V. Yu. Gankin
Yu. V. Gankin

ELECTRO • MAGNETISM

Physics of Twenty-first Century

RENOME
Saint Petersburg
2013

UDC 530.1

We are indebted to many who contributed suggestions, criticized and participated otherwise in the creation of this book. We hereby express our most heartfelt thanks to: Vitaliy Aronov, Irina Gankin-Sigal, Aleksander Gorshteyn, Lyudmila Kolomeyets, Sergey Kryukov, Vladimir Kuznetsov, Olga Kupriyanova, Aleksey Leznikov, Yakov Mazur, Igoris Misyuchenko, Marina Nozhenko, Sofi Perlin, Aleksander Rogach, Alexander Sanin, E. Semenistaya, Liza Sigal and Izabella Shmulevich.

A special thanks to the Tisch Library, Tufts University, represented by Ann Marie Ferraro and Annah Jones.

We are also very grateful to a great chemist, the late Linus Pauling, who encouraged us to continue our work.

Down-to-earth bow from science soldiers

ISBN 978-5-91918-311-2

Contents

Preface

DISADVANTAGES OF MODERN PHYSICS TEXTBOOKS

From our point of view, modern physics textbooks have some significant drawbacks, the chief of which is that pupils and university students possess, at the end of the course, a set of information on certain fields of physics but no idea of the general physical picture of the world.

Most get the false impression that everything in physics has already been discovered. However, the following issues remain unresolved: the physical nature of mass, the nature of gravity and inertia, the explanation of the mechanism of Newton's laws, whether there is a collapse of the masses, what the nature of dark matter and dark energy is, what causes the stability of the solar system, whether it is possible to create a unified theory of everything, and many other questions.

To the present day, the entire scientific and would-be-scientific community believes that the mass introduced by Newton as a measure of the amount of substance instead of Galileo's weight really exists and possesses the property of gravity. In the course of the theoretical work started by us in the 80s and continuing to the present (2013), we have shown (see fphysics.com) that uncharged matter does not exist and, consequently, gravitational mass in the Newtonian interpretation does not exist, and the inertial mass (inertial property) is electrodynamic in nature. We have proved that the gravitational and inertial properties of matter are conditioned by charges. The reason for the manifestation of inertia is the Lorentz force. The Lorentz force acts on the principle of negative feedback and explains the stability of motion of objects in the central force field.

The nonexistence of matter that does not carry charge allowed us to answer the question of why collapse of the masses does not occur.

The generalization of the research results, in the field of both physics and chemistry, shows that the electromagnetic interactions can be considered the basis for building a unified field theory.

The achievements of the second half of the XX century offer the opportunity to eliminate the following drawbacks of modern textbooks.

1. Education's golden rule — that new knowledge must build upon knowledge previously acquired by students — has been broken. An example of this is that elements of the theory of relativity ant quantum mechanics are included in high school textbooks; whereas the mathematical tools required for these subjects are not taught until third and fourth year university courses of mathematics.

2. Textbooks include theories and principles that are being debated in the educational community. An example of such a theory or principle is the Heisenberg indeterminacy principle, which prevails in quantum mechanics. Even after 30 years of their famous debate on the fundamentals of quantum mechanics, Einstein and Bohr maintained their different opinions.

3. The explanation of some physical phenomena is given on the basis of incorrect theories.

Examples of such incorrect theories are Newtonian gravitation theory, the theory of the electrical conductivity of metals, the superconductivity theory, the explanation of the annihilation of oppositely charged particles with the formation of photons and the decomposition of photons to produce charged particles under irradiation.

In the reaction of photon decay to produce positron and an electron under irradiation of quantum of light, and in the reverse reaction, the Coulomb energy is not considered. However, mathematical calculations confirming this phenomenon converge to the fourth sign. This experiment, according to the history of physics, is the only quantitative confirmation of the most famous equation of the 20th century, $E = mc^2$.

4. A number of physical phenomena (theories) that appeared in the late twentieth century and have been recognized are not included in textbooks. Examples of such new theories are the theories of electrical conductivity of metals and the superconductivity theory, a new explanation of the structure of atoms and molecules and the theory of chemical reactions.

Laws, postulates, principles are introduced *ad hoc*, without mechanisms.

Over the past 300 years, Newton's basic paradigm ("I do not invent hypotheses") has changed. At present, this paradigm is formulated as follows: "There is as much science in science as there is mathematics in science." So far, a deeper understanding of phenomena is limited by

the writing of the equations describing the dependences observed in the course of an experiment. The Boltzmann equations, Ohm's law and almost all of the equations given in modern textbooks were created in such a way. The situation is similar with the principles and postulates. Some examples are the equivalence principle, the uncertainty principle and the Bohr postulate.

In the course of our work to attain a deeper understanding of the subject, we came to the conclusion that the so-called mathematical approach to physics was conditioned by the historical period, the transition from religious and declarative explanations to the scientific ones, the lack of experimental data on the structure of matter, the belief in figures of authority (especially Newton) and the inertia of thinking. Our research has shown that the approach to the natural sciences should be changed.

The deeper understanding, the transition from memorization to understanding goes through the following stages:

- experiment (empirical data),
- determination of the cause-effect relations,
- mathematical treatment without any additional qualitative assumptions, if the phenomenon in question allows it.

Before the advent of quantum mechanics and relativity theory, school-level of mathematics was used: arithmetic, algebra and Euclidean geometry. Pseudo-mathematical deviations from mathematics were part of the fundamentals of quantum mechanics and relativity — that is, both the Heisenberg uncertainty principle and the Schroedinger equation, as well as the postulates of the relativity theory.

In fact, there is no cause-effect relationship between mathematics and the natural sciences; there is only a religious one. No explanation of the mechanism by means of mathematics in the natural sciences has been proposed since Newton's time. Mathematics is only a tool for the natural sciences.

New textbooks must be based on a new principle: there is as much science in natural science as there is science actually in it, in chemistry — chemistry, in physics — physics.

There are many roads in science. In order to compare different approaches to the study of physics, we will use the popular Russian textbook "The Feynman Lectures on Physics" [1]. It is one of the best courses of elementary physics and has enormous popularity.

The advantage of the course is the depth of the presentation of the physical side of the considered processes and phenomena in nature and technology.

A number of other explanations of physical phenomena, including criticism of theories (except new explanations) which preceded them, are presented in more detail in our books [2, 3] and published on http://fphysics.com/.

Part 1

HISTORY, EXPERIMENTAL FACTS, CALCULATIONS

1.1. HISTORY OF SCIENCE

The main causes of the emergence of science and the motivations for its development were human curiosity and the need for solutions to concrete problems. It is possible to identify three directions in the history of the development of science: philosophical, mathematical and experimental.

According to F. Rosenberger [4, p. 8 and 10]: “Ancient science was primarily a philosophical science. The most striking figure of ancient science is Aristotle... By limiting the circle of his universe, Aristotle was able to move in that circle completely confidently and categorically. His system clearly demonstrated his conviction that it already contained everything necessary for the resolution of theoretical issues... The categories of ‘matter,’ ‘form’ and ‘movement’ in Aristotle's doctrine of nature immediately exclude any possibility of a quantitative mathematical treatment... it should be emphasized that Aristotle achieved the unity of his worldview and, in particular, of his physics, using — extreme anthropomorphism tools and the most naive teleology. However, it is precisely these distinct manifestations of Aristotle’s reluctance to break with the tradition of his naive sense-based worldview that should have made his speculations successful.”

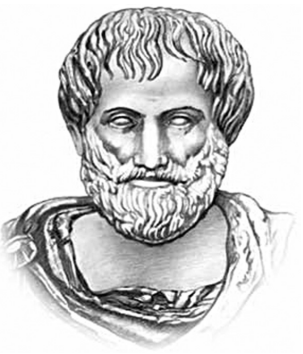


Fig. 1. Greek philosopher Aristotle

“Aristotelian physics also typically tended towards purely qualitative thinking. All the numerous attempts in

the late Middle Ages to use Aristotelianism as a basis for quantitative theories of nature were completely fruitless."

The religious approach was superseded by the philosophical approach, which was refined at the expense of the success of Aristotle's philosophy. In the religious approach to science, it had been postulated that the structure of the world was reported to humanity by God, through the prophets (Daniel, Elijah, Isaiah, Mohammed, Moses, etc.), and described in the Bible. Any doubts and even clarifications offered by people interested in science were considered heresy and were rejected, and the authors of these heresies were persecuted for dissent. The role of prophets in the philosophical approach was performed by Aristotle and Descartes. In works on the history of science, declarations (experimentally unconfirmed assertions) are described as genius prophecies which deservedly left a mark in science.

A widely known statement attributed to a number of authors describes the primary idea of the next direction in the development of science: "There is as much science in science as there is mathematics in science." This idea began 3000 years ago, at the time of Pythagoras, who proclaimed "mathematics is the gate to science." Isaac Newton is the symbol of that era. Four Newtonian laws, as well as the axioms of Euclid, enable us to derive a vast number of other patterns.

We agree with Rosenberger: "...the strength of mathematical physics is the logical completeness and necessity of its conclusions. Adopting certain initial provisions, the mathematical physicist operates using mathematical means. All his conclusions eventually represent an expanded expression of the content of these provisions. However, mathematical reasoning is as unable to create physics as is philosophical speculation. The reasons for this lie in specific features attributable to mathematical reasoning. Like philosophical physics, it must borrow its material from outside, from observations that have already been made. In other words, the same trait of passivity in regard to material is typical for mathematical physics that is peculiar to philosophical physics, which supposes certain limits to its development.

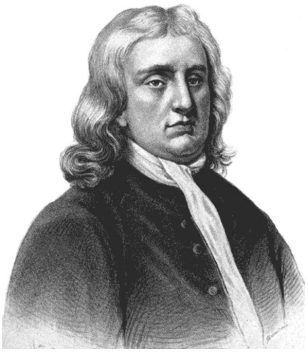


Fig. 2. Isaac Newton

Moreover, by asking only the question 'how big?' mathematical physics essentially does nothing to uncover the qualitative mechanism of the investigated phenomena and is limited only by their quantitative description."

According to Rosenberger, the strength of the next direction, experimental physics, "should be a constant enrichment of science with new material. The activity of the mind questioning nature is concentrated expressly in the experiment. However, to correctly ask a question of nature, it is necessary to start from some common presuppositions and criteria. In order to judge the accuracy of hypotheses based on these criteria correctly, it is necessary to use mathematical constructions to carry out constant quantitative validation of the results, which are in turn experimentally tested. In other words, without the apparatuses of philosophical and mathematical physics, experimental physics is blind. To a great degree, experimental physics can be reduced to a technique of scientific work, and the question is where to use this technique. Philosophical and mathematical physics plays a decisive role in answering this question".

Rosenberger summarizes his views on the relationship of three kinds of physical knowledge: "Human nature in general is characterized by a tendency to try to explain in one single effort everything that is mysterious in nature, not content with methods that move forward by slow, deliberate and strictly checked steps. Moreover, the farther people are from their essential goals, the more natural it is for them to see the experimental way as hopeless and to look for help in pure speculation. However, beware of unfair treatment of the merits of philosophy and mathematics to physics and excessive re-evaluation of the experimental method. Unfortunately, there have been instances of this re-evaluation in the past as well. The art of conducting experiments is completely incapable of advancing science alone. Speculation that looks beyond the current state of experience will always indicate the way of and dictate a plan for further observation. On the other hand, science dealing with the phenomena of nature will always be dependent on mathematics when investigating phenomena quantitatively".

According to Rosenberger and most of the famous philosophers, both ancient and modern, experimenters are the people who are good at conducting delicate experiments but are not able to work with their heads. The phrase "practice without theory is blind" has become a trite slogan. The belief that tasks are given to experimenters

by mathematicians has become fully natural to mathematicians and philosophers and has even taken root among many experimenters. Of course, all three approaches existed in science simultaneously. However, there were periods when mathematicians and philosophers defined fashion in science. A comparison of these periods with periods of science and the works of well-known scientists-experimenters in this period leads to the conclusion that the real qualitative development of science is determined by a very small number of scientists-experimenters working in this period.

For example, the experiments of Galileo, Newton and Faraday, which led to their discoveries of new phenomena, regularities and rules, were milestone works. These scientists were looking for answers to the question "why?" and, therefore, discovered cause-effect relationships; they identified the physical nature of phenomena.

In contrast to this approach, a mathematical approach offers a mathematical equation that describes the experimental data. The result, is usually reached by a solution of the inverse problem. Although we searched through physics textbooks and scientific publications, we did not find a single case where the mathematical approach to solving scientific problems was not also a solution to the inverse problem, or, in other words, was not a fitting (maybe the reader will tell us otherwise). Frequently, in the process of inverse solution, the most basic and simple rules are violated: qualitative assumptions are adopted that have no independent experimental evidence. In the equations compiled on this pseudoscientific basis, coefficients are entered for which numerical values are determined on the basis of experimental data.

In the 20th century, physics has developed under the slogan "... the best way to create a new theory is to divine equations, paying no attention to physical models or physical explanation" [5]. Many laws of K. Maxwell, Dirac, Schrodinger, Born, Planck, Louis de Broglie, Einstein and other scientists are described as postulates (without mechanisms), and without a clarification of the cause-effect relationships. A striking example of the mathematical approach is the Heisenberg uncertainty principle, which establishes the complete absence of cause-effect relationships (at least in the microcosm). What is most striking is that this principle was recognized by the scientific community of the representative and well-known Copenhagen Congress by vote, but not in the course of scholarly dispute. The apotheosis of the generally accepted concept is quantum mechanics and general and special relativity theory.

We have already discussed the current arrangement of priorities in science in detail with the example of quantum mechanics and quantum chemistry [2]. In this article, we want to emphasize that the mathematical approach, as it has been applied in physics and chemistry before the twenty-first century, both contributed to the development of science and, at times, effectively inhibited its development. This approach removed the main driving force behind science the search for the answer to another "why."

Questions, and even hypotheses about the physical meaning of phenomena, led to the confirmation and development of dead-end directions. For example, within the framework of the theory of relativity, cause-effect relationships and the mechanism of the phenomenon ceased to be invariant, i.e., independent of the coordinates and dimension of space. Chance turned from unclear (inconceivable) correspondence into the basis of the uncertainty principle of quantum mechanics. The scholarly dispute "Does God play dice?" between the Aristotles of the twentieth century, Einstein and Bohr lasted 40 years. Einstein believed that "chance is the misunderstood regularity." Bohr, on the other hand, claimed that the uncertainty principle is the ultimate truth. This statement was based on the results of the Copenhagen conference — the first and so far, fortunately, the only case of the resolution of scientific questions by vote.

The mathematical and philosophical approaches were competitors in the process of slowing down development of science.

In the late 1980s, at the start of our activity, the abovementioned statements corresponded with our views. Our respect and even admiration towards each of the three approaches in science and the names of scientists who personify them were close to the religious and proportional to the degree of our misunderstanding of their works. Primarily, it concerned mathematical physics and physical chemistry. Over 30 years of work, we proved that the three directions did not help each other but, as a rule, contradicted each other, like the swan, crawfish and pike in Aesop's well-known fable, and proponents of each direction exaggerated its significance and incorrectly evaluated the two other approaches.

"The ancient Greeks, whose scientific thought anticipated many further discoveries, turned their attention to the nature of the universe and the structure of its constituent materials. Greek scholars, or 'philosophers' (literally, lovers of wisdom), were not interested in ways to procure those

or other substances or methods of their application. They were primarily interested in the essence of substances and processes. They looked for an answer to the question 'why?' In other words, the ancient Greeks first began to practice that which today is called the chemical theory" [6].

We were going to solve our problems in chemistry by asking the question "why?" to ascertain the mechanisms and cause-effect relations between phenomena. The concrete illustration of this conclusion is the model of the hydrogen molecule that appears on the website of the Institute of Theoretical Chemistry. The coincidence of the calculated and experimentally determined values of energy and the bond length in the molecule of hydrogen leads to a number of consequences related to physics and physical chemistry. One of the consequences, deriving from our theory of chemical bonding and chemical structure, is the explanation for the absence of radiation of a single electron moving in accelerated motion and the theory of the electromagnetic nature of mass.

In all known cases of the mathematical approach, the model forming the basis of the approach was behind the achievement of the natural sciences. Maxwell's equations were based on a mechanical model which included such things as rotating gear wheels. All electrical laws (of Faraday, Ohm, Ampere, etc.) were based on the assumption that the electrons in metals are free and not connected with nuclei. At the same time, after the experiments of Rutherford, it turned out that, in order to tear off an electron from an atom, it is necessary to spend more than 4 eV of energy, and the electric current emerged when voltages were less than 0.001 eV. It is interesting that during the period of euphoria towards quantum mechanics, physics textbooks began to question the correctness of the assumption that electrons in metals are free. However, until now, guides to physics and chemistry state that one of the main achievements of quantum mechanics is the explanation of why electrons are free in metals. In 2000, we showed in our work, "How Chemical Bonds Form and Chemical Reactions Proceed," that the quantum-mechanical explanation turned out to be incorrect.

According to I. Misjuchenko [7], in the mathematical approach, the values of coefficients are determined based on experiment. The number of coefficients in the equations is always greater than the number of equations. This means, a priori, the experimental data must be fitted to the theoretical calculations.

"Physical laws should have mathematical beauty", the inscription on the board of the Moscow University, was left by Dirac in the autumn

of 1955. This scientific view of the world is not new, it dates back to ancient times, to the Pythagorean school. And, at the cost of painful search, it was rejected as untenable.

1.2. MASS

1.2.1. Concept of mass

Many words used in physics have precise meanings in the science, although they may not have such precise meaning in everyday language. Where does mass come from? If we exert a certain pressure with our hands on an object that is "light", it moves easily; if we push just as hard on another object that is must "heavier", then it moves much less rapidly. Actually, we must change the words from "light" and "heavy" to *less massive* and *more massive*, because there is a difference to be understood between the weight of an object and its inertia (how hard it is to move it is one thing, and how much it weighs is something else). Weight and inertia are proportional, and on the earth's surface are often taken to be numerically equal, which causes a certain confusion to the student. On Mars, weights would be different but the amount of force needed to overcome inertia would be the same.

We use the term *mass* as a quantitative measure of inertia, and we may measure mass, for example, by swinging an object in a circle at a certain speed and measuring how much force we need to keep it in the circle. In this way, we find a certain quantity of mass for every object.

In the laws of mechanics, it has been supposed that every object "carries" a concept we call the mass — which also means that it "carries" a momentum proportional to its velocity.

1.2.2. The mass-spectrometric experiments

It was proved, in the framework of physics and chemistry, 100 years ago, that matter is made up of electrons, protons and neutrons. From experiments, we know that free neutrons decay to half into electrons and protons in 614 seconds. The inertial properties of electrons, protons and neutrons are determined by the mass-spectrographic method.

A mass-spectrometer is a device used to determine the masses of charged particles and atoms (molecules) by the nature of the movement of their ions in electric and magnetic fields.

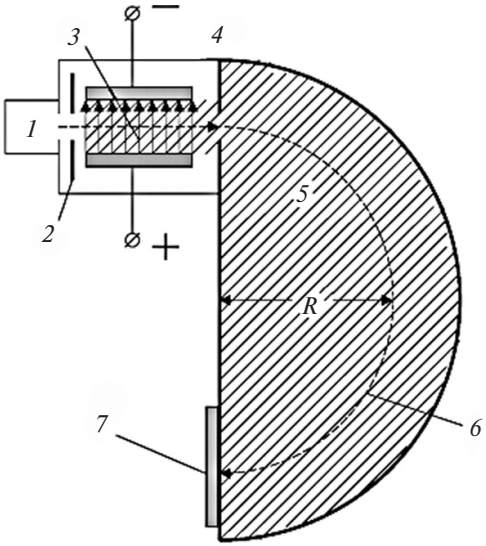


Fig. 3. A mass-spectrometer. *1* — the source of ions, *2* — slot diaphragms, *3* — an area of homogeneous and constant electric and magnetic fields (power lines of electric fields, which are directed along the plane of the figure *m*, are shown by arrows and the area of the magnetic field is shown by hatching with its power lines perpendicular to the plane of the figure), *4* — slot diaphragms, *5* — an area of homogeneous and constant magnetic field (power lines are perpendicular to the plane of the figure), *6* — the ion trajectory, *7* — the detector

It is impossible to measure the mass of a neutral atom by the traditional method of mass-spectrometry. However, if you take away from or add to this atom one or more electrons, it will turn into an ion, and the nature of the movement of this ion in these fields will be determined by its mass and charge. Strictly speaking, it is not mass that is determined by mass-spectrometers but the ratio of mass to charge. If the charge is known, then the ion mass is determined uniquely, and hence it is possible to calculate the mass of neutral atom and its nucleus. Mass-spectrometers can be very different from each other constructively. It is possible to use for them both static fields and time-varying fields, magnetic fields and/or electric fields.

Let's consider one of the simplest variants.

A mass-spectrometer consists of the following main parts. (*1*) An ion source, where neutral atoms become ions (for example, heating

or microwave field) and are accelerated by an electric field, (*3*) areas of constant electric and magnetic fields and (*7*) an ion detector which determines the coordinates of the points where ions crossed these fields.

From the ion source (*1*), accelerated ions enter the area (*3*) of constant and homogeneous electric and magnetic fields through the slot (*2*). The direction of the electric field is given by the position of capacitor sheets and is shown by arrows. The magnetic field is directed perpendicular to the plane of the figure.

In area *3*, the electric and magnetic fields deflect the ions in the opposite direction, and the magnitudes of the intensities of these fields E and H_1 are selected so that the forces of their action on the ions (respectively qE and qvH_1, where q is charge and v is ion velocity) would compensate for each other, so that $qE = qvH_1$. A monochromatic ion beam is created. When the ion velocity is $v = E/H_1$, the ion beam moves in area *3*, deviating, and runs through the second slot (*4*) into the area (*5*) of a homogeneous and constant magnetic field with intensity H_2. In this field, the ion moves in a circular orbit (*6*) whose radius R is determined from the ratio $mv^2/R = qvH_2$, where m is the mass of the ion. Since $v = E/H_1$, the ion mass is determined from the following ratio:

$$m = qH_2R/v = qH_1H_2R/E. \tag{1}$$

Thus, in cases with a known ion charge, the ion's mass is determined by the radius R of the circular orbit in area *5*.

If a photographic plate is used as an ion detector (*7*), this radius will be shown, with high accuracy, by a black dot at the point of the developed photographic plate where the ion beam reached. In modern mass-spectrometers, electron multipliers or microchannel plates are usually used as detectors. A mass-spectrometer can determine masses with very high relative accuracy $\Delta m/m = 10^{-8} \div 10^{-7}$.

Analysis of a mixture of atoms of different masses by the mass-spectrometer can also determine their proportion in this mixture, particularly the content of the various isotopes of a chemical element.

According to the accepted experimental process, inertial forces are *entirely* conditioned by the inertial properties of Newtonian mass m of a neutral matter, which does not carry a charge. However, in experiments, all analyzable particles carry charges. According to electrodynamics, charges themselves possess inertial properties which are not related to mechanical mass. At the same time, the inertial properties conditioned by the presence of charge are completely ignored in the treatment of

experimental results. As of 2012, mass-spectrometry has existed for 100 years but, so far, no work has appeared which contains criticism of the processing of experimental results and, accordingly, no answers to the following question:

Why are the inertial properties of the electric charges of ions not taken into account?

So, in an experiment, an electron having mass m_e and charge q is added to a neutral atom having mass m_A. However, according to electrodynamics, the charge q itself (even having no mass) should exhibit inertial properties which can be expressed in terms of electrodynamic mass m_q. Thus, the total mass of ion should be $m_A+m_e+m_q$. Nevertheless, in the process of mass-spectrometric investigations, the electrodynamic mass m_q is not taken into account. The results are not contradictory. Why?

In previous studies, we have shown that the neutral Newtonian mass (which is not the charge carrier) was the entity introduced 300 years ago to coordinate laws promoted by Newton with experimental data. For 300 years, the physical nature of Newtonian mass was not clarified. The history of phlogiston, caloric and mass showed that when a newly introduced entity cannot be determined experimentally, naturalists send it either to history or to religion. Accordingly, we felt the need to offer an alternative interpretation of the experimental data obtained with the help of mass-spectroscopy.

1.2.3. Phenomenological explanation

The electron mass m_e is the electrodynamic mass m_q. Accordingly, the total mass of the ion is m_A+m_e, so the electron has no *neutral* mass whatsoever.

The task of the mass-spectroscopy experiment is the definition of value M ($M = m_A+m_e+m_q$) in the equation Mv^2/R. During the experiment, the analyzed micro particle goes through electrostatic and magnetic fields where it gets the acceleration v^2/R. Accordingly, the value M is determined by division of the value of centripetal force (in the experimental conditions F_{cp} is Lorentz force) by the magnitude of centripetal acceleration, so the quantitative determinations of the magnitude M in the accepted and supposed explanations are the same. In a uniform magnetic field directed perpendicular to the velocity vector, a charged particle will uniformly move in a circular orbit of constant radius R under the action of the Lorentz force. In this case, the Lorentz force is the centripetal force. The figure below shows that the movement of electron and positron is conditioned by the charges of these particles.

Uncharged particles (such as Newtonian uncharged matter or modern Higgs bosons) do not interact with a uniform magnetic field and thus do not influence either the motion speed of particles in a circumferential direction (v) or the circle radius (R) or the centripetal acceleration (defined as v^2/R).

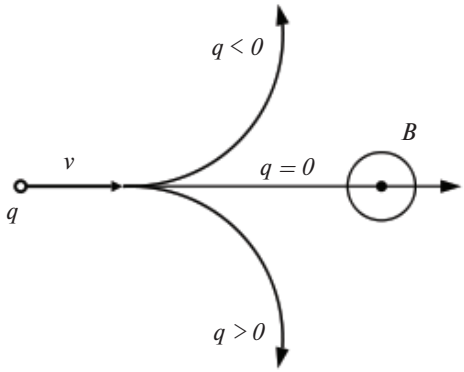


Fig. 4. The behavior of charged particles under crossed fields

As mentioned above, $M = q H_2 R/v = q H_1 H_2 R/E$.

Thus, in the case of an ion with known charge, its mass is determined by the radius R of the circular orbit in the area *5* (fig. 3). Radii of the orbits of electron and positron are identical, and thus the values m for electron and positron are identical. The charges of the electron and the positron are also opposite in sign and equal in magnitude. Therefore, the nature of the deviation of these particles in a magnetic field is determined by the charge. This fact is independent evidence that the curve radius and, accordingly, M, is determined only by the magnitude of the charge.

Another argument for the lack of an independent entity of Newtonian mass (m) is the following proof. According to modern physics textbooks for higher education institutions (for example, Trofimova T. I. [8, p. 176, p. 184]):

"For a qualitative explanation of magnetic phenomena with sufficient approximation, we can consider that an electron moves in an atom in circular orbits. The electron moving along one of these orbits is equivalent to a circular current loop... Faraday's law can be reformulated like this: electromotive force (hereafter EMF) E_i of electromagnetic induction in the circuit is numerically equal and opposite in sign to the change rate of magnetic flow **through the surface limited by this**

circuit. **This law is *universal*:** EMF E_i **does not depend on the method of change of the magnetic flow.**" A self-induction force acting on a charge moving with acceleration (according to Faraday's laws) is always equal to the force that caused the movement of charge with acceleration. The equality of these forces determines the motion of a charge in the circle and the system's stability. If the charge moving in accelerated motion were under the influence of not only the forces of self-induction but also of the forces conditioned by the inertial properties of Newtonian mass, the centrifugal force would be greater than the centripetal one, and the charge would fly out of orbit, rather than spinning around.

Another consideration in favor of the absence of "classical" Newtonian mass is the positiveness of mass (there is no negative mass!), even within the mathematical approach. The equation

$$m = q H_1 H_2 R/E$$

demonstrates that the nature of inertia is *electromagnetic*. Only electromagnetic quantities are in the right part of the equation: charge and the intensities of electric and magnetic fields.

"In the old books, authors often asserted that since nature has not given us two identical particles, of which one is neutral and the other is charged, we can never say what fraction of mass is electromagnetic and what is mechanical. However, it turns out that nature is quite generous and has given us exactly two such objects, so that when comparing the observed mass of a charged particle with a neutral mass, we can say whether the electromagnetic mass exists. Let's take, for example, the neutron and proton." [1, v. 6, p. 318]

In determining the magnitude of the Lorentz force created by a proton in a mass-spectrometer, it was found that the radius of a circle along which the proton begins to move when it gets into area 5 is 1836 times greater than in the case of a positron. Positron and proton charges are equal in magnitude and in sign. Correspondingly, according to the information given above, one would expect the radii to be equal. The difference is currently attributed to the difference in the magnitude of Newtonian masses of these particles.

In determining the magnitude of the Lorentz force created by the neutron (neutronium was sent up in the chamber) in the mass-spectrometer, it was found that the radius of a circle along which neutronium starts to move when it gets into area 5 is 3776 times greater than in the case of a positron. According to the accepted worldview, the neutron has no charge and, accordingly, the difference in inertial

properties of the proton and neutron is attributed to Newtonian mass (uncharged neutral matter). However, despite the zero electric charge, the neutron is not a truly neutral particle.

A comparison of motion patterns of equally charged particles with different masses in the mass-spectrometer shows that the inertial properties are under the influence of not only the magnitude of electric charge but also of something else. In Feynman's lectures [1] it is proved (see also the article "The inductance of electron") that the electromagnetic mass is also *inversely* proportional to the *effective radius* of the charge.

Additional independent evidence that the neutron consists of a proton and an electron is the proximity of the inertial properties of these particles. R. Feynman called the Newtonian mass the mechanical one and the mass conditioned by the inertial properties of charge the electromagnetic one. As shown above, the electromagnetic mass is determined in the mass-spectrometers.

Charged particles make up macrobodies. The total weight of the charged particles is the weight of the macrobody. The number of nucleons in 1 gram of a substance determines the weight of this 1 gram.

The atomic weight of elements is calculated by the formula

$$M = 1.00732\,Z + 1.0087\,N, \tag{2}$$

where Z is the number of protons, N is the number of neutrons and the coefficients 1.00732 and 1.0087 take into account intranuclear interactions. Table 1 shows the calculation of the number of nucleons in 1 gram of various substances.

Table 1

Stable isotopes of some elements	Number of protons Z	Number of neutrons N	Atomic weight calculated by formula (2), g/mol	Atomic weight by Reference book, g/mol	1 g of substance contains atoms, $\times 10^{21}$	1 g of substance contains nucleones, $\times 10^{23}$
^{27}Al	13	14	27.21696	26.98153863	22.12423	5.9735674
^{63}Cu	29	34	63.50815	62.9295975	9.48247	5.9739561
^{64}Cu	29	36	65.52548	64.9277895	9.19053	5.9738445
^{194}Pt	78	116	195.58016	193.9626803	3.07911	5.9734734
^{195}Pt	78	117	196.58886	194.9647911	3.06332	5.9734744
^{197}Au	79	118	198.60488	196.9665687	3.003222	5.9734782

As we can see, the number of nucleons in 1 gram of a substance coincides to the 4th figure. The difference is less than 10^{-3}%. This calculation is an additional argument in the macro-scale that the electromagnetic mass completely determines the weight of substances and that there is no mechanical mass.

1.3. ON THE VIRIAL THEOREM AND ITS PHYSICAL MEANING

We know that physics and chemistry are based on the laws and rules called– either the principles, or the postulates, or the initial entities. The most striking examples of the axioms in physics are the laws of motion and the equivalence principle of Newton, the Bohr postulates and Heisenberg uncertainty principle, Einstein's GTR and STR and the Big Bang theory.

In chemistry, this approach is demonstrated by Lewis's rules, periodic law, resonance theory, etc. Such a way of promotion of scientific thought has a common feature — a lack of cause-effect relationships described in the above mentioned titles. At present, the formation of such rules, laws and theories is considered to be the ultimate goal of physics and chemistry by an overwhelming mass of research scientists, as well as people outside science.

According to the history of science, this situation has existed since the time of the formation of science.

Along with the overwhelming number of people who believe that these achievements are the final result of science, there have always been people who were deeply interested in science and trying to find the cause-effect relationships between phenomena. For us, only the search for causes and consequences is a truly scientific approach, and fortune favored us. In previous works, we found out the cause-effect relationships in a variety of physical and chemical phenomena (for more details, see the sites itchem.ru and fphysics.com).

Currently, the correctness of the virial theorem is not in doubt, either in printed publications or on the Internet. Both in physics and in chemistry, in classical science and in quantum science, the theorem is considered to be proved. Consequently, it is widely used, for example, in describing the hydrogen atom.

In our book we wrote:

"Electrons are attracted to the nucleus because of electrostatic interaction forces. However, the electrons do not fall to the nucleus because they revolve around it with a certain velocity, i. e., have a certain kinetic energy. In its simplest form, the proof of the virial theorem is derived from *the stationary condition of the orbit* (see http://itchem.ru/struktura_atoma_vodoroda), which is stated as follows: *the electron is at a certain distance from the nucleus because both forces — the centripetal* F_{cp} connecting the charged particles and *the centrifugal* F_{cf} tending to tear an electron from the nucleus — *balance each other*:

$$F_{cp} = F_{cf}. \tag{3}$$

The centrifugal force was calculated by the equation

$$F_{cf} = m_e v^2/R_H = 9.1\cdot10^{-31}(2.2\cdot10^6)^2/0.53\cdot10^{-10} \approx 0.83\cdot10^{-7}\ \text{N}, \tag{4}$$

where F_{cf}, m_e, v and R_H are the centrifugal force, the Newtonian mass of the electron, the electron's velocity in orbit and the orbital radius of the hydrogen atom, respectively.

The centripetal force (or, in the case of the hydrogen atom, the Coulomb force) is described by the equation

$$F_{Coul} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{R^2_H}, \tag{5}$$

where F_{Coul}, ε_0 and q are the Coulomb force, the electrical constant and the charge of the electron and proton, respectively."

We substitute the following numerical values in the formula: $8.99\cdot10^9$ Nm^2/s^2 as the electrical constant, $0.16\cdot10^{-18}$ C as the charge of the electron and proton and $0.529\cdot10^{-10}$ m as the radius of the hydrogen atom. We find that the Coulomb force (centripetal force) in the hydrogen atom is $0.82\cdot10^{-7}$ N.

$$F_{Coul} = 8.99\cdot10^9\cdot(0.16\cdot10^{-18})^2/(0.529\cdot10^{-10})^2 \approx 0.82\cdot10^{-7}\ \text{N}.$$

The centrifugal force was calculated by the equation

$$F_{cf} = m_e\, v^2/R_H, \tag{6}$$

where m_e, v^2 and R are the Newtonian mass of the electron, the velocity of the electron in the orbit and the orbital radius of an electron in a hydrogen atom (the radius of a hydrogen atom).

Similarly, substituting numerical values, we obtain the value of the centrifugal force:

$$F_{cf} = 9.1 \cdot 10^{-31} \cdot (2.2 \cdot 10^6)^2 / 0.529 \cdot 10^{-10} \approx 0.83 \cdot 10^{-7}\ \text{N}.$$

In addition, we calculated the numerical value of the accelerations under the action of Coulomb forces and the value of the centrifugal acceleration.

The calculation made by us (in the first approximation, it was assumed that the atomic nucleus was motionless), gave the following values: the acceleration acquired under the influence of the Coulomb force is equal to

$$a_{Coul} = \frac{1}{4\pi\varepsilon_0} \frac{q^2}{mR^2_{\text{H}}}, \tag{7}$$

$$a_{Coul} = 8{,}99 \cdot 10^9 \cdot \left(1{,}76 \cdot 10^{-11}\right) \frac{1{,}60 \cdot 10^{19}}{(5{,}29 \cdot 10^{-11})^2} \approx 0{,}904 \cdot 10^{23}\,\text{m/s}^2.$$

Centrifugal acceleration, calculated according to the formula

$$a_{cf} = v^2 / R_{\text{H}} \tag{8}$$

is equal to:

$$a_{cf} = \frac{(2.18 \cdot 10^6)^2}{5.29 \cdot 10^{-11}} \approx 0.899 \cdot 10^{23}\ \text{m/s}^2.$$

In these formulas, q, m, v and R_H are the charge (of electron and proton), the inertial electromagnetic mass of electron, the velocity of the electron in the orbit and the radius of a hydrogen atom, respectively.

In the calculations, we didn't use the value of the electron mass, but we took another value, which was measured more than 100 years ago: $q/m = -1.76 \cdot 10^{-11}$ C/kg. Different sources give different values for the electron velocity: from $2.22 \cdot 10^6$ m/s to $2.18 \cdot 10^6$ m/s. This is the reason for the inexact equality of the calculated values of accelerations.

Further, the calculation of centrifugal forces and the centrifugal acceleration through Newtonian mass (matter which has no charge) will be called the first calculation, and the calculation via the mass, the inertial properties of which are conditioned by the charge and are described by the laws of electrodynamics, will be called the second calculation.

Let's examine in greater detail the physical meaning of mass in both cases.

In terms of the physical meaning, the first calculation is understood as a magic postulate, the physical meaning (cause-effect relationship) of which is not clear.

Before the discovery of the atomic-molecular structure of matter and the laws of electromagnetic phenomena (particularly Faraday laws), the physical reasons which reveal such coincidences could not be determined. Indeed, before these discoveries, it was impossible to suggest, even in the form of hypotheses, the existence of a cause-effect relationship between the Newtonian mass and the Coulomb forces, not to mention anything about the numerical coincidence.

On the other hand, after the discovery of the nuclear-atomic-molecular structure of matter and the laws of electromagnetic phenomena, the usage of the above-mentioned first calculation and the preservation of the Newtonian physical meaning of the parameter m can be explained only by the inertia of thinking and belief in figures of authority (especially in the indisputable authority of Newton).

As contrasted with the first calculation, the second calculation is a fine demonstration of the need to exclude a mechanical Newtonian mass from the initial entities, as was done with calorie and phlogiston in the course of development of chemistry and physics.

The second calculation can be explained by using the physical mechanism. According to the laws of electrodynamics, when charged particles more with acceleration EMF occurs, which causes the emergence of a force *equal in magnitude* to the force that caused the charge motion with acceleration (in this case, the Coulomb force) and *opposite to this force in direction* (in this case, the centrifugal force).

The electron acquires a linear acceleration under the influence of Coulomb forces. The equality of centrifugal and centripetal accelerations is a demonstration that the laws of electrodynamics do not depend on the type of acceleration. That is, it does not depend on the sign of the acceleration (whether it is positive or negative), or on the type of motion (translational-linear or centripetal-curvilinear), or on what force exactly led to the accelerated motion.

After the cessation of the exposure of the force causing the accelerated motion of the body, the action of the force caused by the EMF also gradually stops, and the body continues to move with the acquired velocity.

In previous works, in the process of determining of the cause of inertial properties of the electron, we concluded that the inertial properties of matter are conditioned by the charge and, therefore, the inertial mass is of electromagnetic origin. On the other hand, in subsequent studies (primarily in the article "Mass" and in this article), we are inclined to conclude that *m* is a factor which, most likely, depends on the structure of the charge. For electrons it is 1837 times smaller than for nucleons.

Such a significant difference in the inertial properties of electrons and nucleons suggests that the inertial properties of matter are primarily conditioned by the nucleons.

1.4. EQUIVALENCE PRINCIPLE OF MASSES

Over the history of physics, the equivalence principle of masses has been the most wondrous principle. Amazingly, this principle has continued to be refined experimentally from the late 19th century up to the present day. The equivalence principle, according to which the gravitational field in a small region of space and time is identical to the accelerated frame of reference for its manifestation, is the basis for the general relativity theory and results in the equality of inertial and gravitational mass.

The equivalence principle of masses was brought forward and experimentally tested by Newton. This principle helped explain the question of why all bodies fall to the ground with the same acceleration. This paradoxical discovery was made by Galileo when he threw bodies of different weights from the Tower of Pisa. In order to explain this phenomenon, Newton introduced the concept of mass — a new quality of matter.

In Newton's laws, mass acts at some times as a measure of inertia and at other times as a measure of gravitational properties. Newton was the first to turn his attention to the equality of inertial and gravitational masses and he proved that they differ by no more than 0.1%; in other words, they are equal, accurate to 10^{-3}.

More recently, R. Eötvös, in a set of very accurate experiments, conducted from 1890 to 1910 and continued in 1922, showed that the equivalence principle of gravitational and inertial masses is satisfied with a level of accuracy better than one twenty-millionth. Eötvös's experiments examined the behavior of a plumbline under the action of Earth's gravitational force and the centrifugal force. The Earth's gravitational force depends on the gravitational mass, while the centrifugal force caused by the rotation of the Earth depends on the inertial mass.

1.4.1. Eötvös's experiment testing the equivalence principle of masses

The experiment was set up in the following way. A rod with two weights on the edges (made of copper and platinum) was suspended by a thread (see fig. 5). The rod was oriented perpendicular to the meridian (the meridian is the straight from north to south; in the figure it is indicated as *NS*). The shoulders of the rod are equal. Cargoes are also of equal weight.

If these (gravitational and inertial) masses were not the same, the direction of the plumbline would depend on the material (copper, platinum, lead, iron, glass, etc.) of the ball of plumbline. However, with the help of the torsion balance, Eötvös determined that the plumbline does not change its direction, regardless of the material of which it is made. Thus, the equality of gravitational and inertial masses was determined (for more details, see http://rozman2.narod.ru/otopdf/oto02.pdf). Classical mechanics did not even attempt to explain the reason for this phenomenon. The equivalence principle introduced by Newton allowed scientists to say that they were dealing with a new entity, which has gravitational and inertial properties. Thus, the equivalence principle reinforced the existence of mass.

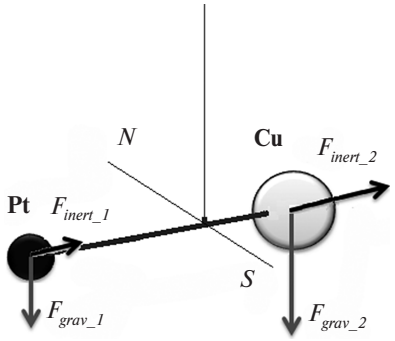


Fig. 5. Eötvös's original experimental device

In the times of Newton, science that dealt with electric charges and their interaction was embryotic. It was known that there are two kinds of charges and that the charges of one kind repel those of the other, and that the charges of opposite kinds are attracted to each other. In those days, they were called resin and amber electricity. Later the names of the charges changed to positive and negative. From the standpoint of the mathematical approach, the attraction and collision of opposite charges ends in their mutual neutralization, and charge disappears. All cosmic and ordinary material bodies were considered, in mechanics, electrically neutral bodies. Newton, therefore, could not explain the physical meaning of the equivalence principle of masses.

After the determination of the atomic structure and composition of atomic nuclei (after the discoveries of Rutherford), it became clear that all elements and, therefore, all of matter, are composed of the same stable charged particles: electrons, protons and neutrons. Charged particles have either positive or negative charge.

Under any forceful influence, a charged particle responds with the force of inertia, the nature of which is electric [2]. In physics, force is an additive concept. The total force of the inertia of a material body is composed of the inertial forces of individual charged particles. The force F_{inert_i} acting on each particle is proportional to acceleration a, according to the electrodynamic mechanism of inertia of the charged particles. Consequently, the total force acting on the whole macroscopic body is proportional to the acceleration a and is the subject of Newton's second law, $\vec{F} = m\vec{a}$.

The same situation exists for the force of gravity. The total force is composed of the gravitational forces of individual particles. Each force F_{grav_i} is proportional to the acceleration g, according to Newton's fourth law, $\vec{F} = m\vec{g}$.

The ratio $F_{inert\_i}/a = F_{grav\_i}/g$ is a constant magnitude. The equivalence principle of masses is expressed in this ratio.

The equivalence principle was repeatedly refined and tested. From 1959 to 1963, the American physicist Robert Dicke increased its accuracy of measurement to 10^{-11}, and in 1971 the Soviet scientists V. P. Braginsky and V. I. Panov brought the accuracy of these magnitudes up to 10^{-12}.

1.4.2. The nature of the equivalence principle of masses

We have compared substances varying in density, conductivity and other parameters. Table 2 shows the calculation of the number of nucleons in 1 gram of the element.

The atomic weight was calculated by the formula

$$M = 1.00732\,Z + 1.0087\,N, \tag{9}$$

in which Z is the number of protons, N is the number of neutrons, and the coefficients 1.00732 and 1.0087 take into account intranuclear interactions. The table shows the calculations for only a few stable isotopes of elements that differ in their chemical and physical properties. The number of nucleons in 1 gram of a substance is identical to the 4th digit, with differences of less than 10^{-3}%. That is why we believe that an equal number of charged particles determines the same inertial

and gravitational properties. This occurs because of the additivity of the inertial and gravitational forces and the absence of other components in any substance.

Table 2

Stable isotopes of some elements	Number of protons Z	Number of neutrons N	Atomic weight calculated according to formula (9), g/mol	Atomic weight by Reference book, g/mol	1 g of substance contains atoms, $\times 10^{21}$	1 g of substance contains nucleons, $\times 10^{23}$
^{1}H	1	0	1.0153282	1.007947	593.12272	5.9738362
^{16}O	8	8	16.12816	15.9994	37.33928	5.974063
^{27}Al	13	14	27.21696	26.98153863	22.12423	5.9735674
^{63}Cu	29	34	63.50815	62.9295975	9.48247	5.9739561
^{65}Cu	29	36	65.52548	64.9277895	9.19053	5.9738445
^{194}Pt	78	116	195.58016	193.9626803	3.07911	5.9734734
^{195}Pt	78	117	196.58886	194.9647911	3.06332	5.9734744
^{197}Au	79	118	198.60488	196.9665687	3.003222	5.9734782

We believe that

1) the inertial and gravitational properties of the charges depend upon electromagnetic induction (see article “The law of gravity” and “The inductance of the electron”),

2) the equivalence principle is the manifestation of the electrodynamic interactions of elementary charges composing the body with other charges surrounding this body.

Why are the other properties of 1 gram of a substance so different? Because these properties are determined by chemical bonds formed by atoms or molecules of the substance.

Inertial properties attributed to mechanical mass exist only as a fact determined by belief in figures of authority and the inertia of human reasoning.

In school textbooks, Newton’s laws are described as ultimate truth, though their creation required the introduction of five new entities. These five entities are the following: mass as a measure of matter, the inertial and gravitational properties of mass, gravitational forces and

inertial forces. All five of these entities were introduced *ad hoc* (Latin — "for this", "for the nonce", "for this purpose"). For example, the gravitational forces and gravitational properties of masses were introduced for the explanation of falling of bodies on Earth, and the centrifugal force (a special case of inertial forces) explained why the cosmic bodies revolve around a common mass center and do not fall under the influence of gravity. Accordingly, the immediate task of science was the independent confirmation of the existence of each of the introduced entities. The most important step in this direction was the equivalence principle declared by Newton.

It was experimentally proved that, during the free motion of the body in the central force field, the centrifugal force is demonstrably evident, and that its value is equal in magnitude to that of the centripetal force causing the motion of a body with acceleration, $F_{cp} = F_{cf} = MV^2/R$, where M, V and R are the mass, velocity and radius of rotation circle, respectively.

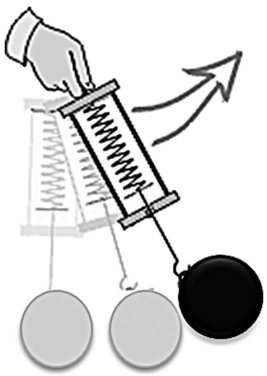


Fig. 6. The experiment with a dynamometer

Let's examine an easily realizable and well-known experiment (fig. 6).

In this experiment, a ball of mass M rotates on a spring. A dynamometer measuring spring tension force is attached to the ball. In this system, we can measure the orbital velocity of the ball's motion, centripetal force (F_{cp}), centrifugal force (F_{cf}) and orbital radius (R).

In the course of the experiment, we can change the speed of the ball in orbit and, accordingly, the orbital radius. With increases in the rotation, the velocity, the orbital radius, the velocity of the ball's motion in orbit and the centripetal and centrifugal forces increase.

$$F_{cp} = \mathrm{M}V^2/R,\ F_{cf} = \mathrm{M}V^2/R. \tag{10}$$

Stability condition is

$$\vec{F}_{cp} = -\vec{F}_{cf}. \tag{11}$$

In Newton's time, the only centripetal force believed to act at a distance (the existence of which was acknowledged by Copernicus, Galileo, Hooke and Newton) was the gravitational force. Mass was

a measure of the amount of substance. Accordingly, the equality of inertial mass and gravitational mass to each other and to mass as a measure of the amount of substance was and is the most weighty proof of the real existence of all the entities mentioned above in the history of physics. As stated above, the equivalence principle was proclaimed 320 years ago. At this time, the mathematical approach dominated in solving physical problems. According to this approach, the primary task of science is to formulate a mathematical equation that describes the observed phenomena. The significance of the theory was defined by the possibility of explaining and calculating phenomena which were not quantitatively described until this time.

For example, the principle of equivalence enables us to calculate the attraction force of the planets to the Sun without knowledge of the physical nature of gravitation. The first, second and third space velocities of bodies were and are calculated under the principle of equivalence.

Therefore, the questions "Why is centrifugal force equal to centripetal force?" and "Why is inertial mass equal to gravitational mass?" had not even arisen. So, the equivalence principle was actually Newton's fifth law. However, it should be mentioned that the resolution of these issues in Newton's time was hardly possible. Meanwhile, the internal contradictions of the laws proposed by Newton were evident even in those times. Newton attributed the forces arising in a rectilinear motion and centrifugal forces to inertial forces. The reason for this assertion was that these forces are calculated by analogous equations. In modern mechanics, it is accepted that a body rotating while affected by the gravitational force drops constantly towards the source of gravity. But, since inertia resists change in velocity of a falling body, the body is forced to follow an elliptical, hyperbolic or parabolic trajectory. In the case of circular motion, the centrifugal force is equal to the force that caused the motion of the body with acceleration, which was confirmed experimentally. Accordingly, we expected that in the case of linear accelerated motion, the inertial force must be equal to the force that caused the acceleration. However, in this case, it would be impossible, in principle, to accelerate the body moving linearly; it is unclear why the pair of forces, which are at any moment of time exactly equal and opposite to each other, cause no uniform motion.

The law of universal gravitation (universal interaction between any types of matter), discovered by Newton in 1678, assumed momentary

long-range action between bodies. The main drawback of this law was that, in this case, the systems (primarily the solar system) constructed according to this law (and according to the rest of Newton's laws) will be unstable and may not always exist in principle. Because of the orbital perturbations of meteors and comets and other gravity features, either the fall of bodies to the center of gravity or their separation and recession must occur. This contradicted the ideas of eternity and immutability of the movements of celestial bodies.

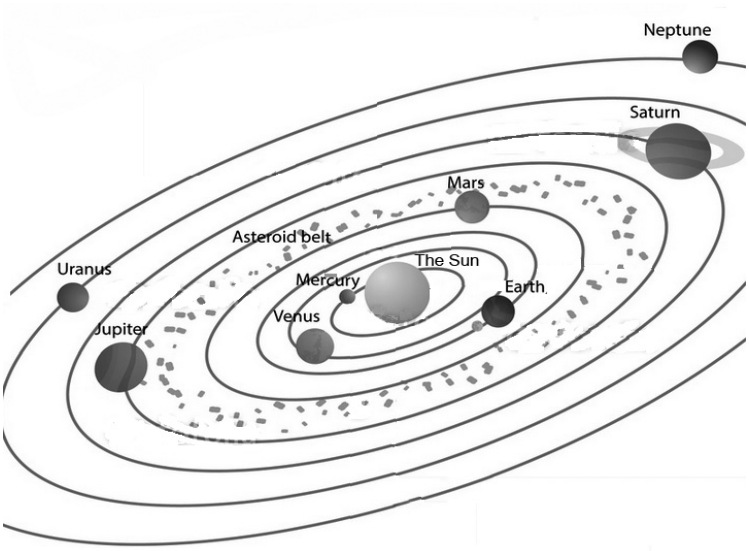


Fig. 7. Solar System

As is well known, there are three equilibrium states in mechanics: *indifferent*, *stable and unstable equilibrium* (see the article "About gravitation").

In spatial and atomic systems described only by the laws of Newton, in case of a small deviation of a body from the equilibrium position, forces emerge which strive to increase this deviation, because both gravitational and Coulomb forces are inversely proportional to the squared distance between the planets for space objects and atoms, and the centrifugal forces are inversely proportional to the first degree of the distance. It would seem, in cases of the slightest deviation of an electron rotating around a proton (an increase or decrease of the distance between the proton and

electron), that the centripetal forces would increase this deviation. The only account of formal conservation laws (of energy, impulse and angular impulse) enables us to solve this problem only by way of mechanics, and, even then, it enables us to solve only a limited number of simple cases. But even in these cases, the physical mechanism stabilizing the orbits remains mysterious and incomprehensible.

According to Wikipedia, Newton knew about this contradiction and therefore, in his theory of gravitation, confined himself to the following phrase: "...the maintenance of the present view of the solar system requires the intervention of some extraneous *supernatural* powers."

Attempts to resolve this contradiction have been made over the last 300 years. A survey of works on this subject is described in the book [9] by V. G. Demin the founder of the Astronautics Academy of the USSR. In the preface to this book, we read: "A little less than two centuries separate us from the days when eminent French scientists Joseph Louis Lagrange and Pierre Simon de Laplace, whose names excite a reverent and admiring respect among the scientists of all times, continuing the great work of Isaac Newton and the glorious galaxy of its followers, created a magnificent work of celestial mechanics. Over nearly half a century, maintaining continuous communication with each other, in the spirit of constant creative rivalry, Lagrange and Laplace devotedly toiled at the general problem of the construction of a theory of motion of major planets. They are both rightly considered to be authors of the statement of a famous problem in mechanics: the problem of stability of the solar system, which generated a number of more specific problems in the evolution of the orbits and the figures of celestial bodies. Lagrange and Laplace first breach at the unassailable mathematical fortress — that is, the problem of the stability of the solar system, and the scientists found its first approximate solution.

For many decades, the most prominent mathematicians and mechanics assailed the Lagrange-Laplace problem. Slowly, step by step, the scientists moved forward, forced to surmount the complicated mathematical hurdles constantly coming up in their way, pulling out of nature, one after another, the secrets of the motion of celestial bodies. Specific issues of the evolution of movement of individual bodies in the solar system were solved, one after another. But the strict solution of the famous problem still remained as distant as in the times of Lagrange and Laplace."

One hundred years ago, it was proved that all material bodies are composed of charged particles (electrons, protons and neutrons) and

that their number in each body is directly proportional to the body's weight.

During these years, a new science — electrodynamics — emerged and was firmly established. It brought into physics new entities and new regularities. Electrostatic and electromagnetic forces became newly accepted forces.

In electrodynamics, it was proved that a charge moving with acceleration causes the emergence of an electromotive force acting on this charge *with a force equal in magnitude to the force that caused the charge's motion with acceleration and directly opposite to this force in direction* (Lenz rule).

The magnitude of the electromotive force does not depend on the type of force that caused the motion of a charge with acceleration. This force can be the Newtonian gravitation force (the attraction of masses), or the Coulomb force (the interaction of charges), or the Lorentz force (the interaction of charges moving with an acceleration with the magnetic and electric field). Acceleration can also be arbitrary (centripetal or linear).

Electrodynamics gives us the answer to the following question: *Why is the centrifugal force equal to the gravitational force?*

In experiments demonstrating the equality of the centrifugal force and centripetal force, charges (of which a body consists) move with acceleration. This leads to the emergence of EMF acting on these charges with a force equal in magnitude and opposite in direction to the centripetal force. It is possible to give the answer to the question "Why is the centrifugal force equal to the centripetal one?" without using mass and its properties. *Since gravitation causes the acceleration of charged particles that make up any body and the result of this acceleration is self-induction, which is exactly equal and opposite in direction to the force that caused acceleration, the inertia of a body caused by gravitation is in a cause-effect relationship with this gravitation. Cause and effect are always separated, albeit negligible, but non-zero time term. That is why gravitation, despite the opposition of inertia, can still change the trajectories of bodies!*

It is not only qualitative but quantitative evidence that mass as an entity and, accordingly, its gravitational and inertial properties, are not the original (fundamental) concepts.

Our explanation of the equivalence principle is an illustration of a well-known statement of Bacon's that the new theory is a child of time but not a child of authority.

The laws and the equivalence principle discovered by Newton appeared two hundred years before Faraday's law, the atomic and molecular structure of substances and the determination of the nature of chemical bonds. We have been writing about this for over 15 years, in both English and Russian. Difficulties with the perception of our explanations are related primarily to inertia of thinking. We hope that simple and clear explanations can shorten the time required to overcome the thinking inertia of the scientific community.

Over the past 15 years, we have managed to explain a number of physical phenomena without the use of such an entity as mass. These explanations were published in our website. During this time, we realized that mass, despite its status as a fundamental entity, does not exist. However, this discovery did not turn into faith immediately even for us, partly because of the existence of the equivalence principle. Only around 2007 did we manage to understand the physical meaning of the equivalence principle. As usual, the explanation turned out to be very simple. It came when we understood and substantiated the idea that inertial forces, including centrifugal forces, are electrodynamic, rather than mechanical, in nature. On the one hand, we got an explanation of the physical meaning of the equation of Newton's third law, while, on the other hand, we found an explanation for the equivalence principle, because the equality of centrifugal forces and forces that caused charge motion with acceleration did not depend on the nature of the forces (whether of Newtonian gravitation or Coulomb forces, or Lorentz forces) or on the type of acceleration. The equivalence principle could have been formulated 100 years ago as follows: *In cases of the motion of material bodies under the influence of any centripetal forces, the centrifugal force is equal to the centripetal force and is caused by the inertia of the charges that comprise any body.* In turn, inertia is determined by the self-inductance of these elementary charges.

1.5. HISTORY OF ELECTROMAGNETIC MASS

1.5.1. History of charge

Even in ancient times, people distinguished "resinous" and "amber" electricity. The concepts of positive and negative charge were introduced by Benjamin Franklin. The interaction of electric charges was first described by Coulomb's law in 1785.

For a long time, the nature of electrical phenomena was completely incomprehensible, and entities like special "electric fluids" were introduced in order to explain it. In 1801, Johann Ritter advanced the idea of a discrete structure of electricity. In his 1846 investigations, Wilhelm Weber introduced the concept of the electricity atom and the hypothesis that its motion around the material nucleus may explain thermal and light phenomena. Michael Faraday coined the term "ion" to describe the carriers of electricity in an electrolyte and suggested that the ion has a continuous charge. In 1881, J. Stoney was the first to calculate the charge of a monovalent ion in electrolysis, and, in 1891, he coined the term "electron" to denote the electric charge of a monovalent ion in electrolysis.

In 1881, in a speech devoted to Faraday, Helmholtz expressed his idea of the atomicity of electricity in the following clear form: "If we assume the existence of chemical atoms, then we are forced to conclude that electricity, both positive and negative, is also divided into certain elementary quantities, which play the role of atoms of electricity." H. Helmholtz showed that Faraday's conception must be consistent with Maxwell's equations.

In 1895, Joseph J. Thomson began to methodically research the deflection of cathode rays (discovered by Julius Plucker) in electric and magnetic fields. Thompson argues that all the particles forming cathode rays are identical to each other and form a part of the substance. During the session of the Royal Society on April 29, 1897, Thomson described the essence of his experiments and his hypothesis about the existence of matter in a state of even greater fragmentation than atoms.

In the early 20th century, American physicist Robert Millikan experimentally showed that electric charge is *discrete*. A body's charge composes an integral multiple of the elementary electric charge. The first experiments in electron investigation showed that the electron behaves not only as a tiny electrical charge, but also as an object with a mass; the electron, in the experiments, displayed mechanical inertia.

If the electron has a mass, its inertia must appear everywhere, not only in the electric field. In 1913, Russian scientists Leonid I. Mandelstam and Nikolai D. Papaleksi ran a new experiment.

They took a coil of wire and twisted it in different directions. For example, they spun it clockwise, then abruptly stopped it and spun it counterclockwise. They reasoned that if electrons really have mass, then when the coil stops suddenly, the electrons should continue to move

for some time by inertia. The movement of electrons through wire is an electrical current. They were correct. They connected a telephone to the ends of the wire and heard the sound. Since the sound can be heard in the phone, the current must be flowing through it.

Mandelstam and Papaleksi's experiment was repeated by the American scientists Richard C. Tolman and T. Dale Stewart in 1916. They also spun a coil, but, instead of a telephone, they connected the coil to a charge meter, the ballistic galvanometer. They managed not only to prove the existence of electron mass, but also to measure it. The data of Tolman and Stewart was then tested and refined many times by other scientists, and it is now known that the mass of an electron is $9.109 \cdot 10^{-31}$ kg.

1.5.2. Electromagnetic mass

The concept of "electromagnetic mass" was introduced in 1881 by J. J. Thomson, who so named that part of the mass which is specified by the energy of the electrostatic field of the charged particles. This work is considered the first to discuss the relationship between energy and mass. In it, Thomson showed that the energy of the electrostatic field of the electron must be linearly related to its mass. Thomson started from the mechanical perceptions of the ether that prevailed in science until the early 20th century. He calculated the field of a charged sphere moving with some speed, assuming that the electric field is deformed with the acceleration. At the same time, an additional electromagnetic mass of charge appears, which, at low speeds, is equal to $2\mu e^2/3a$, where e is the charge of the sphere in electromagnetic units, a is the radius of the sphere and μ is the magnetic permeability of the medium. When the speed approaches the speed of light, the mass increases to infinity. "In other words," Thompson writes, "the increase of the speed of charged bodies moving through the dielectric to a speed greater than light speed is impossible." The relativistic conclusion about the ultimate value of the speed of light was therefore obtained two years before the birth of Einstein.

Even in his early works, Hendrik A. Lorentz started to introduce atomistics into the theory of electricity. In 1892, he stated the basics of electron theory. The world consists of a substance and ether (in the hypothesis of stationary ether), and Lorentz calls the substance "everything that can be part of electrical currents, electrical displacements and electromagnetic movements...All bodies with weight

consist of many positively and negatively charged particles, and electrical phenomena are generated by the displacement of these particles."

Studying the motion of electrons in external fields, Lorentz generalized observations and deduced the force acting on an electron moving at the same time in the electric and magnetic fields, which was subsequently named after him. It has the form

$$\vec{F} = e\vec{E} + \frac{e}{c}[\vec{v} \times \vec{B}]. \tag{13}$$

Here e is the particle charge, E is the electric field intensity, B is the magnetic induction, v is the speed of a charged particle with relation to the coordinate system in which the values F, E and B are calculated, and c is the speed of light in a vacuum. The formula is valid for any values of the velocity of a charged particle.

The first term on the right side of the formula is the force acting on a charged particle in an electric field, while the second term is the same force, but in a magnetic field. The magnetic part of Lorentz's force is proportional to the vector product of v and B; it is perpendicular to the particle's velocity and the vector of magnetic induction. Consequently, it does not perform mechanical work; it only curves the trajectory of a particle without changing its energy. According to Lorentz's audacious hypothesis, all molecular forces are electric!

So, it was clear in the early 20th century that:

1) tiny carriers of electric charge and mass exist,

2) electrical, magnetic and mechanical phenomena are closely related,

3) the atoms of substance consist of oppositely charged particles, and

4) all the grounds for a correct answer to the question of the essence and nature of inertia, mass and Newton's laws were prepared.

However, for a variety of reasons, the question was not answered...

1.5.3. The era of Maxwell–Einstein

Historically, it was Michael Faraday who first introduced the concept of the "field," which was strengthened by the works of Maxwell. Significantly later, experiments confirming the existence of elementary charge appeared. At first, the concept of the field was only intended as a temporary model, but it became an increasingly real physical entity in the physics of the 19th century. It led to the understanding of many facts

already known in the field of electrical and magnetic phenomena and to the prediction of new phenomena. The system which provided the basis for Maxwell's equations was called Maxwell's electromagnetic field theory. A new type of physical reality was proclaimed: a field, which is not reducible to material points or to any substance or to atoms.

Electromagnetic field theory did not manage to solve a set of problems related to the relation of charge, mass, Newtonian laws and the laws of Faraday. In order to resolve the accumulated contradictions, Einstein proposed a mathematical model of physical reality. Einstein pointed out that it is not points of space or time that possess physical reality, but the events themselves that are defined by four numbers x, y, z and t.

The special theory of relativity, based on the consideration of inertial reference systems, allows us to determine an important relationship for accelerated motion. In relativistic physics, it is believed that the higher the velocity of a body's motion, the harder it is to increase it. Since the resistance to speed change in the velocity of the body is called its mass (inertial), it follows that the mass of the body increases with the increase of the velocity of its motion. This is true with one condition: it is tacitly believed, in this reasoning, that the electron is accelerated by a constant force, but this belief has never been seriously tested. In classical mechanics, mass is considered a constant value, which, in relativistic mechanics, is called the "rest mass." Changes in mass can be detected only at high speeds.

Based on the principle of equivalence of gravitational and inertial masses and the dependence of the mass on velocity, Einstein drew a radical conclusion in SRT about the equivalence of mass and energy.

As for the physical reasons for the origin of mass, they remained undiscovered.

1.5.4. Feynman's search

The question of mass did not leave the minds of scientists, and in 1962 it was raised by Richard F. Feynman.

Feynman suggests that the nature of mass is electromagnetic. The great teacher discusses it as follows: "Where does the mass come from? In our laws of mechanics we have supposed that every object 'carries' a thing we call the mass — which also means that it 'carries' a momentum proportional to its velocity. Now we discover that it is understandable that a charged particle carries a momentum proportional to its velocity. It might, in fact, be that the mass is just the effect of electrodynamics.

The origin of mass has now been unexplained. We have at last in the theory of electrodynamics a grand opportunity to understand something that we never understood before. It comes out of the blue — or rather, from Maxwell and Poynting — that any charged particle will have a momentum proportional to its velocity just from electromagnetic influences" [1, chapters 28-3].

The results of his calculations give, as electromagnetic mass, the expression

$$m_{em} = \frac{2}{3}\frac{e^2}{ac^2} \tag{14}$$

and, correspondingly, for energy,

$$U_{em} = \frac{4}{3} m_{em} c^2 . \tag{15}$$

As you can see, this expression does not coincide with the known formula $U = mc^2$.

Even before Feynman, in 1958, Sommerfeld obtained his formula for electron rest mass:

$$m_0 = \frac{\mu_0 q^2}{6\pi r_0} [\text{kg}] \text{ (System International).} \tag{16}$$

The discrepancies in the results of these calculations forced R. Feynman to admit that electron mass (and thus the mass of other elementary particles) consists of not only the electromagnetic part, which has a physical nature, but also of some mysterious "mass of non-electromagnetic origin," which has no distinct explanation.

Another issue unresolved by Feynman is the relation of the neutron and proton masses, the two particles which are so similar in terms of strong interactions and different in terms of electric interactions. At the time, the experimental data about the presence of variously charged regions inside the neutron did not exist.

So, the nature of mass was not detected by Feynman. However, his weighty opinion was the reason that further development of the topic was put off for the foreseeable future.

What kinds of mistakes are there in the logic of R. Feynman and A. Sommerfeld? And what else must be "added" to electrodynamics in order to create a unified field theory?

The excellent teacher and great scientist Feynman, when speaking of mass, lost sight of the fact that bodies show inertial properties only when their velocity is changed (with acceleration). In cases of uniform motion of the body, or at rest, we cannot talk about the demonstration of inertia. At the same time, Feynman and Sommerfeld carried out their calculations considering the field of a uniformly moving electron and basing their work on Lorenz's ideas about the distortion of the field of a moving electron. However, in both Newtonian mechanics and the mechanics of Einstein, as well as in practice, there is no way to ascertain the fact of uniform rectilinear motion of a closed physical system. If the field of a uniformly moving electron really was distorted, it would create the possibility of observing such motion. Accordingly, the field of a uniformly moving charge is not distorted!

Another of Feynman's fundamental mistakes was his use of Poynting's vector to describe the energy transfer by an electron field. Poynting's vector can only be applied to electromagnetic waves. In the case of a moving charge, it is necessary to use Umov vectors, which are associated with convective energy transfer. (The Poynting vector is a special case of the Umov vector.) An easy-to-understand explanation of the difference between these devices is given in the works of Maria Korneva and Victor Kuligin [10].

Our discovery of the inaccuracies in Feynman's approach and the recent confirmation of Enrico Fermi's hypothesis of a complex structure of the neutron (launched in 1947) returned us to the idea of electromagnetic mass.

We believe that the well-known phenomenon of self-induction is responsible for the inertia of the electron and other elementary particles. According to the definition of electric current, the motion of a charged particle is current. Accelerated (irregular) motion is a time-varying current. Any time-varying current is accompanied, according to M. Faraday, by the phenomenon of self-induction. Self-induction, according to the rule of Lenz, is always directed against the force that caused the change in the current (caused the acceleration of charged particles). This is the force which is accepted as inertia.

Since uncharged matter does not exist, as has been shown in our studies (see http://en.fphysics.com) all bodies are composed of charges. This leads to the natural conclusion that the inertia of any body, even an electrically neutral one, can be explained by the phenomenon of self-induction. Let us consider this conclusion in more detail.

Let us remember the definition of self-induction.

The electric current in a certain coil produces a magnetic flux, which penetrates this coil. If the current in the coil varies with time, the magnetic flux through the coil will also change, inducing an EMF in it just as it occurs, when the transformer is working. The emergence of the EMF while the current is changing in the coil is called self-induction. Self-induction influences the current in the coil. Likewise, the inertia influences the motion of bodies in mechanics; it slows the establishment of direct current in the circuit at power-up and prevents it from instantaneously stopping at shutdown. In an AC circuit, the self-inductance creates a reactance limiting current amplitude.

In the absence of magnetic materials near the motionless coil, the magnetic flux's penetration of it is proportional to the current in the circuit. According to Faraday's law, in this case, the 1 EMF of self-induction should be proportional to the rate of change of the current, as in

$$E = -L\frac{di}{dt}, \tag{17}$$

where L is the coefficient of proportionality called self-induction or inductance of the circuit. The formula can also be considered the determination of the value L. If the EMF (E) induced in the coil is expressed in volts, the current i in amperes and the time t in seconds, then L is measured in henrys (Hn). The "minus" sign points to the induced EMF opposing increases in the current i, as follows from the law of Lenz. External EMF overcoming the EMF of self-induction should have a "plus" sign. Therefore, in AC circuits, the voltage drop across an inductance is equal to $L \cdot di/dt$.

When a body moves with acceleration, all the charges in the body are also moving with acceleration. The charge moving with acceleration is by definition a variable (alternating) current. The alternating current causes the phenomenon of self-induction. The EMF of self-induction obstructs the force that caused the change in current; it obstructs the acceleration of the charge.

The total force of inertia is made up of the forces of self-induction acting on each charged particle of the macrobody individually. The revealed mechanism shows that inertial forces are not fictitious and that they are conditioned by electromagnetic phenomena.

1.5.5. Calculations and conclusions

Now let us consider the second and third laws of Newton,

$$\vec{F} = m\vec{a} \text{ and } \vec{F}_1 = -\vec{F}_2 .$$

By applying force to any body, we are accelerating the body, and we are thus accelerating all micro-charges which form parts of this body. Consequently, each particle of the body becomes the current, notably alternating current. The phenomenon of self-induction emerges, which is described, according to Faraday, through the EMF of induction.

$$E = -L \cdot di / dt .$$

Here

$$L = \frac{\mu_0}{2\pi} r_0 \tag{18}$$

is the inductance (coefficient of self-induction) of the sphere. In the formula, the minus sign appears according to the rule of Lenz, showing that the EMF is always directed against the forces that caused the change in current.

The EMF of self-induction causes the emergence of electric field $E_i = 2E/r_0$ of self-inductance, and it acts on the charge by the force

$$F = qE_i = -\frac{q \cdot L}{2r_0} di / dt . \tag{19}$$

Therefore, it is clear that the force counteracting the acceleration is directly proportional to the current change associated with the charge motion. Now, let us express the change in current intensity over the course of time:

$$\frac{di}{dt} = \frac{d}{dt}\frac{qV}{2r_0} = \frac{q}{2r_0}\frac{dV}{dt} = \frac{q}{2r_0} a . \tag{20}$$

Consequently, the force that emerges in case of the body's acceleration can be expressed as the following:

$$F = -\frac{qL}{2r_0} \cdot di / dt = -\frac{q}{2r_0}\frac{\mu_0}{2\pi} r_0 \frac{q}{2r_0} a = -\frac{\mu_0}{8\pi}\frac{q^2}{r_0} a . \tag{21}$$

Comparing this with Newton's second law

$$F = -ma, \tag{22}$$

we see that particle mass is determined by the expression

$$m = \frac{\mu_0}{8\pi}\frac{q^2}{r_0}. \tag{23}$$

We mention here the important fact that the mass derived from the law of self-induction corresponds completely with Einstein's mass $m = U/c^2$, if the total energy of the electron U is understood as the self-energy of its electric field.

Correspondingly, both the second and third laws of Newton simply express the properties of electromagnetic induction. Newton's method — the development of a model of the phenomenon without inventing hypotheses, and then, if the data are sufficient, the search for the causes of this phenomenon — can be discarded. *The substitution of charge for mass* reveals the mechanism of Newtonian laws and a set of other phenomena.

Now the stability of the orbits of planets in the solar system becomes clear. Since gravity acts on the planets with some force F_{grav}, and the substance (the planet) resists with the combined power of self-induction $F_{\Sigma i}$, provided that

$$\vec{F}_{\Sigma i} = -\vec{F}_{grav} \tag{24}$$

no forces act wholly on the planets, and therefore planets do not change the nature of their movement.

In the virial theorem, the emerging EMF of self-induction counteracts the centripetal force. Feedback appears. The EMF grows until it equals the F_{cp} in magnitude.

Using the laws of electrostatics and the virial theorem, we have calculated the bond in the hydrogen molecule. The results speak for themselves; the discrepancy between the calculated value of molecular size and the experimental value is less than 4%. Thus, our theory of bonding explains the stability of molecules and atoms. The absence of electron radiation in an atom is a weighty argument for the electromagnetic description of the world.

The spectacular confirmation of the theory of relativity — the phenomenon of electron and positron annihilation — also works for the electromagnetic conception of mass. Thus, in classical mechanics, the charged particle (either electron or positron) has its own mass m, kinetic energy K (if the particle is initially moving) *and* the self-energy of the electric field of the charge $q\varphi/2$, where φ is the potential of the electric field near the particle. The energy of γ-quanta born as a result of the annihilation of electron-positron pairs is exactly equal to $2mc^2 + 2K$.

And where, in this case, is the energy of the electric fields of particles? Where did their Coulomb energy go? This hitherto unresolved question of physics can be easily explained by our theory. In the electromagnetic concept of mass, charge does not have two masses (the non-electromagnetic mass m and the mass of field $q\varphi/2c^2$) but one — and this mass is entirely of electrical origin! The energy of the "masses" of particles is the self-energy of their Coulomb fields.

It is enough to look around closely and you will find numerous confirmations of the electromagnetic nature of mass. The method of mass spectrometry is used to determine the mass of elementary particles. It affords an opportunity to measure the ratio of mass to the charge of the particle. What kind of mass do we mean? Inertial. Experience shows that the inertial mass to the 3rd sign is equal to the weight of the particle. Using the equivalence principle (inertial mass is equal to gravitational mass), we see that there is nothing left for the neutral mass of Feynman. Uncharged particles in crossed electric and magnetic fields do not deviate. This also leads to the conclusions of the unbreakable bond of charge and mass and of the absence of uncharged mass.

So, the inertial, electric and gravitational properties of a body are determined by charge but not mass. It is not mass that is the original initial essence of matter, but charge. The replacement of one value with another allows us to get rid of the contradictions in the laws of Newton, in which the inertial properties of the body appear instantly with changes of speed, and the opportunity to impart acceleration to a body exists instantly. In reality, these events occur with some time latency. Such hitches in time lead us to thoughts about the existence of "ether," presumably composed of particles such as positronium (in which an electron and a positron circle a common center of mass). Mass as an independent concept does not exist. Introduced by Newton 300 years ago, it has not received a physical explanation, and, according to the laws of history, it should leave the arena of physical activities.

Another well-known fact: the work of modern power generators and motors proceeds with an efficiency factor close to 100%. This means that, in these devices, most of the energy is expended to overcome the inertia of the charges in the matter, and virtually all the mechanical energy is converted into electricity and vice versa. Consequently, the idea of the electromagnetic nature of mechanical forces finds direct evidence here.

When Faraday first published his remarkable discovery that the change of magnetic flux creates an EMF, he was asked (as everybody is asked who discovers some new phenomenon): "What is the benefit of it?" After all, all that he discovered was the emergence of a tiny current in the wire. Faraday replied: "What is the benefit of a newborn baby?" The "fully-grown child" has given us a point of view on electrodynamics from the perspective of the concept of the field. All industry works on that foundation. Faraday's laws explained the mechanism of Newton's laws, the stability of the orbits of the solar system and the physical meaning of the virial theorem.

Thus, gravitational forces, which are difficult to unite with other forces, have ceased to be an obstacle to the creation of a unified field theory. Faraday's discovery brought us closer to a unified theory of everything.

Newton's mechanical mass dominated science for about 200 years, before individual scientists made the very first attempts to discover the physical mechanism of the phenomenon of inertia and to connect mass with the electromagnetic properties of elementary particles. It took another 100 years of struggle in order for this idea to finally be formed and take its rightful place in modern science.

Part 2

HYPOTHESES, THEORIES AND FINDINGS

The exclusion of classical mass from the original essences, and the transition to the charge (of electromagnetic mass) leads us to the following conclusions:

1) elementary (indivisible) particles like quarks do not exist because otherwise repulsive forces are compensated for nothing,

2) the division of the charges is limited by nothing,

3) the extrapolations of experimentally determined cases (Solar system, molecule, atom, proton, neutron) show that those systems are stable in which two oppositely charged charges revolve around the center of inertia or two equally charged charges revolve around the third oppositely charged charge (we suggest two versions of the organization of positronium and hydride anion).

With the decrease of the effective radius of complex particles and the growth of their effective charge, their stability increases (more energy is required for their decomposition) and their inertial properties are increased (according to the old concept, the inertial mass).

The interaction between complex particles and cosmic bodies, in the range of distances $10^{-15} \div 10^{15}$ m, is determined by the ratio of the distance between them to their sizes (by effective radius). For example, during the interaction of hydrogen atoms with effective radius 0.529 Å with each other at a distance of more than five effective radii, the power of their interaction is close to zero.

As they approach each other, the interaction force changes depending on the distance.

At distances on the order of 4–3 effective radii, it is inversely proportional to 1–3 degrees; at distances of 3–2 effective radii, this comes to 7 degrees. Further approximation dramatically changes the

type of the dependence of the interaction force on the distance. At a distance of 0.7 Å, the interaction force becomes zero. With further approach, it changes its sign. If, before the distance 0.7 Å, this force was a force of attraction of one atom to another, after passing the mark of 0.7 Å, the attraction is replaced by repulsion.

2.1. EXPLANATION OF THE PHENOMENA BASED ON THE LORENTZ FORCE IN THE MASS-SPECTROMETER EXPERIMENTS

The Lorentz force is the electromagnetic force. It occurs when charge moves in the electric and magnetic fields.

This force is centripetal. When a charged particle moves under the influence of the Lorentz force, the particle acquires centripetal and centrifugal acceleration.

1. The action of the Lorentz force in the experiments shows that the mass of the particle is proportional to the charge. These experiments demonstrate that the neutral matter (the Newtonian mass, which does not contain charges) does not exist and, accordingly, there is no gravity in the Newtonian view.

2. The charge causes EMF, calculated according to the formula

$$\varepsilon_i = \oint_L \vec{E}_B dl = -\frac{d\Phi}{dt}, \tag{25}$$

where $d\Phi/dt$ is the changes of the flux of the magnetic field generated by the charge's accelerated motion. The presence of this EMF reveals the mechanism of the second Newtonian law and helps explain why it is impossible to give the body an acceleration instantaneously.

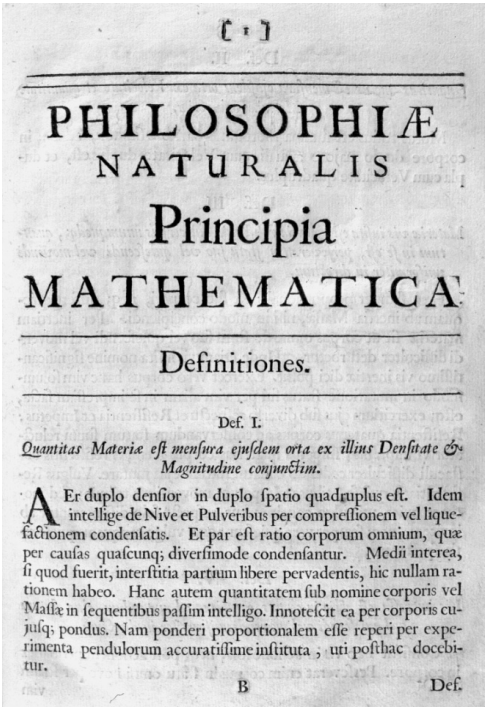
3. We have already discussed that the orbiting electron is under the action of the Coulomb centripetal force and centrifugal force. Two forces of electrical origin oppose each other. The charge motion in the accelerator/magnetometer/along a circular orbit around the "empty center" is not fundamentally different from the previously discussed situation. The centripetal force — the Lorentz force — acts on the side of the magnet, and the centrifugal force (opposing the centripetal one) is the same force of self-induction which can be examined as the Lorentz force acting on the side of the environment in which it is moving.

4. The Lenz rule applied to the Lorentz force explains the stability of atomic and planetary orbits. This is the solution of one of the issues that have given impetus to the emergence of quantum mechanics.

2.2. ABOUT GRAVITY

Clarifying the physical meaning of the equivalence principle (the absence of mechanical mass in charged particles) led us to the clarification of the physical sense of Newton's law of gravitation.

In Feynman's lectures, in the chapter devoted to gravity, only a few examples of the explanatory and predictive capabilities of the Newtonian theory are considered. The most convincing evidence of the correctness and wide predictive capabilities presented by Feynman were the prediction of the location of Neptune and an explanation of the



[1]

PHILOSOPHIÆ
NATURALIS
Principia
MATHEMATICA

Definitiones.

Def. I.

Quantitas Materiæ eſt menſura ejuſdem orta ex illius Denſitate & Magnitudine conjunctim.

AEr duplo denſior in duplo ſpatio quadruplus eſt. Idem intellige de Nive et Pulveribus per compreſſionem vel liquefactionem condenſatis. Et par eſt ratio corporum omnium, quæ per cauſas quaſcunq; diverſimode condenſantur. Medii interea, ſi quod fuerit, interſtitia partium libere pervadentis, hic nullam rationem habeo. Hanc autem quantitatem ſub nomine corporis vel Maſſæ in ſequentibus paſſim intelligo. Innoteſcit ea per corporis cujuſq; pondus. Nam ponderi proportionalem eſſe reperi per experimenta pendulorum accuratiſſime inſtituta ; uti poſthac docebitur.

B Def.

Fig. 8. Newton's "Principles"

appearance of twice-daily tides. Feynman did not notice any defects or contradictions in Newton's theory of gravitation. Moreover, he believed that this theory is a prime example of the mathematical approach to the questions of natural science. As Feynman said in his Nobel lecture, "probably the best way to create a new theory is to guess equations, ignoring physical models and physical explanations". In his famous lectures, in the chapter devoted to gravity, he wrote: "...since Newton's times and to the present day, no one could describe the mechanism hidden behind the law of gravity, without repeating what Newton has already said, without complicating the mathematics or predicting phenomena which do not actually exist. So we still have no other model for the theory of gravity, except the mathematical one".

Over the 320 years since the adoption of Newton's law of gravitation, it was found that his theory of gravity is self-contradictory. The accepted theory leads to the paradoxical conclusion that some of the bodies under the action of their own gravitational force should uncontrollably shrink and "collapse", or virtually disappear from their surroundings. In the book "Gravitation" [11], American physicists call «collapsing to a point» the greatest crisis of physics. This view is shared by many scientists, both physicists and philosophers.

Starting in the second half of the 20th century, astronomers began to find evidence that huge star clusters break Newton's laws. The most popular hypothesis explaining the "wrong" behavior of galaxies suggests that Newton's laws are not broken and that the observed deviation from the laws is caused by the presence of dark matter. This term is used to denote substance which has not yet been observed experimentally and which takes part in gravitational interaction but does not participate in electromagnetic interaction. Dark matter creates additional mass which is responsible for the slowing of the galaxies [12].

Observations of supernovae of type Ia, conducted in 1998 under the Supernova Cosmology Project, have shown that the Hubble's constant changes over time can be explained by an appropriate selection of the value of the cosmological constant Λ, contributing Ω_Λ to the average density Ω. This part of the hidden mass is called dark energy.

The interpretation of the data on the anisotropy of relict radiation obtained in the course of the work of the WMAP (Wilkinson Microwave Anisotropy Probe, 2003) led to the following results: the observed density Ω is close to Ω_{crit}, and the arrangement $\Omega = \Omega_\Lambda + \Omega_{vis} + \Omega_{dark}$ along components: baryon matter Ω_{vis} — 4%, dark cold matter (WIMP)

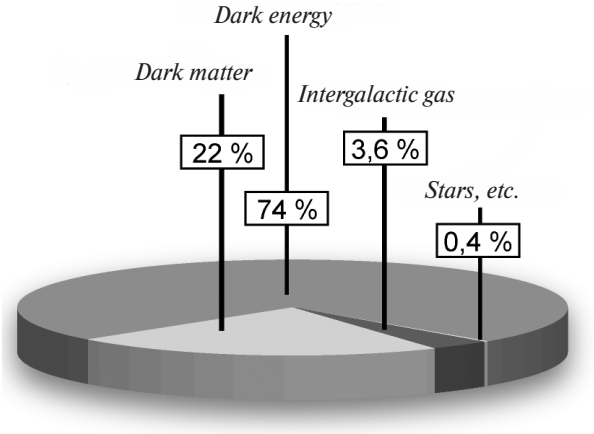


Fig. 9. Structure of the Universe according to the data from WMAP

Ω_{dark} — 23%, "dark energy" Ω_{Λ} — 72,6% [13]. In our Galaxy, in the neighborhood of the sun, the mass of dark matter is approximately equal to the mass of ordinary matter.

Dark energy is a much stranger substance than dark matter. For one thing, it does not gather into clumps but is uniformly diffused throughout the universe. There is as much dark energy in galaxies and clusters of galaxies as outside them. The most unusual thing is that dark energy, in a certain sense, experiences antigravity. We have already mentioned that, with the help of modern astronomical techniques, one can not only measure the present rate of expansion of the universe but also determine how it has changed over time. Astronomical observations testify that currently (and in the recent past), the universe's expansion is accelerating; the rate of expansion is increasing over time. In this respect, we can speak about antigravity. The usual gravitational attraction would have slowed the recession of galaxies, but, in our actual universe, it turns out to be the opposite.

Generally speaking, such a picture does not contradict the general relativity theory, but dark energy should have a special property for this — a negative pressure. This fact dramatically distinguishes it from normal forms of matter. It is no exaggeration to say that the nature of dark energy is the mathematical mystery of fundamental physics of the 21st century.

Mass is the original entity of the law of gravity. However, the physical nature of mass is not yet known.

Thus, according to the Academician of the Russian Academy of Sciences L. B. Okun, the nature of mass is the number one question of modern physics [14]. It is currently believed that the accepted theory of gravity allows us to calculate the density of the Sun. The density of matter is determined by the length of the bond between atomic nuclei and the number of nucleons in these nuclei. At temperatures above 6,000 degrees (the Sun consists of 93% hydrogen and 7% helium, heated to a temperature of more than 10,000 K), bonds between the electrons and nuclei in hydrogen and helium break with a binding energy of about 15 electron volts. At a temperature of 6,000 degrees, hydrogen and helium are already in the form of plasma. Coulomb and magnetic forces, which differ in strength from gravitational forces by more than 40 orders of magnitude, protect the plasma from spreading on the Sun. The specific weight of the Sun, therefore, should be less than the specific weight of hydrogen under ordinary conditions, and should have a corresponding value less than 0.0000899 (at 273 K = 0° C) g/cm^3, which differs from the value determined according to Newton's gravitation laws, 2 g/cm^3, by more than 2,000 times.

It is proved that the Sun is positively charged and that the electrostatic interaction of the Sun with other stars should be considered when calculating gravitational interactions.

What can we say today about the physical nature of the gravitational force and its quantitative evaluation?

It is widely known that the most effective way to solve particular problems is to solve general problems. As mentioned above, the main unresolved issues in modern physics are the physical nature of mass, the collapse of masses and the nature of dark matter and dark energy. In our previous work, it was proved that the idea of mass introduced to science by Newton was an intermediate entity in the course of the historical development of physics. In the article "Inertial forces and gravitational forces," we explained that inertial mass has an electromagnetic origin. Since uncharged masses do not exist in nature (even bodies that are generally electrically neutral consist of charges), electromagnetic mass is attributable to all bodies. Since mass turned out to be an entity unnecessary to the explanation of inertia, a suspicion that gravity — another property of matter — is determined by the interaction of charged particles appears reasonable.

Newton considered space systems to be systems of centripetal forces. Atomic and molecular systems are also connected by centripetal (Coulomb) forces.

The proof of the electromagnetic origin of inertial properties of matter allows us, we believe, to answer another question of modern physics and chemistry, which follows from the exclusion of mass as a necessary initial entity. In general, this question can be formulated in the following way: why are systems of centripetal forces stable?

Let's remember the equilibrium conditions. There are three states of equilibrium in mechanics: neutral equilibrium, stable equilibrium and unstable equilibrium.

Neutral equilibrium means that, with a small deviation, the body remains in equilibrium. An example is a wheel rolling on a horizontal surface. If you stop it at any point, the wheel will be in a state of equilibrium. A ball lying on a flat horizontal surface is in a state of neutral equilibrium (fig. 10).

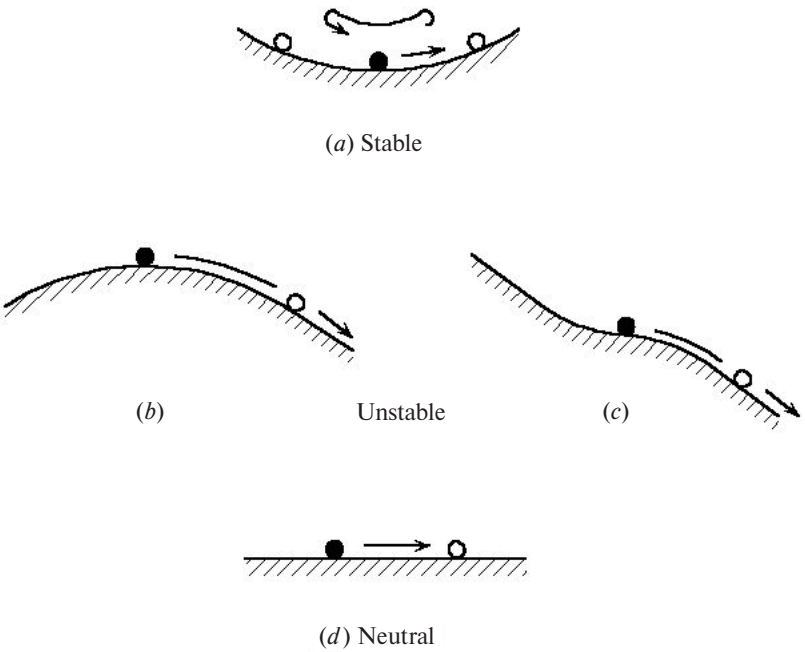


Fig. 10. Different types of equilibrium of the ball on a support

Unstable equilibrium means that, with a small deviation of the body from the equilibrium state, forces emerge which tend to increase this deviation. A ball located at the top of a spherical projection is an example of unstable equilibrium.

Stable equilibrium means that, with small deviations of the body from this state, forces or moments of forces emerge which tend to return the body to the state of equilibrium. A ball located at the bottom of a spherical deepening is in a state of stable equilibrium.

An atom is an unstable system; at the slightest deviation in an electron's rotation around a proton (an increase or decrease of the distance between the proton and electron), centripetal forces increase this deviation.

The planetary system described only by Newton's equations is also unstable. Maybe that is why Newton said that the maintenance of the present type of solar system requires the intervention of some extraneous supernatural forces.

We believe that these supernatural forces are the electromagnetic ones described by Faraday's law. Charge moving with acceleration generates EMF that acts on a charged particle with a force equal in magnitude and opposite in direction to the force that caused the motion with acceleration.

These forces explain the equality of centripetal and centrifugal forces and the stability of the orbits of both space objects and electrons in atoms and molecules.

In the process of the electrodynamic explanation of this picture of the universe, gravitational interaction can be explained only by electromagnetic forces.

Consideration of these forces allows a qualitative explanation of the aforementioned contradictions in the accepted theory of gravity, the role and nature of dark matter and energy, and such phenomena as the recession of galaxies without additional introduction of entities which are not detected experimentally. Within the framework of this electrodynamic explanation, galaxies scatter because the burning stars bear excess positive charge. Dark matter is the clouds of excited and unexcited microparticles (electrons, protons, neutrons, positrons, positrons, positroniums, anions of positroniums, etc.).

An evaluation of the magnitude of the joint action of the above-mentioned forces on a cosmic scale can be made with the help of the Newtonian formulas relating to force, inertial masses and centrifugal acceleration.

2.3. THE PLANETARY MODEL OF THE ATOM

The proximity of the values of the electron energy and the length of the bond in the hydrogen molecule calculated (2,800 kJ/mol, 0.61 Å) and experimentally determined (2,800 ± 83 kJ/mol, 0.58 ÷ 0.62 Å) provides evidence for the proposed model and, consequently, for the G-theory of chemical bonding [3]. As a consequence, a rejection of the planetary Bohr model of the hydrogen atom seems unreasonable. The Bohr-Rutherford planetary model of the hydrogen atom is the ideal object to clarify the physical meaning of the equivalence principle and explanation of the physical meaning of Newton's laws.

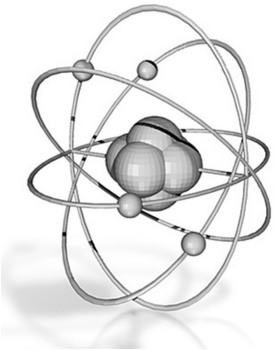


Fig. 11. The planetary model of the atom

The equivalence principle, which has been repeatedly experimentally proven, argues that gravitational mass is proportional to inertial mass. Newton's second law claims unified acceleration for all falling bodies and, correspondingly, the independence of the acceleration of the fall from the mass of the falling body.

In the planetary model of the hydrogen atom, the electron moves round a circle. Such movement is accelerated. According to Faraday's laws, an accelerated motion of an electron potential, called EMF, arises. The force acting on the charge on the side of the EMF becomes equal in magnitude to the force that caused the accelerated motion of a charged particle and is directly opposed to it in direction. In the case of atomic hydrogen, this accelerating force is the centripetal force. Currently, in the calculation of the Bohr model of the hydrogen atom, it is assumed that the centripetal force is equal to the Coulomb force, and its value is determined by the equation

$$F_c = mV^2/R, \tag{26}$$

where m is mechanical mass and V^2/R is centripetal acceleration.

Newton introduced new concepts (gravitational mass, the mass of inertia, the centrifugal force) and formulated laws, without offering an

explanatory mechanism. Faraday's laws, unlike Newton's laws, have a mechanism — they have a cause-effect relationship. They appear in the experimentally established phenomena. The charged particle moving uniformly and slowly in a straight line creates a magnetic field. The charge, moving with acceleration, changes the energy of the magnetic field, regardless of what caused the acceleration. The change of the magnetic field's energy leads to the emergence of EMF, which is oppositely directed to the EMF that caused the acceleration. The change in the stress field affects the acceleration of the charge.

Experiments that studied the motion of the electron and positron in the electromagnetic fields have shown that particles that have no charge do not interact with these fields. In the calculation of centrifugal acceleration in the hydrogen atom, it was found that the acceleration conditioned by Coulomb forces is equal to the centrifugal acceleration conditioned by the charge of the electron. Thus, nothing is left for the mechanical mass. This is evidence that the mechanical mass of the electron does not exists.

Calculations carried out by us (assuming, originally, that the nucleus of the atom is motionless) resulted in the following values: the acceleration under the influence of Coulomb's forces is equal to $0.902 \cdot 10^{23}$ м/sec^2, and, under the influence of EMF, equal to $0.898 \cdot 10^{23}$ м/sec^2.

The calculation was made using the following well-known equations:

$$a_{Coul} = F_{Coul} / m_e \tag{26}$$

and

$$a_{cf} = v^2 / R_{\text{H}},\ F_{Coul} = (1/4\pi\varepsilon_0)\, q^2 / R^2, \tag{27}$$

where a_{Coul}, F_{Coul}, q, a_{cf}, v and R_{H} are the Coulomb acceleration, the Coulomb force, the charge of the electron, the centrifugal acceleration, the velocity of the electron and the radius of a hydrogen atom, respectively. The Coulomb interaction (F_{Coul}) of the electron and the proton was calculated by the equation

$$F_{Coul} = 8.99 \cdot 10^9 \cdot (0.16 \cdot 10^{-18})^2 / (0.529 \cdot 10^{-10})^2 \text{ N},$$

where $1/4\pi\varepsilon_0 = 8.99 \cdot 10^9$ Nm^2/s^2, $0.16 \cdot 10^{-18}$ C, $0.529 \cdot 10^{-10}$ m — the Coulomb constant, the charge of the electron and the proton, and the radius of a hydrogen atom, respectively.

2.4. UNIFIED THEORY

The principles of physics' unified theory have different names. They are called the Unified Theory of Matter, the Unified Field Theory, the Theory of Grand Unification, the Theory of Everything, etc. Despite the differences in denomination, the ideas behind these names are similar.

Currently, the main obstacle to the creation of a **Unified Theory of Everything** is the unification of all known interactions with a gravitational one. Other, equally important tasks of the Unified Theory are the clarification of the nature of chemical bonding and the clarification of the nature of bonding of nucleons (strong interactions).

In our previous investigations, we have shown that gravitational Newtonian mass is not an independent entity and should be excluded from physics. Accordingly, there is no Newtonian gravitational interaction. Currently, all developed Unified Theories are based on the concept of Newtonian mass. Charge is not even mentioned in these theories. The proof of the absence of mass as an independent entity allows us to assert that the foundation of these theories is incorrect and that they are, therefore, futureless.

In our investigations, we have shown that the nature of chemical bonding and nucleon bonding (strong interaction) is electromagnetic. The difference between these interactions is only quantitative. The main contribution to the energy of the chemical bonding is made by a Coulombic component. The proportion of the magnetic component does not exceed 3%. In the process of bond formation between the nucleons in the nucleus, the role of the magnetic component is much greater.

The proof of the electromagnetic nature of all types of interactions and the exclusion of the entity of mass, as well as the demonstration that only a single entity — charge — is sufficient to explain basic physical and chemical phenomena, is a *qualitative step* towards the Unified Theory of Matter and the Unified Field Theory.

In the above discussion of the tasks and difficulties of the Grand Unification, the question of which forces bind charge and mass was not touched on.

The exclusion of mass as an independent initial entity and the explanation of the chemical and physical phenomena on the basis of electrodynamic interactions have revealed the physical nature of the interrelation of mass and charge and eliminated the difficulties in uniting the gravitational interactions of masses with the interactions of charges.

2.5. COMPARISON OF GENERALLY ACCEPTED AND PROPOSED APPROACHES TO THE DEVELOPMENT OF SCIENCE

Yes, time knows fine the true value
Of all the things placed around the world,
And only time sweeps away the peelings
Blows away the froth,
And racks a wine from amphora...

Igor Guberman

The basic dogma of the generally accepted approach to the development of science is a well-known utterance attributed to a number of authors: "There is as much science in science as there is mathematics in science." This began in the times of Pythagoras, who proclaimed that "mathematics is the gate to science." The mathematical era that started over 3000 years ago continues to the present day, and Isaac Newton is a symbol of this era. Newton's four laws, as well as Euclid's axioms, enable us to derive many other laws.

However, not only Newton's laws but Bohr's, Maxwell's, Ohm's and Einstein's and many other scientists' laws are described as postulates (without mechanisms), meaning that they do not describe cause-effect relations. A striking example of the mathematical approach is the Heisenberg uncertainty principle, which declares a complete absence of cause-effect relations, at least in the microcosm. The most striking thing is that this principle has been recognized by the scientific community on the most representative and well-known Copenhagen Congress by poll (not in the course of scientific discussion).

In the 20th century, physics developed according to the following motto: "...the best way to create a new theory is to guess equations, ignoring physical models and physical explanations" [5].

The generally accepted ranking of physicists is as follows: A. Einstein, Galileo and Newton, N. Bohr and Maxwell, Schroedinger, Heisenberg, etc. The apotheosis of this ranking includes quantum mechanics and also general and special relativity theories.

According to Rosenberger [4], "...the strong point of mathematical physics is a logical finality and obligatoriness of conclusions. After accepting certain starting provisions, the mathematizing physicist then operates with a help of mathematical tools, and all of his conclusions finally represent the detailed expression of the content of these provisions.

However, mathematical reasoning cannot create physics...They should borrow their material from outside, from those observations which are already available. In other words... passivity in regard to the material is typical of mathematical physics. And it suggests certain limits to its development. In addition, by asking only one question, "how big is...", mathematical physics essentially does nothing in terms of discovering a qualitative mechanism for the explored phenomena and confines itself to their quantitative description."

We did not manage to find in physics textbooks (perhaps the reader will direct us) a single case of the mathematical approach used to solve scientific questions that would not be a solution of the inverse problem (simply said, would not be a fitting). In the process of compiling dependencies, assumptions are introduced which have no experimental evidence. Often, for the equations composed according to this pseudoscientific basis, the coefficients were chosen whose numerical values were determined by experiment.

Hereafter, we propose to consider and compare two conceptions of the universe. One of them is firmly settled in academic institutions and, therefore, is generally accepted. The other conception, which in our opinion is a more progressive one, is electromagnetic.

I

Thus, the **generally accepted conception**:

Initial material essences: mass, charge, inertial properties of mass, gravitational properties of mass.

Interaction forces: electrodynamic, gravitational, interatomic, intranuclear (weak and strong).

Space is more than three-dimensional.

Paradigm: There is as much science in science as there is mathematics in science. Let's not waste time repeating what you know from school textbooks.

II

And now let's examine the **electromagnetic** (EM) **approach**.

The main essence of substance is the property that, historically, has been called a charge. This essence exists in nature in two forms: positive and negative charge. It has been deduced from experiments that similar charges repel each other, and opposite charges attract (only point charges). The magnitude of the interaction forces of the charges is described by Coulomb's law. According to intranuclear and molecular

theories, all material bodies, from space objects to microparticles, are complex and, therefore, divisible systems. These systems consist of negative and positive charges rotating around a general center of inertia. The charges have inertial properties. According to mass-spectrographic experimental data, the inertial properties of protons are 1840 times greater than the same properties of electrons, although their opposite charges are equal in absolute magnitude. At the same time, according to the experimental data, the inertial properties of positrons and electrons are also equal (though they have opposite directions). This data allows us to suggest that a dramatic difference between the inertial properties results from the different structures of electrons and protons (such as the difference between their effective radiuses).

The forces of interaction are only electrodynamic.

Interactions are described by cause-effect relations established during experiments studying the currents in conductors, convection currents and displacement currents.

Space is three-dimensional.

The basic conception: There is as much science in science as there is science in science (whether physics in physics, chemistry in chemistry, etc.).

We believe that the EM approach is more correct. Let's examine why.

1) **Basic essences**. According to the generally accepted approach, there are two basic essences — the mass of a substance and its charge. According to the proposed approach, there is only charge. The larger number of initial essences (the introduction of new postulates) makes the generally accepted system less versatile.

2) **Destruction.** According to the accepted approach, when elementary charges approach each other they are destroyed (for example, electron + positron), and the mass inherent in the charges turns into energy, according to the law $E = mc^2$. After this, the Coulomb energy disappears somewhere. It is logical to suppose that the Coulomb energy should also turn into energy. However, in practice, the amount of released energy is substantially smaller than would be expected in this case.

$$E_{annil} = E_{Coul} + 2mc^2. \tag{28}$$

If they were annihilated, then, according to Coulomb's law, the amount of released energy of point charges would be endless. Coulomb energy would add to the energy derived from mass. In practice, this is

not observed! The Coulomb interaction energy of converging particles seems to disappear mysteriously.

According to the proposed EM approach, as opposite charges approach each other, they do not annihilate each other but form a pair (particle), rotating around the charges' center of inertia. These charges are tied together by Coulomb forces. According to the EM approach, all material objects (macro- and microscopic objects) are composed of oppositely charged charges that rotate around the center of inertia. Complex particles are stable formations. When energy is imparted to them, they can reach an excited state. For example, when a hydrogen atom absorbs a quantum of electromagnetic energy (about 13.5 eV), it reaches an excited state. After this, the distance between the electron and the nucleus increases 10 times compared to the distances between them in the ground state of the hydrogen atom. Over 10^{-13} seconds, an excited hydrogen atom returns to its ground state, emitting a quantum of EM energy of about 13.5 eV. It is experimentally proved that an electron and a proton approach each other to a distance of 0.529 Å and form a hydrogen atom, in which the electron and proton rotate around the center of inertia.

Likewise atoms, molecules, nucleons and all the other elementary particles are formed. During the formation of complex particles, energy is released. The release of energy results from the fact that, during the formation of a complex particle, potential Coulomb energy turns into kinetic energy of particles rotating around a common center of inertia.

3) According to the generally accepted approach, when an electron and a positron approach each other, positronium is first formed and then "disappears" emitting a quantum of energy, according to the law $E = mc^2$. Furthermore, during the irradiation of the nuclei of heavy elements by the energy quantum of such power, an electron-positron pair is formed. Within the framework of the generally accepted theory, the chargeless EM energy transitions into oppositely charged particles with the same mass and equal in magnitude but opposite in sign. According to the generally accepted theory, charges are formed from the uncharged EM matter! This phenomenon at least requires an explanation of what the charge is and how it is formed from an uncharged substance.

This explanation supposes that the formed energy quantum remains in the space where it was formed. Despite such a contradiction in interpretations, this experiment and its explanation are presented in almost all textbooks. The main reason for the wide use of this explanation

stems from the fact that this experiment is nearly the sole quantitative confirmation of the transition of mass into energy, according to the most famous equation of the 20th century.

According to the generally accepted approach, the phenomenon of positronium formation and its subsequent disappearance is related to the fact that the positronium observed in the course of the experiment at the first stage is in an excited state. The excitation of positronium accounts for the decrease of potential energy during the approach of the charges. The excited positronium then calms to the ground state. During irradiation by the energy quantum, the positronium in the ground state segregates into an electron and a positron.

Everything takes place almost identically to the process of formation of a hydrogen atom from an electron and a proton and the process of decay of a hydrogen atom into an electron and a proton under irradiation with sufficient quantum energy near the nuclei of heavy elements.

4) **Inertia.** According to the generally accepted approach, two primary definitions of the forces of inertia are used. In popular encyclopedias, the following is presented:

The force of inertia is a vector value numerically equal to the product of the mass m of a material point on the module of its acceleration, which is directed opposite to the acceleration.

In the case of curvilinear motion, the force of inertia can be decomposed into a tangential component.

The force of inertia is a fictitious force that can be introduced into a noninertial reference system so that the laws of motion will coincide with the laws of inertial systems. In mathematical calculations, the introduction of this force is due to rearrangement of the equation

$$F_1 + F_2 + \ldots + F_n = ma \tag{29}$$

into

$$F_1 + F_2 + \ldots + F_n - ma = 0, \tag{30}$$

where F_i is an actual operating force and ma is "the force of inertia".

The allocation of forces of inertia to the fictitious force was connected with the fact that these forces, unlike all other forces, contradict Newton's third law

$$\vec{F}_2 = -\vec{F}_1 . \tag{31}$$

A confirmation of our hypothesis is this quote from the encyclopedia "Krugosvet": "If, in order to change the state of rest or state of uniform

and straight motion, we need an external force, obviously something counteracts such change. The ability to resist change in the state of rest or motion common to all the bodies is called inertness, or inertia. When it comes to pushing a car, you need to expend more effort to move it from its place than to keep it rolling. Here, inertia is manifested in two ways. First, it is manifested as the resistance to the transition from a state of rest to a state of motion. Second, if the road is smooth and slick, it is manifested as a tendency of the rolling car to continue in its state of motion. In this situation, everyone can feel the inertia of the car trying to stay in its motionless state. Making the car start moving requires much more effort than sustaining its movement" [15].

V. I. Nikolaev wrote in his article, "The forces of inertia in the general physics course", "Now, let's return again to the question of the 'queerness' of the inertial forces. The inertial forces have peculiarities which distinguish them from the so-called 'usual' forces. In particular, it's impossible to apply Newton's third law to them, because the inertial forces are not interaction forces, and hence it is impossible to point out the body from which they operate. With close examination of the peculiarities of the inertial forces, it is not difficult, however, to find that in our reasoning we actually treat them like 'usual' forces. Thus, in discussing the question of the applicability of the third law of Newton to them, we have to remember how to introduce the forces of inertia. Any violation of Newton's third law is out of the question. After all, if each of the varieties of inertial forces results from the contribution to the 'absolute' acceleration, which an observer doesn't see in his noninertial system, even at this early stage of the generation of the inertial forces (forces as the concepts of the dynamics of point motion), confirmation of the meaninglessness of the application of Newton's third law to them is practically formed; yes, the inertial forces are forces too, but they are not interaction forces, and hence the question about the application of Newton's third law is eliminated" [16].

Within the framework of the proposed conception, we prove that the inertial forces result from the charges which comprise the material bodies. First of all, they are determined by the charges of nucleons. Mechanical mass — the inertial mass introduced by Newton — is not an independent essence but reflects the phenomenon of self-induction. Accordingly, the laws of motion must be described not by the laws of Newton but by the laws of electrodynamics. Thus, Newton's second and fourth laws must be described by the laws of self-induction. According to this approach, the inertial forces are the essence of the self-induction

force of accelerated charges. There is a cause-effect relationship between them and the forces that caused acceleration. The equality of these forces is caused not by a miracle but by the laws of electrodynamics and Lenz's rule. Inertia is the reaction of elementary charges to an attempt by external forces to accelerate them. This is why they are equal in value, and one is a direct and an unavoidable consequence of the other.

5) **Self-induction**. "The electric current in a separate coil produces a magnetic flux which permeates this coil. If the current in the coil varies with time, the magnetic flux permeating through the coil will also vary, inducing an electromotive force in it, according to Faraday's law, exactly as it proceeds with the transformer work. The occurrence of EMF in the coil at the current change in it is called self-induction. Self-induction influences the current in the coil much as inertia influences the motion of bodies in mechanics; it slows down the setting of a direct current in circuit at startup and hinders its momentary stop at shut down. It also causes the appearance of sparks jumping between the contacts of breakers when a circuit opens. In AC circuits, self-induction creates reactive impedance, which limits current amplitude" [15].

Using the example of a hydrogen atom, we have proved that the laws of conventional current are identical to the laws of normal current streaming through the wires [2]. According to the laws of induction and self-induction, inertial forces are not fictitious but are the usual electromotive forces. These forces are the same as the forces caused by the motion of bodies with acceleration. In electrodynamics, not only the mechanism of the emergence of inertial forces but also the peculiarities of those forces are explicable without additional assumptions. Thus, the electrodynamic substantiation of the phenomenon of inertia explains the action mechanism of Newton's laws and eliminates the internal contradictions emerging when applying these laws. The knowledge of the electrodynamic mechanism of inertia even allows us to exclude the concept of mass (such as gravitational and inertial mass), a physical entity the scientific community has been unable to understand for over 320 years.

6) **Gravitation.** According to the generally accepted approach, gravitation is a fundamental force that results from the interaction of masses. All that is stated in textbooks on gravitation is that it is described by the fourth law of Newton:

$$F_{grav} \sim m_1 m_2 / r^2.$$

According to R. Feynman [5], the most convincing proofs of correctness and manifold predictive opportunities were the prediction of the location of Neptune and the explanation of twice-daily tides. Feynman did not note any disadvantages or contradictions in Newton's theory of gravitation. Moreover, he believed that this theory was a good example of the mathematical approach to issues of natural science, or, in the words of Feynman from his Nobel lecture, "...the best way to create a new theory is to guess equations ignoring physical models or physical explanations."

We consider gravity an electromagnetic phenomenon.

Our conclusion is based on the following facts.

A. Macrobodies and microbodies differing from each other in size by 30 orders ($10^{-15} \div 10^{15}$ cm) are arranged uniformly. Charges of opposite signs rotate around a common center (a molecule of hydrogen, positronium, an atom of helium, the Sun, Earth). The position of the point around which opposite charges rotate is determined by the concentration of the charges in space. According to experimental data, the inertial properties of atomic nuclei are proportional to the number of nucleons contained in them. The inertial properties of nucleons are completely charged to account for the mass of the nucleons. In the same way, the inertial properties of electrons are also charged to account for the mass of electrons. It is assumed in all calculations that the charge of the nucleons and electrons is the same in absolute value and, consequently, that their difference in inertial properties results from the different amounts of mass contained in them. In the currently accepted explanations, the inertial properties of electric charges of elementary particles are not considered at all, nor are they anywhere stipulated or explained.

All the compound bodies interact with each other according to the laws of electrodynamics because they consist of charges moving with acceleration.

Absolutely all bodies interact with each other according to the electrodynamic laws. In cases of the interaction of bodies whose net charges are of opposite signs, the bodies approaching each other form system that rotates around a common center of inertia. In cases when bodies are charged similarly, they diverge. In both of these extreme cases, the interaction force between these bodies is inversely proportional to the squared distance between the bodies. If you give these bodies the opportunity to move freely according to the action of Coulomb forces

then, as far as changing the distance between the bodies, the rate of motion acceleration of these bodies increases in the first case and decreases in the second. The variation in acceleration of these bodies leads to variation in the EMF of self-induction of the charges moving with acceleration. When the EMF of self-induction becomes equal to the Coulomb force, the bodies cease to approach or diverge. The only possible movement available in the case of forces of mutual attraction is rotation around the center of inertia. In this system, the body moves with a constant magnitude of centripetal acceleration. At the same time, the centrifugal forces are equal to the centripetal ones, because the EMF of self-induction balances the Coulomb force.

When bodies do not have nonequilibrium (excess) charges, they join together by the mechanism of association of the atoms in the molecule and association of the nucleons in the atom nucleus. In this case, the dependence of the forces on the distance is more complicated.

B. A study of microparticles arriving from the Sun and from space, and resulting in a cyclotron and collider, found that all stable microparticles (with lifetimes longer than 1 sec) and even some unstable microparticles (with lifetimes shorter than 10^{-5} sec) are complex and consist of charges. The complexity of particles and the presence of the charges in them is proved experimentally by:

- the presence of magnetic moment in all the particles
- the composition of the decay products of unstable particles
- the spontaneous decay of free neutrons
- the proximity of the inertial masses defined by the deviation in the electric and magnetic fields to the sum of the masses of decay products. Electrons and positrons in the fields of these forces fly in circles of equal radius, and the centripetal forces are the Lorentz forces. Their circular motion is opposite in direction
- the detection of unstable particles, which are the excited states of stable ones

So far a substance that does not consist of charges has not been detected. Work aimed at the detection of microparticles which do not bear a charge (such as the search for Higgs particles at the European Hadron Collider and the American Tevatron) has been unsuccessful. Moreover, experiments conducted at the Tevatron before 2009 show, with a probability of 95%, that neutral particles do not exist.

The most fashionable theoretical justification for the origin of mass, the Big Bang theory, has been strongly criticized in scientific

writing. Already, more than 350 professionals worldwide have expressed agreement with the criticism of this theory.

Investigation of the composition and structure of material bodies and particles shows that they all have analogous nuclear, atomic and molecular structure and consist of stable charged (or composite) particles: electrons, positrons, protons and neutrons.

C. A charge moving with acceleration causes the appearance of the EMF of self-induction opposing the acceleration of the charge. Similarly, when the charge slows its movement, the EMF appears, counteracting the slowing of the charge's motion. Accordingly, in cases of variation of direction of the charge's motion, EMF prevents variation in the direction of motion. The EMF of self-induction is the mechanism that explains the inertia of matter. Inertial mass has electromagnetic origin. All the matter and particles bearing charges have inertial mass. As for the others — as we have just proved, there are no others.

Now, when explaining gravitation, it is logical to assume that gravitation, like inertia, is an electromagnetic effect.

According to the electrodynamic explanation of the universe, only electrodynamic forces take part in the interactions referred to as gravitational: Coulomb forces, electromagnetic forces, including the Lorentz forces, etc.

The consideration of these forces can explain the contradictions in the generally accepted theory of gravitation, the role and the nature of dark matter and energy and such phenomena as the recession of galaxies, without superinduction of experimentally undetectable entities. Galaxies scatter as they do because the burning stars bear excess positive charge. Dark matter represents clouds of excited and unexcited microparticles (electrons, protons, neutrons, positrons, positroniums and so on).

The assessment of value of summary action of the mentioned forces in cosmic scales can be made according to formulas of dependence of force on the inertial mass and the centripetal or centrifugal acceleration, according to Newton's second law.

What is the progression of the transition from mechanical mass to electrodynamic mass, and what issues have now become the foremost questions?

So, electrodynamic mass is an integral feature of the charges manifesting itself when they move with acceleration. How does this compare to the mechanical mass of Newton?

In contrast to mechanical forces, inertial forces, when electromagnetic mass in the accelerated motion of bodies arises, are always diametrically opposite to the action of forces that caused the acceleration. They do not depend on the type of operating forces. They may be gravitational and Coulomb forces, or any mechanical forces, such as centripetal ones (from atoms to planetary systems).

The inertial forces associated with the electromagnetic mass's accelerated motion do not depend even on the nature of the acceleration. This can be either centrifugal acceleration perpendicular to the motion's direction or acceleration coinciding with the forces' direction.

What kind of phenomenon, in our opinion, can be first explained by the conception of electromagnetic mass? It is, first of all, the principle of equivalence of masses (gravitational and inertial).

The mechanical mass, considered a separate feature of matter, not connected with either its internal structure or its electrical properties, allowed scientists to believe that an uncharged, electrically neutral matter can exist in nature.

There are no assumptions in our explanation which have not been included in the existing textbooks adopted by the scientific community for the last 150 years. The main starting point is the nuclear, atomic and molecular structure of matter.

In particular, it is well known that:

a) Matter consists of atoms (the theory of Dalton and Rutherford). An atom consists of charged electrons and the nucleus. Nuclei consist of charged protons and neutrons. Free neutrons decay over 860 seconds (average) with the formation of the charged electron and proton.

b) The charges moving with acceleration, being an alternating convection current, generate the electromotive force of self-induction, according to a well-known Faraday law. According to Lenz's rule, this EMF is directed against the source of the acceleration of charge.

The advantage of our worldview over the generally accepted mathematical one is expressed primarily by the number of initial entities. The fewer initial entities, the more universal a worldview is.

The next factor that determines the advantages of one conception over another is the number of phenomena that can be explained with the help of the conception. The more phenomena it explains, the more universal the proposed conception is. The EM conception does not contradict any existing physical law and helps to eliminate a number of contradictions. In particular, it takes into account the Coulomb energy

at annihilation, explains the complexity of any charged particle, and more (this will be discussed in a separate article).

The third philosophical criterion of the advantage of one conception over the other is the potential for further development of the conception.

2.6. THE THEORY OF ELECTRICAL CONDUCTIVITY. SUPERCONDUCTIVITY

The clarification of the nature of metallic bonding and the physical nature of electrical conductivity has allowed us to advance in explaining the phenomenon of superconductivity.

Fig. 12. The discoverer of superconductivity Kammerlingh Onnes

Currently (in 2010), two theories are used to explain the phenomenon of superconductivity — the magnetic vortex theory and quantum-mechanical theory.

2.6.1. The magnetic vortex theory

When a superconductor enters a magnetic field, the field penetrates it, in the form of thin fluxes called vortices. Electric currents emerge around each vortex. These vortices replicate themselves and are scattered when the temperature of the material increases. Since the vortices tend to be attached to long thin holes in the material, called the prismatic defects, researchers assumed that the vortices would behave

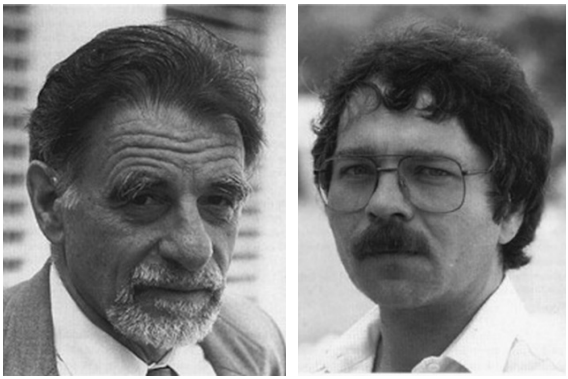


Fig. 13. The authors of the theory of high-temperature superconductivity Nobel Prize winners Alex Muller and Georg Bednorz

differently in the presence of such defects. They also found that when the number of vortices is greater than the number of holes, the vortices begin to scatter in two stages instead of one as the temperature rises. If we manage to delay the process of the scattering of the vortex flows, it will be possible to achieve the effect of superconductivity at higher temperatures.

2.6.2. Quantum-mechanical theory

The quantum-mechanical theory of superconductivity (BCS theory) considers this phenomenon to be the superfluidity of Bose–Einstein condensate of a Cooper pair of electrons in metal, with the absence of friction attributable to superfluidity. The conductivity electrons move freely in a superconductor, without "friction" with the inhomogeneities of the crystal lattice. The main peculiarity of superconductors is that the mutual attraction of electrons, which causes the formation of electron pairs (called Cooper pairs), emerges in them. The reason for this attraction is the additional (to the Coulomb repulsion) interaction between the electrons under the influence of a crystal lattice, which leads to the attraction of the electrons.

In the quantum theory of metals, the attraction between electrons (the exchange of phonons) is associated with the emergence of the elementary excitations of the crystal lattice. An electron moving in

Fig. 14. Authors of the most popular model of superconductivity (BCS) (1957) John Bardeen, Leon Cooper, John Schrieffer

a crystal and interacting with another electron through the lattice converts this lattice to an excited state. In the process of the transition of the lattice into the ground state, an energy quantum of sound frequency (a phonon) is radiated and then absorbed by another electron. The attraction between electrons can be represented as an exchange of electrons by phonons, and the attraction is most effective if the pulses of interacting electrons point in opposite directions.

The emergence of the superconducting state of a substance is connected with the possibility of the formation of bound pairs of electrons (Cooper pairs) in the metal. The evaluation shows that the electrons that form a pair are separated by distances of about a hundred periods of the crystal lattice. The whole electronic system of the superconductor is a close-knit formation extending to enormous distances, according to the atomic scale.

If, at incredibly low temperatures, the Coulomb repulsion between electrons prevails over the attraction that forms pairs, the substance (metal or alloy) retains its usual properties. If, at the temperature T_c, attractive forces dominate repulsive forces, the substance passes into a superconductive state.

We have a different explanation of the phenomenon of superconductivity, which we believe is clearer than those described above. The explanations mentioned above are based on the existence of

free electrons and electronic pairs. We believe that there are no free electrons, but electrons moving along chemical bonds do exist.

In the articles "Theory of electrical conductivity" (by Yu. Gankin, V. Gankin) and "Semiquantative modelling of electrical conductivity in metals and nonmetals" (by Yu. Gankin, V. Gankin, A. Sanin), it was shown that the difference between the electrical conductivity of metals and of nonmetals is determined by the different natures of chemical bonding in metals and nonmetals. In metals, this bonding is one-electron and dynamic, and in non-metals the bonding is two-electron and static. The bonding energy in nonmetals is 70 times greater than the bonding energy in metals. Electric current in metal is a movement of valence electrons along the bonds under the influence of the field. The mathematical model that we have developed allows us to calculate the energy change of electrons as they move along the chemical bond, for two cases of double and triple-core models. We determine the dependence of electron energy on the ionization potential of bonded atoms and on the degree of freezing of the system, which is defined as the modification in proportion of the velocity of transport of nuclei and electrons along with reduction of temperature. The model shows that the smallest change in energy of the system occurs when the ionization potentials of the bonded atoms are close to 8 eV and the degree of freezing is 30%.

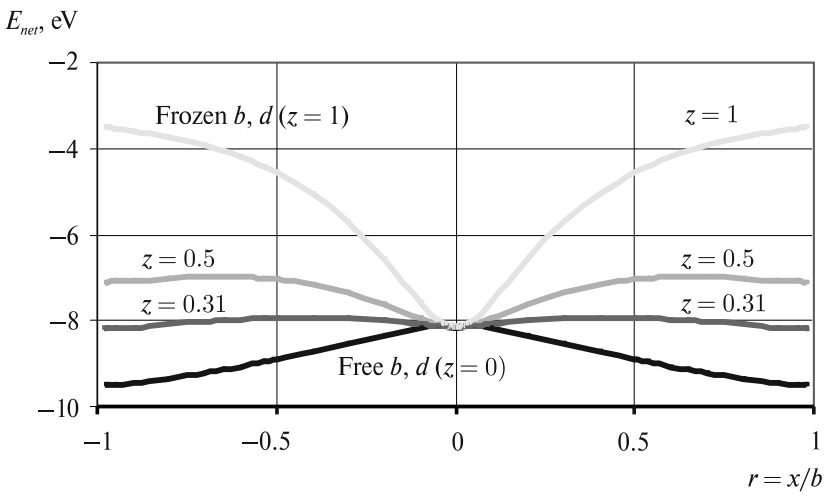


Fig. 15. E_{net} vs $r = x/b$ for 3-nucleus schemes with $N = 0.7698$ (FIE = 8.056 eV) and different degree of frozenness ($z = 1, 1.05, 0.31, 0$)

According to experimental data[1], superconducting alloys discovered between 1910 and 1993 include the following metals: niobium (6.88)[2], aluminum (5.98) tin (7.34), beryllium (9.32), lanthanum (5.61), barium (8.3), copper (7.72), tallium (7.88), cobalt (7.86), mercury (10.43), germanium (7.88) and calcium (6.11). These figures allow us to confirm that the experimental data and model calculations do not contradict each other.

2.7. ONCE AGAIN ON PHYSICS

The clarification of the physical nature of chemical bonding has allowed us to improve the interpretations of many physical phenomena. The immediate problems arising in physics during the development of this science in the 20th century were the following:

1) the consolidation of mass and electric interactions,

2) the physical nature of intermolecular and internuclear forces,

3) the interpretation of diffraction in experiments with microparticles.

These problems have been well described in this book. Here we will endeavor to offer brief responses to these points.

The experimental data found after the introduction of mass interactions (gravitational and inertial) allows us to exclude these interactions as separate essences. This data includes the study of atom structure, the affinity of atoms to the electron and proton and the study of the atoms' ionization potentials. A positive affinity of atoms to the electrons presumes a superfluous positive charge. If the electrons are torn away from the macrobodies with ease (with a small energy consumption), as compared to protons, this also presumes a superfluous positive charge.

A direct experimental confirmation of the presence of a surplus positive or negative charge on macrobodies and microbodies (generally, on all bodies with a mass) is the presence of the charge on the sun, on the earth and on all microparticles. Common bodies occupy an intermediate position in the following row: cosmic bodies — common bodies — microbodies.

The data on the measurements of the negative charge concentrations in the close-to-earth and cosmic space have allowed us to build a model

[1] J. H. Schon, Ch. Kloc, B. Batlogg, Bell Laboratories.

[2] In a parenthesis the ionization potential of these metals in electron-volts is set.

of gravitational interaction. According to this model, gravitational interaction is analogous to the attraction of the nuclei in a molecule; positively charged macrobodies are attracted to the electronic clouds concentrated between the positively charged macrobodies. Other possible models are given in the above-mentioned article.

The presence of a charge in the macrobodies and microparticles defines the inertial properties since, according to the experiment, when the charges move with acceleration, it is necessary to keep adding energy.

A comparison of our approach in explaining the physical essence of mass with that of others undoubtedly speaks in favor of ours. Indeed, in the traditional approach, mass interactions were conditioned historically and introduced during the mechanical stage of the development of science. At this stage, physical bodies were considered electrically neutral. Therefore, the attraction of bodies to one another and the inertial properties of bodies were regarded as masses contained in all bodies.

A logical conclusion of the development of the mechanical stage were the Theory of Relativity and Quantum Mechanics. According to the Theory of Relativity, the body's mass abruptly increases when its speed is close to that of light and it is turned into energy as a result of internuclear transformations. In Quantum Mechanics, the particles' impulse (mv) defines the length of the wave via the De Broglie equation

$$\lambda = h/mv. \tag{32}$$

The Theory of Relativity describes the behavior of mass at speeds close to that of light, while Quantum Mechanics describes the behavior of microparticles with respect to waves. Traditional mechanics described the movement of great masses with speeds much smaller than those of light. One couldn't help but marvel at the beauty and completeness of this mechanical picture of the world!

Indeed, energy and mass in this description were united via a simple equation: $E = mc^2$. Waves had the properties of particles (radiation proceeded in portions); particles had wave properties. All the relations between the main characteristics of the mechanical world were defined by simple equations. In cases when the complete equation appeared to be too complex (such as Schroedinger's equation), its simpler form was initiated.

In the framework of this accomplished description of the world, we actually have a repetition of the century — old history of the mechanical interpretation of the world. It was then that there was so much talk

about the end of physics, about the possibility of foretelling all the events on the basis of the knowledge of the impulses and coordinates of microparticles.

Unlike this description, wave mechanics supposes that we can define only the possibility of events and believes that there is great progress in this matter.

Such a description of the world is more like a final attempt at offering a mechanical interpretation of the electric world. Indeed, the beauty and simplicity of the equations, to say nothing of the completeness of the whole conception, are very suspicious.

There are questions concerning the principles of the structure of such a world. The basis for the interpretation is mass, the physical nature of which is unknown. We only know how to measure it. Mass is a coefficient between the force and the acceleration. The wavelengths of such particles as the electron (whose main property is charge) depend on this coefficient.

Mass turns into energy when speed changes, and all this takes place without any comprehensible cause-effect connections. In microparticles with a measured mass of immobility, the mass has a charge, and the charge is invariably connected with the mass.

What is it that bonds the mass and the charge?

Mass has the property of being inertial; it hinders acceleration. The influence of the environment on speed and acceleration is easily detected experimentally. However, in the mentioned mass theory, the mass itself, without any influence of other bodies, has the same property. Accordingly this is the property of mass.

Most importantly, the mechanical interpretation has no room for electrodynamic interactions, nor for electromagnetic energy. Such interactions and energy are independent of everything; they are a stage on which mechanical interactions take place. That is, there are no cause-effect bonds between mechanical and electrodynamic interactions. It is this problem that Einstein considered most important, and it is to this problem that he devoted the last 30 years of his life.

From our point of view, the described accomplished picture of mechanical interpretation of physical interactions is actually a final accord in the stage of mechanical descriptions about physical interactions. The fact that this is only a stage, and not the final point in the development of physics, is clear from the history of physics.

The interpretation of the regularities observed in nature (cause-effect relations) undergoes a number of stages: religious, natural-philosophic

and natural-scientific. The transition from one stage to another occurs via evolution during hundreds of years. All three forms of cognition can exist, at times, simultaneously. Only the correlation of the number of supporters of each of the stages changes over time.

During all the stages, the true value of the explanation is defined by the number of initial essences on which the given explanation is based.

The natural philosophical stage of development also used to have many initial essences (such as water, fire and earth), which were later exchanged for the philosophical atom. Thus, in each stage, when explaining various phenomena, people strove to reduce the number of initial essences. The decrease of initial essences, which are actually axioms, is the very essence of words, explanation and comprehension. This reduction of essences is not based on adherence to some criterion or scientific game rules, but it is the essential of understanding, the stimulus of which is curiosity.

Now, let's return to the natural scientific stage.

We know that the explanation of the attraction between bodies and that of the inertial phenomena in mass interactions were introduced by Newton. Newton imagined gravitation as an attraction between masses, which explained the heavenly mechanics and the falling of bodies onto the earth. The main idea of this hypothesis was the supposition about the natural existence of an attraction force between bodies with visually perceivable volumes and masses.

Newton formulated the basics for the interpretation of the world's physical phenomena. The framework of his description was the realization of mass and its transition due to mechanical forces in absolute time and space. Mass was regarded as an initial essence. Other initial mass essences, like mass attraction and inertial mass properties, were considered.

Throughout the history of the development of science, the term *mass* had always been one of the most comprehensible concepts, and there was no need to raise any questions about its essence. *Mass* is what we constantly observe in our everyday life, which comprises the essence of matter itself and which is given to us through perception.

Thus, it is not surprising that Newton's introduction of *mass* as a proportional coefficient between the force and acceleration appeared to be one of the most obvious.

The description of the mechanical picture of the world was completed in the frameworks of the Theory of Relativity (where mass was transformed into energy due to internuclear reaction and increased

with an increase in speed) and Quantum Mechanics (where mass defined the wave length).

All the above-mentioned mass properties are actually initial, independent essences, introduced to coordinate theories with experiments. If we should briefly sum up all the properties attributed to mass, then the general picture would be as follows:

There is an essence, the physical nature of which is unknown. Its value is determined by the behavior of bodies made of charged particles, the interaction between which is by dozens of orders of magnitude greater than what is attributed to mass. The introduction of this essence occurred at that historic period in the development of the natural sciences when scientists were ignorant of the structure of matter, or had a distorted impression of its structure. They were equipped with false knowledge.

When mass was introduced as an essence, it was given two properties: attraction and inertia. Then, in the process of the development of the mechanical interpretations of physical phenomena, mass began to gain the property of changing into energy — both mechanical and electromagnetic — and it began to define the microparticles' wave lengths in *probability waves*.

According to experiments, immobile mass particles are all charged, and they have a mass; that is, mass is connected with charges to a greater extent than are all the other known forces, including the internuclear ones. The action of these forces becomes obvious only at distances commensurable with the minutest microparticles.

The contradiction of the mechanical description appears to be even greater if we examine the transition of mass into energy quantitatively. According to the Theory of Relativity, mass increases when its speed is increased with a consumption of mechanical energy. When the particles are destroyed, the mass turns into electromagnetic radiation energy; when forming a bond between nucleons, the mass changes into energy of unknown nature with powerful interactions. All this, together with the mass properties, is considered a complete description of the physical interpretation of the world.

We think that a simple enumeration of the properties contained in mass, the physical essence of which is becoming more and more incomprehensible in the process of the development of science, leads us to the following logical conclusion:

Mass was an intermediate essence introduced into science at a definite period of its development (at a stage of ignorance), just as were the *philosophical atom, philosopher's stone, etc.* Correspondingly,

it became necessary to explain some known physical and mechanical phenomena without the introduction of the notion of *mass*.

Besides the mechanical phenomena, there is a whole world of electromagnetic phenomena explicable in the framework of electrodynamics, where the initial essence happens to be the charge. According to experimental data, charge is always connected with mass via a force whose nature and value are unknown. The next fundamental task in the understanding of nature is to deepen the understanding of the main essences (answers to all the WHYs) and, first of all, the physical essences of *mass* and *charge*, the nature of the forces bonding them and all the properties appropriated to *mass* and *charge* in the course of explaining the observed physical phenomena.

From our point of view, one of the most rational approaches to the solution of these problems is the description of mechanical phenomena, the explanation of observed regularities, in the framework of electrodynamics. That is, explanations of mechanical phenomena should be made on the basis of electrodynamic essences.

An analogy to such an approach is seen in the explanation of the Periodic Law, which was originally formulated by Mendeleyev as follows: *the properties of elements are in periodic dependence on their atomic weights (mass), and then on their nuclear charges*. A reconstruction of the explanatory system is a lengthy and complex process. The first approaches are qualitative and semi-quantitative explanations, which, most importantly, should not be qualitatively contradictory.

Switching to the electrodynamic description of the world, it is necessary, besides the phenomena explained on the basis of the *old essences* (mass, gravitation, inertia), to also re-explain those phenomena which were explained in the Theory of Relativity and Quantum Mechanics.

Now, let's discuss an explanation for a number of phenomena formerly explained using mass and other essences attributed to mass, in electrodynamics. The main difference between this new approach and the traditional one is as follows.

It was traditionally supposed that bodies, as a rule, are neutral and have a mass which, in turn, has gravitation, inertia, a charge, wave properties and is able to transit into energy.

Our approach supposes that all bodies and particles carry positive or negative charges and are not neutral. Therefore, the phenomena which used to be described with the introduction of mass and its essences are now described using charges and their essences.

2.8. THE ROLE OF CALCULATIONS, HYPOTHESES AND EXPERIMENTS IN THEORY

At present, the main method of scientific cognition offered in school textbooks is as follows. In the course of experimental and practical activity, we are confronted with questions concerning the cause-effect relations between phenomena. A hypothesis is put forth which explains this phenomenon. On the basis of this hypothesis, a theoretical forecast of the results of a possible experiment is made.

The coincidence of the experimental results and the theoretical forecast is a confirmation of the correctness of the hypothesis, which is turned into a theory. We have shown that such a scheme for science is idealistic and its non-critical acceptance leads to an incorrect understanding of the role of the experiment and of the ideas and the theoretical calculations in scientific work.

In reality, a scientific work is a work directed at elucidating and explaining the phenomena observed in nature and in activities such as experimentation. Explanation includes interpretation on the basis of old essences. Deepening the explanation presupposes the reduction of the initial essences (the decrease of the basis and/or the increase of the number of phenomena to be explained).

This is actually the work of those who have proper scientific capabilities and are classified by ranks. Those in the highest of the ranks are capable of approaching the problem in a new way; they are capable of finding connections between independent phenomena and can see the main points in the question under study. Those in the lowest ranks are capable of offering ideas independent of their quality.

Experiments and abstract, theoretical reasoning are the main points of such work, and their relation to each other cannot be evaluated or, at least, should not generally be evaluated. Evaluation is possible only as a result of a scientist's work in deepening the understanding of natural phenomena, and not as a result of his method (abstract logic and/or experimental work).

The role of the experiment has changed over the course of the development of science. For example, in the stage of structuring phenomenological theories, science is a set of rules, which are the product of theoretical works, the results of the work of scientists searching for general regularities and rules on the basis of existing experimental material.

In the phenomenological stage of the development of chemistry, the existence of chemical bonding and transformation, the Periodic Law, the Lewis Rules and VSEPR were discovered. The next stage for deepening the understanding was a decrease in the scientific basis for explaining chemical phenomena and chemical regulations based on physical essences. In this stage, the role of the experiment was changed.

Thus, when elucidating the physical essence of chemical bonding on a hydrogen molecule where no additional suppositions were made and which had an analytical solution, the coincidence of the calculation and the experimental results are proof of the correctness of the understanding of molecule structure and the essence of chemical bonding.

The bonding energy in molecules composed of atoms with more than one electron cannot be calculated without additional suppositions; it can be evaluated only qualitatively. In this case, experiment is the only way to get quantitative information.

SOURCES

1. Feynman R., Leighton R. & Sands M. (2004), *The Feynman Lectures on Physics*, 9 vols, Editorial URSS, Moscow.
2. Gankin V. Yu. & Gankin Yu. V. (2007), *How chemical bonds form and chemical reaction proceed*, Granitsa, Moscow.
3. Gankin V. Yu. & Gankin Yu. V. (2011), *General Chemistry. Twenty-first Century*, Khimia, St. Petersburg.
4. Rosenberger F. (1934), *History of physics*, Pt. 1, ONTI, Moscow.
5. Feynman R. P. (1972), 'The Development of Space-time View of Quantum Electrodynamics', Nobel Lecture, 11 Dec. 1965, In *Nobel Lectures*, *Physics 1963–1970*, 155, Elsevier Publishing Company, Amsterdam.
6. Azimov I. (1965), *Greeks: A Great Adventure*, Houghton Mifflin (Juv).
7. Misjuchenko I., *The Last Mystery of God*, URL: http://electricaleather.com/d/358095/d/poslednyaya-tayna-boga.pdf
8. Trofimova T. I. (2004), *Course in Physics*, 9th edition, Academia, Moscow.
9. Demin V. G. (1969), *Solar System Destiny*: Popular essays about celestial mechanics, Nauka, Moscow.
10. Korneva M. V. & Kuligin V. A., *A Mathematical error which distorts physics*, URL: http://n-t.ru/tp/ns/mo.htm
11. Misner C. W., Thorne K. S. & Wheeler J. A. (1973), *Gravitation*, Freeman, San Francisco.
12. Cornell University Library, URL: http://arXiv.org
13. Dark energy, In *Wikipedia*, URL: http://en.wikipedia.org/wiki/Dark_energy
14. Okun L. (1989), 'The Concept of Mass (of Mass, Energy, Relativity)', *Uspekhi Fizicheskikh Nauk*, 158 (3), 511–530.
15. Internet encyclopedia Krugosvet, URL: http://www.krugosvet.ru/
16. Nikolaev V. I. (2000), 'The Forces of Inertia in the General Physics Course,' *Physical Education*, 6 (2), 5–17.
17. Wikipedia, URL: http://wikipedia.org