mathematical mythmaking, which is not harmful to movement, but harmful to the knowledge of the essence of movement. But there is no way to keep the motion on the IFR tether, so a further step was taken into non-inertial reference systems (NFR), but this is another field of interest – GRT.

GRT. Let's bypass the problem of equality of inertial and gravitational masses, experimentally verified with an error of up to 10-12, because Galileo already knew about it 400 years ago. But thanks to this property, it became possible to establish an analogy between the movement of bodies in a gravitational field and the movement of bodies that are not in an external field but are considered from the point of view of the gravitational field. This circumstance is called the principle of equivalence. But the fields equivalent to the NRF are not completely identical to the real gravitational fields existing in the IRF. Not to mention the situation at infinity, the fields equivalent to the NRF disappear as soon as we go to the IRF. Real gravitational fields also exist in IRF, and they cannot be excluded by any choice of reference systems.

The principle of equivalence is cumbersome and inconvenient to use. Therefore, in practice, its alternative version is used – the principle of general covariance. Its content in relation to the effects of gravity is that the equation will be valid in the gravitational field if it is valid in its absence. Thus, gravity can be considered as the equivalent of acceleration. This acceleration does not depend on the bodies on which the forces of gravity act, but only on the point in space where they ended up.

To understand this, it is not necessary to cross the threshold of GRT. To do this, it is sufficient to compare the formulas (2.12) and (2.13) of the dynamics of free gravitational fall in our real world. If in the first one of them, inertial and gravitational masses appear (actually one and the same), then in the second they have reduced. As a result, we are tied to the trajectory of space, which can be interpreted as an infinite set of its points!

The justification of the principle of covariance should be given as follows. Real physical behavior should not depend on an arbitrary choice of frame of reference. And therefore the laws of physics, whatever they may be in reality, must be expressed in a way that does not depend on the choice of a specific frame of reference. Therefore, the problem arises of finding formulas of specific physical laws that would be covariant with respect to arbitrary coordinate transformations. Although the total covariance itself has no physical contents.

In GRT, the question arises: how to describe this trajectory, given in our case by the boundary value problem at least (2.17), in practice. After all, in GRT, our real world is narrow, because it is homogeneous and isotropic. Therefore, in order to implement this idea, it is necessary to move to a curved space-time with components of the metric tensor that change from point to point. It is this connection that provides the GRT, created in 1915.

Without delving into the labyrinths of theoretical constructions of GRT, let us illuminate the equation of gravity with the first two fragments from the book [5] and the third from the book [9]:

1. "The gravitational field equations were established by D. Hilbert, who applied the variational principle to the action functional

$$S=\int\left(-\frac{1}{2\kappa}+L_m\right)\sqrt{-g}\,d^4x; \qquad \kappa=\frac{8\pi G}{c^4} \tag{5.20}$$

and A. Einstein, who proceeded from a number of assumptions, from which the general covariance condition became the final criterion for choosing equations in the form:

$$R_{ik}-\frac{1}{2}g_{ik}R=-\kappa T_{ik}, \tag{5.21}$$

where R_{ik} is the Ricci tensor, R is the scalar curvature, T_{ik} is the energy-momentum tensor of matter, κ is the constant, and L_m is the Lagrangian of matter. Equations (5.21) were called Einstein's gravitational equations. There are 10 of them ($R_{ik}=R_{ki}$) for 10 metric components ($g_{ik}=g_{ki}$). They are 2nd-order partial differential equations for g_{ik} and relate the space-time curvature (gravitational field) to the energy-momentum tensor of matter T_{ik}."

2. "A. Kartan showed that these conditions are satisfied by the G_{ik} tensor of a more general form than the left side of Einstein's equations (5.21), namely:

$$G_{ik}=R_{ik}-\frac{1}{2}g_{ik}R-\Lambda g_{ik}, \tag{5.22}$$

where Λ = const is the so-called cosmological member. The cosmological term was introduced into the gravitation equation by A. Einstein for phenomenological reasons."

3. "The path that Einstein followed inevitably led to the same equations that Hilbert obtained. It is quite obvious that Einstein obtained them independently and, not only that, he suffered from them, as he went to them for several years... Both authors – and Hilbert and Einstein did everything to have their names together in the name of the gravitational field equations. But the general theory of relativity is Einstein's theory."

At one time, Einstein nevertheless abandoned the cosmological constant Λ in (5.22), with the help of which he wanted to obtain a stationary universe. However, interest to Λ has now been revived in connection with new observations of the motion of galaxies, which indicate the existence of a larger mass of dark matter in the universe than observed. Therefore, the numerical value of the cosmological constant is by no means known.

The following can be said about (5.20). Actually, as an action in the variation principle, D. Hilbert proposed the so-called *universal function*, which follows from the Riemann tensor, as the scalar curvature of a four-dimensional manifold. In order to legitimize the universal function, he had to formulate the axiom that the laws of a physical event are determined by it. One can agree with such a statement if this function presents involvement in one or another type of energy, and not in certain demands of the mathematical apparatus. But, as far as is known [9]: "in the current theory of gravity, there is no energy tensor of the gravitational field, there is not even a hint of the presence of energy in action."

The question of action is too responsible. If it is recorded for some system, then this determines its both classical and quantum behavior. The first is through the principle of least action (3.3, p. 94)), and the second is through Feynman's integral over trajectories. At the same time, it is written in the same way for classical and quantum cases. And about the quantum theory of gravity is not mentioned at all in the GRT.

K. Schwarzschild was the first to solve equation (5.21) in 1916 for a *fixed* spherical body. In spherical coordinates r, θ, φ, his metric had the form

$$ds^2 = \left(1 - \frac{R_g}{r}\right) c^2 dt^2 - \frac{dr^2}{1 - \frac{R_g}{r}} - r^2 \left(d\theta^2 + \sin^2 \theta d\varphi^2\right), \tag{5.23}$$

where R_g is the gravitational radius (2.6), (2.9). When $r \to \infty$ the Schwarzschild metric (5.23) turns into the Poincare metric

$$ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2. \tag{5.24}$$

Schwarzschild's and our paths to the gravitational radius (2.7)-(2.9) can be compared in terms of complexity. Moreover, (5.23) r is not a metric distance. If it were so, then in (5.23) the second term would be dr^2, and thus the metric distance is greater.

The principle of general covariance is also suspended because the system of 10 differential equations for 10 components of the metric ($g_{ik} = g_k$) is indeterminate. We read in [9]: "The basic system of GRT (ten equations) is universally covariant. But the complete system of equations, necessary for solving the problems, is non-generally covariant since the four equations expressing the coordinate conditions cannot be tensor, they are always non-generally covariant."

It is difficult to agree with the statement of relativists in another fundamental question that "Newton's law of universal gravitation in the first approximation is a consequence of Einstein's gravitational equations." Because the proof is based on the expression of action for a particle in a gravitational field in the form [5]

$$S = -\int \left(mc^2 - \frac{mv^2}{2} + m\varphi \right) dt, \tag{5.25}$$

where φ is the gravitational potential, which is far from the relativistic Hilbert universal function (5.20). Thus, we have a frank exchange of concepts.

And it is necessary to step on the same rake a second time, but now in gravitomagnetism (p. 121). To be honest, gravitomagnetism is not an appendage of GRT, but rather its negation – the inability to solve relevant practical problems in its own warped space. If it were not so, then the GRT would come to the results of gravitomagnetism as a special case from its own height of "strong fields and relativistic velocities" through the universal function (5.21), and would not, like an ostrich, bury its head in the sand of Maxwell's space and time.

Therefore, it is not surprising that there are a large number of other theories that propose radical changes in the GRT, or even contradict it. Among them are string theory and its generalization. All of them have different degrees of development and are reluctantly accepted by official science. Based on even these small debatable issues, it must be recognized that GRT is still not a physical, but a geometric theory of gravitation, or even an overgeometrized one.

It's worth thinking about. It is believed that the involvement of surrealism in the sociocultural creativity of a person dates back to the 20s of the 20th century, and the primacy is intercepted by artistic creativity, with its "appeal to subconscious images freed from the control of rational thinking, the use of optical illusions, a paradoxical combination of forms" and etc. But we cannot agree with that in any case. Because thought cannot be completely free from any control by the mind, not dependent on morality, the intellect of the creator. So, in fact, we must give primacy to rational thinking, which was the first to master this effective influence on reality through superreality. And in front of everyone is none other than the famous SRT and GRT, under the supremacy of the best minds of that time.

You should not be afraid of the term "surreality", because it, like the term "reality", when used skillfully in human creativity, serves the same purpose – the knowledge of the truth. For example, we can name the expressions of the gravitational radius obtained in different ways: (2.6), (5.23) – based on GRT, and

(2.7)–(2.9) – in the real Euclidean world. The advantage of surrealism is that there are many of them, but there is only one reality. Let us at least name the world of Lorentz transformations and our world of limiting velocities, which overlaps in a narrow range of the first, but in the zone of this overlap guarantees the same identical results, but obtained much, much simpler.

The wonderland of both theories – SRT and GRT – on the boundless expanses of surreality fascinates and will fascinate many generations for a long time no less than the starry sky overhead. The question is: what is the use of that? – And such as from the starry sky. But, if he were not above us, we would not be either. In this regard, it is worth listening to the authors [8]: "Only due to supernova explosions, the interstellar medium is enriched with heavy elements previously hidden in the bowels of stars. Penetrating into clouds of gas and dust, they then become part of second-generation stars, which are formed from the secondary matter of the Universe, and together This is how the Sun – a star of the second generation - and the Solar System were formed. Therefore, the fact that we are created from the ashes of long-extinct stars is not just a beautiful artistic phrase. It very accurately reflects the events taking place in the universe."

SRT and GRT are, above all, an asset of the 20th century. And no matter what anyone says, their steps are among those difficult ones on the way to the knowledge of the truth, about which Poincare writes. The main thing is that everything is noble. Unfortunately, relativism started its course not in the best way, announcing in SRT the failure of Galileo's transformations, and in GRT declaring Euclid's flat world as narrow in favor of the distorted Riemannian one. Now we know that is not the case. A further walk along this road will show whose side the perspective is on. Disputes on this topic may be premature. After all, only the first steps, including our children's ones, are made in Euclid's familiar space and physical time. It is a pity that at one time the world did not listen to the warnings of one whose personal contribution to the development of relativism was almost decisive, regarding the fact (as was said earlier) that "no physical experience can confirm the truth of some transformations and reject others, as inadmissible".

These words once again remind us that the methods of surreal modeling must be used quite carefully and skillfully. Not to subjugate reality, but on the contrary, the final results of hyperreality must be subordinated to reality, not to impose one's own physical laws, because such laws are, in fact, in reality. The theory of relativism made two such not scientific, but tactical mistakes. First, it outlawed the already mentioned transformations of G. Galileo. Secondly, D. Hilbert proposed a no-energetic surreal action functional (5.21), built on his own so-called global function. And in order to legitimize this function, he formulates the axiom that real physical events are determined by it (?).

So, XXI century. is attacking the defensive lines of the GRT more and more aggressively. This is done in various forms – alternative theories, scientific persuasion, open discussions, and even hostility. Our research is not opposed to relativism, but, serves the purpose of unifying the equations of electricity and gravity, and overlaps with them in a sufficient range of possibilities.

Since our proposed unification of the mathematical description of two physical fields at the level of knowledge is knocked on infinity, it is worth considering one more case of purely surreal modeling involving a singularity.

5.4. Mathematical singularity

Singularity is too broad a concept: it can be about mathematical, physical, philosophical, informational, biological, and other singularities. Let's touch a bit on the mathematical one, which we encountered twice. A mathematical singularity is a point at which a mathematical function tends to infinity. If this definition is given a little physical nuance (in our cases), then it may be about the threshold limit beyond which the mathematical function tends to infinity. Since the human brain is not yet ready, but only struggling to understand this phenomenon, it is better to talk about it in the section on surreality. On the pages of the book, we saw: if the mind in search of truth reaches too high, or too deep, it inevitably falls into the trap of the singularity of black holes, those warnings, what's next! We touched it not only thanks to theoretical efforts but also through simulation.

Thus, in example 2.2 (p. 27), we experimented in 1D space with the celestial black hole – collapsar GROJ 0422. The simulation results are shown in fig. 2.2 and 2.3. In example 2.4 (p. 41), we once again experimented with it, but in 2D space, where more complex problems were solved. The simulation results are shown in Fig. 2.7 – 2.13. But they did not cross the threshold of singularity, because this phenomenon has been studied. However, in example 2.7 (p. 56), we theoretically came across a mathematical singularity in the depths of matter – a possible (if quantum physics veto is not used) appearance of a gray electro-mechanical hole (2.67) with its own singularity, which is evidenced by fig. 2.28 (collapse of the rate constant *c*). Here we could not restrain our own curiosity, because we were the first to come across something like this.

In order to somewhat whiten the blackness of mathematical black holes, the cornered human thought tries to give them a physical meaning – to see in their absolute blackness glimpses of the lights of the ports of interuniversal communications. Perhaps it is so, if we adhere to an interesting opinion [8]: "If other universes exist, then their existence obeys fundamentally different laws than the existence of our universe. And this means that we cannot receive information from them at all. After all, the physical connection between different objects is possible according to similar laws." In this case, interuniversal contact is possible only based on our and their natural laws. And the transformation of natural laws is possible only by supernatural, limitless forces that boil not elsewhere, but precisely in singularities.

A diametrically opposite development of events is also possible. It is possible that with the development of human knowledge, black holes will eventually turn white. This is described in subsection 1.5 (p. 15), which refers to the conflict-free mathematical model of the electron. Until now, it was believed that, according to the laws of classical physics, in a charged point body, when its radius is directed to zero, the intensity of the electric field, and at the same time, the energy, go to infinity. And this is a case of pure mathematical singularity. But when solving the "4/3" paradox (self-action of an electron on itself), we substantiated the presence of a white hole with a so-called electric radius $r_e = 1{,}185246 \cdot 10^{-15}$ m in the center of a spherical electron (p. 19). Inside a white hole ($r \le r_e$), the classical laws of electricity do not apply. In this way, the singularity of the electron was self-liquidated.

But, frankly speaking, such a course of events makes it sad. Because human curiosity in our native observable Universe with its Hubble radius of 4,000 Mpc ($1{,}234 \cdot 10^{26}$ m) and the absolute horizon described by it becomes cramped. So, give us other universes, even if they are surreal!

What was said resonates with the beautiful words [13]: "Man was born billions of years after the Big Bang, but his brain draws pictures of this explosion, and then it turns out that "that's how it was." For man has little surrounding universe – and he builds models of other universes".

No less interesting is the singularity in the singularity, to which belongs the so-called gravitational paradox, and at the same time the punctuation of the charge.

Gravitational paradox. If the density of matter is arbitrarily distributed in space, then its gravitational field in the classical theory is determined by the gravitational potential subject to the Poisson equation and its general solution

$$\Delta\varphi = -4\pi G\rho; \quad \varphi = -G\int \frac{\rho dV}{r} + C, \tag{5.26}$$

where r is the distance between the volume element dV and the point where the potential is determined φ; C is a constant.

In 1894-1896, K. Neumann and G. Seeliger analyzed the behavior of the integral (5.27) for the entire infinite (static) Universe and found out: if the average density of matter in the Universe is nonzero, then the integral diverges to a singularity. To get out of the impasse, many hypotheses have been proposed, starting from the "improvement" of Newton's law of gravity (2.52), (2.54), ending with an attempt to impose a non-Euclidean geometry on the universe. However, due to internal contradictions, none of them was able to completely eliminate the problem. In the end, the Newtonian theory of gravitation was replaced by the general theory of relativity, in which the gravitational paradox really does not arise, since the force of gravity here is a local consequence of the non-Euclidean metric of space-time (5.24), and therefore the force is always uniquely defined and finite. Einstein referred to the gravitational paradox as proof of the inapplicability of Newtonian theory in cosmology.

Regarding the gravitational paradox, a paradoxical thought arises in the field of surreal modeling. It is not so much about the paradox of a physical phenomenon in a static world as it is about the paradox of paradoxes. Because already at the beginning of the problem, an artificial (not physical) mathematical singularity - "the entire infinite universe" was laid. The concept of an infinite universe contains a pure mathematical singularity. And it is not surprising that in the field of mathematical singularity, many derived mathematical singularities arise - from an argument to a function.

Warning. It is quite natural that with a non-zero average density of matter in a homogeneous static universe, the potential increases in proportion to the square of the radius. But it is no less natural that this density can be zero.

And yet, the efforts spent on the gravitational paradox did not sink into obscurity. Thanks to them, we can more confidently look at our universe as a dynamic closed Hubble's ($r \leq 1{,}234 \cdot 10^{26}$ m), in which the gravitational paradox simply does not exist (it is a process related to the process of fig. 1.1, p. 20).

Punct charge. Their mathematical singularity of the density of the electric charge is also introduced here in advance: $\rho = \lim_{r \to 0} 3q / (4\pi r^3) \to \infty$.

5.5. Superanthropic principle

Being in the hot field of the mystery of creativity, it would be a sin not to drink cool water from its deepest well - the oldest sacred writings of the world - the "Veds", written in Sanskrit - a proto-Indo-European language, the closest to the current Slavic languages, in particular, Ukrainian. Their most interesting collection "Rigveda" (XVI century BC), consists of 1028 hymns collected in 10 separate books. These numbers, surprisingly, tend to be equal to 2^{10} = 1024. That's how many RAM cells my first unforgettable computer "Minsk-1" had in an electronic-tube design with a half-meter diameter air cooling pipe, from its hummed the walls Alma Mater. And it was back in 1967.

We present an interesting book from the Vedas "Cosmogony" translated by the outstanding Ukrainian orientalist Pavel Ritter (1872-1939), who was innocently murdered in Russian torture camps.

Cosmogony

Being and non-being then did not exist -
There was no air and no vault of the sky.
What was covered? Where? What protected?
Was there water? A deep abyss?
And there was no death, immortality, too,
There was no difference between day and night.
It breathed the same, alone, without wind.
And there was nothing else but Him.
Darkness covered the darkness from time immemorial,
This entire universe is like an ocean without light,
That germ that was covered with chaos,
One was born from the heat.
Love first arose from him,
What became the first seed for thoughts;
Found a connection between the being and the bearer,
In the heart watching thoughts, wise.
The thought of those rays extended through.
What was upstairs? And what's underneath?
There are spermatozoa, there is their perception.
Effort from below, jerking from above.
And who knows it, and who will tell about it?
Where did this Universe come from?
Were the gods born later than him?
And how Oce was created, who knows?
Where did this worldview come from?
Was it created or otherwise?
In the highest heaven Who watches over her,
He probably knows, or maybe He doesn't?

You are amazed how more than 36 centuries ago, humanity at the subconscious level gained access to modern philosophical assets – a dualistic interpretation of being and the anthropic principle of the emergence of conscious life, and at the same time to modern assets of astrophysics – the beginning of the history of the hot universe when the temperature rose to 10^{27} ^{0}K and a strong interaction separated from weak and electric. But there is a miracle in another way – as during the IV-XII centuries. N. e. the advanced European nations at that time parted with such a bright outlook. We can only be glad that we are among the last among them. Everyone knows what it turned out to be for human progress - a flaming bonfire on Campo dei Fiori in Rome in the 1600s.

I thought, what would the current Cosmogony look like?

After long reflections based on modern science about the physical world, as well as on the generalization of collective connections with the transcendental, a rather interesting panorama of being and consciousness, inseparable from each other, emerges.

New Cosmogony

(*a surreal excursion into the depths of being and consciousnes*s)

A pulsating world. Singularity point. Big explosion. From it emerges the spatiotemporal Universe with its own set of world constants and with the Universal Mind inseparable from it, not subject to space and time, with conscious life and laws of the universe subordinate to it, the guarantor of their unfeelingness. Despite the materiality of the Universe and the ideality of the Universal Mind, they are surprisingly interpenetrating and inseparable. The material universe, not observed by the Universal Mind, loses its meaning. And for this, He needs material self-regenerating bio observers, involved in the forefront of world metamorphosis (the process of change and generation of new forms). For the sake of self-sufficiency, a part of the conscious resource of working memory is allocated to them for use, with personal freedom subordinated to it. Up to 5% of separated information is transferred to this part, and the rest of it enters the Universal Information Field through a subconscious resource. Usually, the observation points are located in the currently optimal place of space with adaptation to the available temperatures. We are witnessing such a localization around 310^0 K on the third planet of the Solar System at a distance of 1/3 of the diameter of the Galaxy from its center of gravity with a time shift of about 13.6 billion Earth years.

The meaning of a concious life (without a claim to an avant-garde role in the Universe!) is to learn at an elite level the Harmony of the Universe, access to which the Universal Mind gives him in the process of progress in the form of cultural creation with access to the natural, and partly to the supernatural. The main components of culture are art and science. If art gravitates to the knowledge of the external Harmony of the Universe, then science, on the contrary, to the internal, oriented to the mathematical capabilities of the rational mind. If in the process of cultural progress, these components do not merge, then the cherished road to the Harmony of World-Building is cut off. The observation point is subject to liquidation. The new one appears in a more convenient place in a different temperature range and with a new, more perfect biological resource.

"*Where did this universe come from?*" – the main question of the Vedic "Cosmogony". If it had been known 36 centuries ago that no system, according to K. G?del's theorem, can be fully known from the inside - apart from its connection with other systems of a higher order, then even then we would have come to the concept of the existence of many others, apart from ours universes, which subjected to their own laws and also observed in the field of those laws.

This is the proposed so-called super anthropic principle of the origin of conscious life, which interprets man as an indirect guarantor of the universe's existence due to his direct involvement in the Universal Mind. In his own way, he answers the main questions that modern philosophy poses to the anthropic principle: "Let a person exist in this world, not by chance, but why does he exist in it? What is the meaning of such an existence? What can be the human purpose?"

Our answers are the product of scientific and intuitive modeling, so it is not about their truth, but about the right to exist as information for thinking about a person's place in the world.

In the next, final section, we will meet our longed-for, to which we are forever paving the way.

The word Truth makes the human heart beat harder, because the knowledge of the Truth is almost the main content of man's mission in this world. G. Hegel

5.6. Truth

The Word of Truth actually makes the human heart beat harder throughout the entire conscious age. This concept has appeared many times on the pages of our book. Therefore, it is worth looking at it a little more widely - with different eyes.

From a philosophical and religious point of view. The concept of truth was introduced by Parmenides in ancient Greece as opposed to thought. Gautama Buddha called to "keep the truth in oneself as a single light", and the "four noble truths" were laid as the basis of the Buddhist worldview. Jain's philosophy emphasizes the relativity of truth. In Christianity, it is based on the image of Jesus Christ, and "every man speaks a lie" (Psalm of David 115:2). In most Eastern religions, in parti-cular in Hinduism and Buddhism, truth is understood as the word of the Teacher, which indicates the right path to salvation. If the existence of the soul is denied (Buddhism) or questioned (ancient Chinese tradition), then the truth is overcoming the illusion in favor of the true image of reality, or the way to restore world harmony, for example, through respect for traditions in (Confucianism), the laws of the Em-pire (Legism), etc. In Judaism, truth is understood as faithfulness to the commandments that were "given by God" and outlined in the Talmud. A similar position is maintained by Muslims, for whom the words of the Prophet Muhammad, outlined in the surahs of the Koran, leading to a blissful existence, are the truth. In classical philosophy, two alternative paradigms of interpretation of truth are formed – one of them is based on the principle of correspondence as the correspondence of knowledge to the objective state of affairs of the objective world, and the other – on the principle of coherence as the correspondence of knowledge to the immanent characteristics of the ideal sphere.

In non-classical philosophy, truth is deprived of objective status and is thought of as a form of the mental state of an individual. Postmodern philosophy avoids formulating the problem of truth altogether.

From a humanistic and natural point of view. In the social and humanistic, natural, and technical sciences, truth is understood as the conformity of its provisions with the possibility of empirical or theoretical verification. On the one hand, truth appears as the goal of scientific knowledge, and on the other – as an independent value, which provides the fundamental possibility of scientific knowledge to coincide with objective reality. *Science is a limitless process of achieving such a coincidence, a movement from limited, approximate knowledge to ever more general, deep, and precise knowledge*.

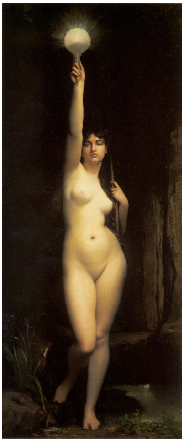
The application of the concept of truth in literary studies is somewhat limited, where the term truth can refer only to extra-aesthetic reality, but loses its scientific status when considering "artistic truth", in which the synthesis of objective and subjective takes place.

When talking about scientific knowledge, a distinction is made between absolute and relative truth, which are components of objective truth. Such knowledge is considered absolute, which completely exhausts the subject and cannot be refuted in the further development of knowledge. Instead, relative truth reflects the object not completely, but within known limits, conditions, and relationships that are constantly changing and developing. The development of science in this way is a constant movement toward the mastery of absolute truth.

Can the truth be achieved in the process of human knowledge? The concept of truth assumes that knowledge coincides with reality. However, we do not really have such knowledge. Therefore, the concept of truth becomes a reference concept: it outlines the ideal possible state of knowledge. "Such a state is unattainable for human knowledge, but the standard of truth becomes the basis for a balanced assessment of real knowledge, and also gives our knowledge a strategic direction, a final goal and an ideal... The concept of truth cannot be removed from the cognitive process, although we should not identify truth as a concept with certain concrete knowledge. The latter must always be oriented towards truth, and truth has meaning only when real knowledge exists and functions [10]".

This balanced philosophical word cannot run away from the achievements of science. Thus, in classical mechanics, a particle occupies a strictly defined place in space, determined by its coordinate and momentum. In 1927, Heisenberg showed that an object of the microcosm cannot be characterized by its coordinate and momentum at the same time. One of these quantities can be measured with a predetermined accuracy, but only at the expense of reducing the accuracy of the determination of another quantity. *This is Heisenberg's principle of uncertainty*, as a fundamental principle of quantum mechanics: $\Delta x \Delta p_x \geq h$, where Δx is the uncertainty in the measurements of particle coordinates; Δp_x is uncertainty in measurements of the pulse component along the same coordinate; h is the Planck constant.

The principle of uncertainty is now interpreted more broadly, for example, if a particle is at a certain energy level with a given energy for a certain time, then both of these quantities can also be given in the same way with a certain accuracy, we have something similar in optics, etc. It may seem that we have reached the limit of our knowledge, but if so, then the world is unknowable. But this is not so: the principle serves only as a measure of the extent to which the model representation of microparticles as mechanical particles is suitable for microparticles.



Jules Lefebvre
"Truth", 1870
(Orsay Museum)

Recently, in the "twilight of physics", we have to observe a strange phenomenon, when scientific knowledge is understood as faithfulness to the precepts of one or another physical teaching – a kind of natural-religious symbiosis. First of all, this applies to those who deeply believed in the infallibility of GRT and quantum physics, although the foundations of these teachings are filled not with the basic laws of the universe in real space, but with postulates in the unreal – David Hilbert, in the distorted, and Erwin Schredinger, in the complex.

Let's say a little more about the mentioned concept of truth. In English, artistic truth and truth are one-word "truth", in our language artistic truth and truth are distinguished. Artistic truth is the truth related to a person's position in life, personal experience, and life gains and losses. "If the truth as an ideal of science presupposes a detached, objective delineation of what is and as it is, then artistic truth is synthetic, always someone's, not abstract... Artistic knowledge, like creativity in general, is not evaluated by with the help of the concept of truth, but through the truth [10]".

However, the last words are strongly and convincingly denied by the French artist Jules Lefebvre. Cognized by him the artistic Truth with a radiant ball in a right hand raised high above his head (see illustration) does not worse either philosophical-religious or humanistic-natural knowledge. On the contrary, on his side is the national (Latin from ancient Greek) – *in vino Veritas*.

It is thought that the intelligent Reader will forgive the author for an unexpected funny joke at the end of the book, the purpose of which is only one – to relieve emotional tension from the disturbed secrets of the world structure and their vision.

* * *

I can be wrong in science, in art, in philosophical thoughts. But even if that's the case, even then it's nice to live on such a green field of your own illusions, and it's endless for me – from the dept of an electron to the cosmic distances, conquered by electricity, gravity, and human love. In creativity (I repeat) it is permissible to make mistakes because *even your mistake will accelerate someone's "difficult steps forward*"! The search for the Truth has always been not only a creative self-expression for me but also a source of a higher life sense. It was he, overcoming space and time, who took me beyond the limits of the individual and taught me to be worthy of the gifted chance of life. In creativity, I realized myself and my own freedom and tried to multiply the socio-cultural assets of my people.

And there were also unforgettable friends, and unforgettable loved ones, without whom there is no road to the Truth... But few people know – what a thorny road that is...

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