FUNDAMENTAL PROBLEMS

in

ELECTRODYNAMICS

and

GRAVIDYNAMICS

by

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J.G. KLYUSHIN
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A MESSAGE FROM THE RUSSIAN EDITION

This book was conceived as a challenge to the crestfallen conformism in science. And any such challenge is addressed first of all to the youth cognizant of the laws of nature for the first time, and therefore potentially more inclined to perceive non-standard ideas.

My words are to you, student and postgraduate. Your life will not be devoted to specification of the hundredth digit of a well-known constant. The very foundation of modern physics has collapsed, and its edifice is tumbling down. You will have space to develop, and subject to think over. To realize and formulate ideas...What can be more worthy? And what can give greater joy of life? I have lived my life, and I can say: neither money, nor power, nor even love (I do not even speak about wine and drugs) can give you the wonderful, keen feeling that embrace a person when the heap of discrepant and seemingly unrelated facts suddenly find just proportion, simplicity, and you begin feeling harmony of the universe. I believe that something like this is felt by a woman who keeps healthy and crying baby against her breast after a long and difficult pregnancy and childbirth. Creative work is the only way for a person to experience this feeling.

But my words are also for venerable scientists of my own generation. You are knowledge curators. It is impossible without you to create hierarchy, canon so important for the science of the coming millennium, so necessary to construct “Beads game” on the place where today we observe a mixture of strange fantasies called physical concepts. So let us not become like politicians who put their personal ambitions higher than the interests of our common pursuit. In the great evolution movement the Lord prescribed to us the role of the humanity brain. So let us be worthy of our destination.

I take this opportunity to express my gratitude to everybody who directly or indirectly helped in my difficult journey to modern physics. And first of my thanks are addressed to I.V. Prohorzev. This book could not have appeared at all without his attention and support. I am very grateful to all my colleagues in the St. Petersburg Physical Society seminar, and first of all to the seminar curator A.P. Smirnov, and to the ‘first between equals’, V.A. Fogel, who attracted my attention to electrodynamics and persistently revived that interest, sometimes even despite my resistance.

As always professional was Svetlana Begacheva who typeset the earlier Russian edition of this book. As always forbearing and benevolent was my wife, Alena, about my love to whom I would like to speak here because I seldom pronounce this in everyday life. My thanks to my teachers – professors of

Leningrad State University who has given the habit for quantitative investigations and perhaps naive believe in the final victory of truth to me, also to all my friends, and first of all to A.N. Proszenko who always found strength to support me in my foolhardy initiatives. Also many thanks to you, my reader, who have had enough endurance to come to these words.

J.G. Klyushin, 1999

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ABOUT THE AUTHOR

I was born in Leningrad in April of the year 1940. My father Gr. V. Klyushin worked as an engineer at tank plant. My mother, in her girlhood A.Y. Paletskaya, was a singer in the Leningrad Opera Theater at that time. Her father (my grandfather) was the grand grandson of a Polish insurgent exiled to Siberia for participation in the Kostzushko revolt against Russia. Her mother (my grandmother) was Georgian. I know nothing about her. My father's father (my grandfather) V.A. Klyushin worked as head of Kronstadt electric-power station during the year 1917 of the revolution. Kronstadt is a military sea base just near St. Petersburg (later Leningrad, and again St. Petersburg since 1991). He was said to be a man of soft benevolent character. He always tried to help everybody. Therefore his subordinates liked him.

My father inherited these features, and I did as well, it seems, though sometimes I feel the rebellious character of my other grandfather, and the emotions of my Georgian grandmother. My grandfather's mentality helped him twice or thrice in his life. Kronstadt seamen were shock troops of the Bolshevik revolution. During the insurrection in October 1917, all fleet higher officers were killed in Kronstadt. My grandfather preserved his life even though his duty corresponded to vice-admiral rank. The station workers defended him. This was repeated in March of 1920, when the Kronstadt seamen already rebelled against Bolsheviks. The insurrection was suppressed under Trotsky's command. Any denunciation of any person meant that the person was embarked into a ship hold, the ship went into the open sea, and kingstones were opened. Any chief has somebody who is dissatisfied with him. Therefore practically all chiefs of any rank were killed in Kronstadt that time. My grandfather again became an exception. There were no denunciations of him.

The station workers also helped my father when he tried to enter university. Only children of workers were permitted to join the university. The station workers wrote a special letter to the Bolshevik authorities to help my father.

My father's mother (my grandmother), in her girlhood A.G. Bosenko, was the daughter of a Ukranian peasant who grew rich and managed to organize the entry of his daughter into the Smolny Institute of Noble Girls, to which only daughters of noble men were usually permitted to enter. She studied very successfully, and graduated from Smolny Institute with the Big Golden Medal, a very rare award for excellent academic performance. In1930 her husband and my grandfather, V.A. Klyushin, died after an unsuccessful appendix operation. My grandmother didn't marry again, but had, using present-day language, a ‘boy-friend’, Latvian by nationality. I do not know his name, but in 1937 he was arrested for ‘nationalism’, and sentenced to “10 years imprisonment without right to write letters.” Nowadays we know this meant condemnation to death. Because my grandmother was not his official wife, she was not arrested, but just sent from Leningrad to the village Totszkoy in the Ural region, where she was allowed to live and work as a physician in accord with her previous specialty.

In May 1941 my father took me from Leningrad to her to have a rest in the village. «I shall take him in August», he said. But on 22 of June 1941 a war between Hitlerist Germany and Stalinist USSR began. My father, together with personnel of the tank plant where he worked, was evacuated to Chelyabinsk (Ural region). He could not take me because he worked 12 hours a day without days off and could be arrested for being 5 minutes late. My mother came to me, but soon went to Chelyabinsk to her husband. It was decided that starvation in the village was not so strong as in the cities, and I was left with my grandmother for my whole life. as it turned out.

In 1949 my father went to Taganrog (Asov sea) to work as a professor at the Radiotechnical Institute, which was organized there. We went to him, and just in time, because soon an experimental atomic bomb was exploded on the Totsky military site. I was told that after effects of this explosion are felt up till now.

By this time my father had already divorced from my mother. She lived in Leningrad, and I with my father and grandmother in Taganrog. In 1953 my father went to work in Melitopol Agricultural Institute (Ukraine). I stayed with grandmother in Taganrog up to 1957, when I joined the Institute of International Relations in Moscow, Oriental Faculty, Burmese Language Group. There I first witnessed levitation of my Burmese lanquage teacher, which greatly impressed me, and later attracted my attention to the problems of gravity.

I studied international relations until 1962, the year when the KGB arrested me for “creation of an anti-soviet organization”. The real cause was discussions that I organized among students and which were devoted to problems of democratization of the Soviet regime. The main point of my accusation was that I saw definite analogies between Hitler and Stalin. My KGB investigator told me “You are lucky to have found yourself here nowadays. Five years ago I would do a roast beef from you”.

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The time was really comparatively liberal; it was “Khruschev’s thaw”. In two weeks I was set free. But certainly any thought about a diplomatic career was useless. I was dismissed from the Institute, and went to Zaporoszje (Ukraine) where by this time my father was a professor in the Industrial Institute (the previous year he came from Menitopol).

Up to the summer of 1963, I lived with my father and worked as a milling machine operator at a car plant. In 1963 I entered Mathematico-Mechanical faculty in Leningrad State University, from which I graduated in 1968 and began working in the Game Theory laboratory of the Leningrad Department of Central Economico-Mathematical Institute USSR Academy of Sciences. The head of our laboratory was N.N. Varobjev, who can be called the father of Game Theory in the USSR. I deliver a Game Theory course up till now at the University of Civil Aviation in St. Petersburg (previously Leningrad).

The task of our laboratory was creation of mathematical apparatus for socio-economic simulation and construction of corresponding models. I remember that I paid attention to the fact that many socio-economic phenomena take place in different countries in different times but have just similar structure. For instance, the revolution in England (Cromwell), the French revolution (Jacobins), and the revolution in Russia (Bolshevics) all had similar oscillating peculiarities.

I believed that all these processes could be described mathematically by an equation which can be found with help of a variarional principle, just as we obtain a wave equation in physics. But my attempts to use Game Theory principles or Principle of Minimal Action were unsuccessful. Then I proposed a variational principle of my own with which I hoped to describe socio-economic development. I called it the ‘Logarithm Principle’, because a logarithmic function appears under integral sign in the functional. But some years of efforts did not bring a result that I would be satisfied with. At last I came to the conclusion that modern economy sociology and psychology which combination as I hoped could lead me to the desired result were not ready for accurate mathematical description.

Then I decided to understand what Logarithm Principle forecast in physics, the science that seemed to me a pattern of successful application of mathematical methods for practical aims. I used Logarithm Principle for description of Electricity, and obtained Maxwell equations. This encouraged me. Having produced the corresponding calculations for gravity, I got similar equations but with the second time derivative, and nothing like general Rela-

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tivity. I was greatly inspired, wrote an article, and went to gravity specialists. Some of them were my friends but all of them refused to discuss the problem.

Some digression from my narration is reasonable here. The Philosophically materialist Lenin condemned the "idealistic theories" by Mach, Poincar, *etc*. Therefore, before the war (1941) Soviet authorities did not approve of Einstein's Relativity Theory (RT). But to the best of my knowledge, nobody was arrested, and supporters and opponents of Relativity Theory lived together comparatively peacefully. The situation changed after the war, when the USSR began A-bomb production. Just RT supporters were attracted to the project. They persuaded Beriya, and Beriya persuaded Stalin, that the A-bomb cannot be done without RT. After that time, objection to RT became a synonym of anti-soviet-activity. The situation persisted up to the disintegration of the USSR. Expression of an alternative point of view in science became possible when democratization of society took place.

I say "became possible" meaning that RT opponents were not arrested. But the Academy of Sciences controlled science publications and financial flows, as previously. And it understood that proof of Relativity Theory invalidness meant invalidity of the main departments of the Academy of Sciences.

But under new circumstances, the Academy could not control all scientific publications, and therefore could not hush up corresponding criticism. It behaved in good Bolshevik style. Bolsheviks established the Extraordinary Commission (future KGB) and the Russian Academy of Sciences established a commission to struggle with dissident views. Fortunately, this commission has no authority like that of the KGB, and the useless work of many academic institutes became evident for Russian government, which finances the Academy. Therefore main question for the present-day Russian Academy of Sciences is the problem of survival, and it cannot essentially limit dissident activity.

In the mid 1990's, the International Scientists Club was established. It associates engineers and scientists mainly from the republics of the previous USSR, but also from Europe, USA, Japan, and China. I was elected ISC president. We strive to help all the scientists to express their ideas. Although some members of ISC are professors of physics of mathematics, the majority of our members are engineers who in their everyday practice encountered phenomena that contradict mainstream doctrine. Mainstream physics does not want to hear these persons. And often they are compelled to invent explanations which look naive and which sometimes allow the mainstream officials to scornfully pin point their mistakes.

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Therefore every even year ISC organizes international conferences: “Fundamental Problems of Natural Sciences and Engineering”. We welcome any reasonable idea at these conferences. Any participant can express his ideas in lectures and discuss them in the lobby. We try to coordinate our efforts with friendly organizations in other countries, and first of all with the Natural Philosophy Alliance in the USA, whose activity is a pattern for us.

Of course the truth is unique, and the set of dissident ideas is great. But if the time comes when we make a step to truth, we shall do it through multiplicity of opinions. The way is not easy, but I am sure that a fate similar to that of the USSR will overtake today’s official physics. Neither a tremendous army nor a multi-million person communist party could save that structure based on falsehood. Neither millions of dollars nor hundreds of journals that do not want to hear critics will save today’s official physics, because the foundation on which it is based is false. And I am sure I shall be alive on this day.

Today, my personal scientific interests are concentrated on the links between Electricity and Gravity. But I am more and more interested in problems of thermodynamics. Its presnt-day methods are completely unsatisfactory. I am sure that new methods similar to Electrodynamics and Gravidynamics can be developed for thermodynamics as well.

I feel sad now that many people important to me in this journey have passed away. Many were members of ISC and participants in the St. Petersburg Physical Society seminar, which had so greatly enlarged my personal abilities. By their criticism, and even non-reconciliation, they helped me to write the first edition of this book in 1999. Especially acute, I feel the absence of V.A. Fogel. Gone too is my University colleague Prof. Pavel F. Parshin, who introduced me to Galilean Electrodynamics, and through that to the Natural Philosophy Alliance, and to many scientists in the western world, all of which enlarged my life even more. On the 15th of September 2005, my wife Alena, who had been helping me to go through this life for forty years, also passed away. What can we do? Such is apparently the will of the Lord.

But I thank the Lord that these later years have brought me new friends throughout the whole world, and intersected my life path with those of brave and clever scientists: Professor Domina Eberle Spencer, and my English-language editor, Dr. Cynthia Kolb Whitney, and many, many others whose names are in my heart but cannot all be mentioned here because of their multiplicity. Their existence warms my life and gives it meaning.

J.G. Klyushin, 2008

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FORWARD TO THE ENGLISH EDITION

This book presents a new approach to Relativity Theory (RT) and Quantum Mechanics (QM). The main motivation for this work is that RT and QM appear to be incompatible with one another. In addition, a number of physically important cases and well-documented experiments cannot be explained within the framework of those two theories.

Starting in the 1990's, this new approach was presented at a number of conferences and symposia organized by the International Scientists Club (ISC) in Russia and the Natural Philosophy Alliance (NPA) in the USA. Several historical remarks about presenting such new ideas are relevant here. In the 1980's, B.G. Wallace analyzed the results on Venus location obtained by US spacecrafts. He came to the conclusion that the classical mechanics rule for simply summing the velocities describes the observed results much better than the relativistic one. His work was ostracized, and journals refused to publish it. At present, the same problem is encountered in connection with Global Positions Systems. In 2006, one of the participants of the NPA conference (held in Tulsa, OK) delivered a report on experimental data on summing the light velocity from Jupiter satellites and Earth' velocity. The result was $c \pm v$. He told me that he was not allowed to deliver this report anywhere else. I find it puzzling that mainstream journals are closed for alternative views. It is high time to discuss this problem openly.

As detailed in the present book, all of the known, properly verified, experimental data that can be explained within the framework of traditional Electrodynamics, RT and QM can be explained just as well within the framework of the proposed theory. But, in addition, many other data (obtained in the USA, Russia, and other countries) cannot be explained within the traditional framework, and find their explanation instead within the theory proposed here.

The book is a collection of this author's previous publications devoted to analyses of the connections between electricity and gravity. Paper [36] is the foundation of the whole work. It is essentially supplemented here. Some examples are investigated in greater detail. The role of ether, a medium filling all space and all material bodies, is formulated more accurately and understandably. In particular, an ether explanation for dielectric attraction into a capacitor is proposed.

The concepts of diamagnetism and paramagnetism are linked with ether compressibility in bodies. The example of a magnetic field from which paramagnetics are expelled and into which diamagnetics are attracted is considered. An example is considered where a curve does not envelope current, but nevertheless a magnetic field exists inside it. The cause of such an effect is that additional items that are absent from traditional considerations appear in the generalized electrodynamics proposed by the author. The problem of the validity of Newton's third law in generalized electrodynamics is considered in greater detail. As is well known, the traditional Lorentz force formula does not satisfy this demand.

Links with gravity are formulated in several Appendices. Each Appendix constitutes a logical step from generalized electrodynamics toward gravidynamics, which is described by Maxwell type equations in which the first time derivatives are exchanged for the second ones. Appendix 1 is devoted to the problem of dimensions of electrodynamic quantities, which are at last expressed in mechanical terms. One can immediately see that the electromagnetic field is a field of velocities and the gravidynamic field is a field of accelerations. There is no problem with the gravidynamic field; from the very beginning it was described in mechanical terms by Newton.

Appendix 2 is devoted mainly to the historical causes that determined General Relativity Theory as victor in its struggle with other theories. A description of the new approach linking electricity and gravity is also given.

The author's propositions for description of the gravidynamic field are given in Appendix 3. The corresponding equations and formula for force between two moving masses is found. In addition to the static gravity law, this formula includes a dynamic part somewhat in the same way that the Lorentz force formula does in electrodynamics. This dynamic force depends upon velocities, accelerations, and the third and fourth time derivatives of the radius vector. The appearance of the dynamic part of the formula is connected with existence of a gravimagnetic field.

Appendix 4 may be considered as a work done in anticipation. Accurate analogies of conservation laws in electrodynamics are valid for the gravidynamic field as well. Conservation laws in electrodynamics, just as in hydro- and thermodynamics, are mathematically formulated in continuity equation depending on velocity of a fluid flowing through a surface. But that formulation is not sufficient in processes with accelerated flow. But just such processes are observed in gravidynamics. Appendix 4 is called "The Second Continuity Equation". It enables us to describe accelerated processes.

FORWARD TO THIS EDITION

This author plans to go on with considerations of different applications, and first of all, cosmic manifestations of gravidynamics; in particular, the effect of 'dark mass' in galaxies.

I hope that this English edition of the book will stimulate more discussions, and I would be quite interested in hearing objections from its readers.

The help of my students (in particular, of Alexey Bogdanov) is gratefully acknowledged. Many thanks to my students Svetlana Myshenko and Olga Zshbanova, and to Svetlana Begacheva, who took on their shoulders the not-easy work of typesetting the Russian earlier editions of this book. Finally I thank my English-language editor, Dr. Cynthia Kolb Whitney.

Jaroslav G. Klyushin, April, 2008

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INTRODUCTION

All of the sciences can be divided into two classes: sciences ‘long’ and sciences ‘wide’. Mathematics is an example of a ‘long’ science: it constructs long chains from initial axioms-assumptions and to conclusions. Examples of ‘wide’ science are provided by History and Economics. In these sciences, there exist a lot of different and not clearly related facts, from which small ‘pig tails’ (conclusions) emerge.

In accord with widely spread opinion, Physics is a ‘long’ science: just see how many facts follow from it. But more attentive analysis shows that in this respect modern Physics is much closer to Economics than to Mathematics. Multiplicity and semantic confusion of what appear to be fundamental terms, use of mathematics, not to clear up, but rather to obscure, the essence of the problems, citation of authority as a proof - all these are birth-marks of wide sciences, and are also characteristics of Physics nowadays. The author is sure that modern Physics is in crisis – a crisis more profound even than a hundred years ago. One can call it the ‘lengthening’ crisis.

This situation in Physics means that it is useful to look at how other sciences, and especially the first-of-all pattern for other sciences, Mathematics, have passed through such times of crisis. One can say that the last crisis of mathematics began from realization of the problem of Euclid’s fifth postulate in the second half of the 19^{th} century, and ended in the beginning of 20^{th} century by formulation of the ‘axiomatic method’ in mathematics.

And what was realized in this Mathematics crisis process? First of all it was realized that it was impossible to define everything with the help of everything. Some notions should be given to the scientist’s intuition. For instance, the notion of ‘set’ is not defined in mathematics, but there exists a set theory. But there should not be too many such non-defined notions. Otherwise, different persons may have different understanding of the same assertion. Later on, construction of new theory must begin with formulation of axioms. These axioms are not compelled to be ‘self-evident truth’. The set of axioms certainly must satisfy some demands of non-contradiction and completeness, *etc*. But these assumptions can be absolutely free in other senses.

What can Physics of new millennium take from this mathematical tradition? I believe first of all that it is necessity to essentially decrease the number of non-defined notions. Nowadays there are tens, if not hundreds, of such notions in Physics. Conservation of energy is enunciated as a ‘principle’, but nobody knows what energy is. They write textbooks on field theory, but nobody knows the field's definition. They call 'equation' everything where an equality sign appears, although half of these 'equations' are really identities and definitions.

One example follows. Apparently the first one who spoke about this was Lagrange. Kirchhoff was the first one who put the question point-blank. The reasoning of A. Poincare in his "Lectures on Mechanics" [1] is reproduced below, in a slightly free manner perhaps. Poincare wrote approximately the following: In what case may the correlation $\mathbf{F} = m\mathbf{a}$ be called a law? Only if we have three independent definitions: force $\mathbf{F}$, mass m and acceleration $\mathbf{a}$. Only after this can a clever man after sitting under apple or plane tree come to us and say: "All of you old chaps thought that these things are not connected with each other and I tell you there is the equality here, let us come to experiments".

But the situation is actually quite different. In a pinch we can say that we understand what $\mathbf{a}$ is, if we understand what space and time are. Then Poincare shows that all mass definitions he knows are flawed in this or that aspect. And already completely, - Poincare goes on, - we do not understand what force is. The conclusion: the assertion we call the second law of Newton is definition at best: if mass velocity changes as a result of external causes and the mass is accelerated we assert that a force acts on the mass.

But let us turn further the pages of physical textbooks. We see the very mass in gravitational field with potential Φ. A new definition appears: force $\mathbf{F} = m \operatorname{grad} \Phi$. Technically, these definitions are completely different. Are the definitions equivalent, or do they differ in some aspects? We shall consider Lorentz and Weber forces in electrodynamics below. How are these concepts linked with the one mentioned above? I have not found an answer in the textbooks I know.

The following passages are typical in modern textbooks. A long discussion takes place concerning electromagnetic forces acting on an electron. Then they remember: ah but the force is the impulse time derivative, let us equalize these concepts. And why is the force not potential gradient? And who has given us right to equalize things of different origin? And who said to us that electrically charged body reaction to the force is the same as of electrically neutral? As a minimum, the validity such assertions must be grounded for a long time. But any consequence can follow from a false premise. Therefore, they sometimes come to valid conclusions.

INTRODUCTION

But let us return to the Physics crisis. What seems to be the first and most important step? It is to enumerate and minimize the number of non-defined notions. Perhaps we should limit ourselves to the intuitively clear concepts of space, time, mass…Perhaps 3 or 4 notions in addition are needed. I am afraid that many spades will be broken in this battle. Because one of the greatest losses Relativity Theory inflicted upon physics is the habit to behave in a familiar way with notions of space and time: to mix them up with corresponding concepts in mathematics. Metric, topology for a mathematician is just a convenient way for him to build his logical construction. He attaches no physical meaning to them. Although physical space and time in which we live may be supplied with some qualities of mathematical metric, actually it is linked with no logic definitions. This is something given us by the Lord who also supplied us with the capability to orientate ourselves. Meanwhile there are amateurs proposing to consider physical space as a general topological space, and even a fiber space.

Thus the first task is to select and reach common understanding of fundamental notions in physics. The second step would be formulation of main postulates. Certainly desires for mathematical axioms are not sufficient for physical postulates. We must demand that the corollaries of axioms be corroborated by experiments. The problem of what experiment is correct, and above all what its interpretation is, certainly will need long discussions.

Here we only note that capability for a theory to explain an experiment cannot yet be the ground to proclaim the theory correct. For almost two millennia, Ptolemy's astronomy and Aristotle's belief that movement with constant speed must be maintained by external force were confirmed by experiments. But nowadays we do not believe in that. For almost a century, some experiments were considered to be confirmation of Special Relativity theory. Nowadays they found explanation within the framework of other theories that explain dozens of other facts that cannot be explained in the framework of SRT, and up until recently were explained either *ad hoc* or were not explained at all.

It seems that the English root in modern physics proclaiming primacy of experiments prevails also in the current science, and suppresses the French root demanding transparent logic and elegant theory construction. The future for physics apparently lies in the prospect of somehow harmonizing these principles.

And what should the physical axioms look like? Apparently, the equations of fundamental fields must become such axioms. There has already being been such a tradition in physics. But today the theorems, *i.e*. the corollaries, the consequences from the equations are constructed completely unsatisfactorily using vague and previously non-defined notions. Therefore it seems that physics development during the near future years must look as follows. Fundamental filed equations are written, for instance equations of electrodynamic, gravidynamic, or thermodynamic fields. All the consequences from these equations are looked over. It is ascertained why some facts cannot be understood as consequences from the equations. After that, either initial equations are generalized or new postulates are introduced.

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1. HISTORICAL REVIEW OF ELECTRODYNAMIC THEORIES

Electrodynamics is considered to be truly a fine example for the other branches of physics, as far as its logical aspects, as well as its experimental proof are concerned. Houses are lit by the bulbs; electric power stations work; we communicate by means of INTERNET. What more can there be?

However, if we make a more detailed examination, we will find out that everything is all right only in some special cases, like parallel wires with electric current. And yet, the present explanation of induction raises a number of objections, which we shall only mention here. Doctorovich [2] documents the more detailed considerations.

A great many, or even all, problems in electrodynamics arise from the fact that in modern terms the theory was formulated as a result of sometimes very different approaches to the description of phenomena. Those approaches were consequently being matched to each other without a unifying train of a thought. The logical flaws were exacerbated by artificial, sometimes apparently non-symmetric, definitions.

Let us mention here the basic stages of formation of electrodynamics, which are usually rendered in present-day university courses. The attraction of electrified objects, experimentally known since the ancient times, was formulated in terms of rigid mathematical definition, known as Coulomb's law: the force of interaction of two electric charges q_1 and q_2

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21} \tag{1.1}$$

Let us investigate this formula. What does it say? First of all, the force $\mathbf{F}_{21}$ is a vector, and (1.1) points out the direction of this force: the force is radial and directed along the radius going from charge 2 to charge 1. Its proportionality to the radius vector $\mathbf{r}_{21}$, going from charge 2 to charge 1 accounts for the directionality. Value r, the modulus of radius vector $\mathbf{r}_{21}$, is in the denominator of the fraction.

We will further use the Descartes' three-dimensional rectangular system of coordinates, points of which will be denoted as $\mathbf{x} = (x_1, x_2, x_3)$, where x_i, $i = 1, 2, 3$ are projections of this point $\mathbf{x}$ to the coordinate axes. So, we have the following (in Cartesian rectangular three-dimensional coordinate system):

$$\mathbf{r}_{21} = \left[(x_1^1 - x_1^2), (x_2^1 - x_2^2), (x_3^1 - x_3^2) \right] \tag{1.2}$$

$$r = \sqrt{(x_1^1 - x_1^2)^2 + (x_2^1 - x_2^2)^2 + (x_3^1 - x_3^2)^2} \tag{1.3}$$

The upper indices denote numbers of the charges. So, for example, $(x_1^1 - x_1^2)$ means the distance between the charge 1 and charge 2 along the axis x_1. It is supposed here that the size of charges is negligible in comparison with r. If it is not mentioned to be untrue, we will suppose it to be true, below. The formula (1.1) contains a radius, as the vector, which stands in the numerator, and the third power of its scalar value, which stands in the denominator. This means that the value of a force decreases as the square of a distance.

Some more values, besides the distance, appear in (1.1). First of all, these are the charges q_1 and q_2. The modern manuals consider the conception of any electric charge as some primary essence. We will return in Appendix 1 to the question of the physical meaning of the charge. Here we will follow this traditional point of view, mentioning only the fact that in the SI-system, which we will apply, the unit of the charge is Coulomb. And, even now, we encounter some problem making a correct definition.

The next approach would be natural. Of course, we do not understand the exact meaning of the conception 'charge', but we are sure, that there are particles, carrying minimum quantity of this quality. So, one can assume the charge of electron, proton, or some quantity of these charges, to be equal to a unit charge, for example $6.25 \times 10^{18} e$, where e means a charge of electron. One usually proceeds this way. But at the same time, one does not determine the unit of a charge, which is equal to the previously written number of elementary charges, and called 'Coulomb' (in SI-system). Instead, at the beginning the speed of changing of the charge e 'coulomb per second' is defined. This value is called the 'Ampere', and it is defined as a force of constant current, if it goes through a pair of parallel straight conductors of infinite length and infinitesimally small cross-section, provided the distance between the conductors placed in vacuum equals 1m, so the current induces the force between these conductors, which is equal to 2×10^{-7} Newtons per meter.

What is interesting here for our discussion? One wants to determine the unit of a charge and the force of current in terms of force, but not *vice versa*: such-and-such force corresponds to such-and-such quantity of resting or moving charges. Such inconsistent determinations seem to be natural from the historical point of view.

As a matter of fact, even now, all the electrical devices that measure electrodynamic characteristics measure the force, or angular momentum of the force. We will mention, before coming to the discussion of the main stages of the development of electrodynamics, that there is one more value present in (1.1); namely, ε_0. This constant is usually called the 'electric constant' or 'permittivity' of free space. It characterizes interaction of charges in vacuum. It can be measured experimentally:

$$\varepsilon_0 = \frac{1}{4\pi \times 9 \times 10^9} \mathrm{C^2 N^{-1} m^{-2}} \tag{1.4}$$

This constant indicates that the force of interacting charges is not equal to, and only proportional to, the product of charges, as well as inversely proportional to the square of distance. This constant arises only in SI-system. If one changes the value and dimension of an electric charge, the constant can be equal to unity, which happens in CGSE-system. Although, it is convenient sometimes for calculation process, we will see that it obscures very much the physical meaning of electrodynamic expressions, whereas ε_0 has a fundamental mechanical meaning of free ether mass density (see Appendix 1).

So, in the middle of the 40th of the XIX century, physics knew two fundamental laws: the law of gravitation and the Coulomb's law. Both laws predicted the existence of radial force of interaction between two charges, the magnitude of which decreases as the square of distance.

In 1846, Wilhelm Weber offered the generalization of Coulomb's law for the case of moving charges, when the passive charge equals unity. Weber probably took the value of the passive charge equal to unity just as a matter of convenience. Nevertheless, as we will see later, this inconspicuous simplification stemmed up a certain ideology, which is natural for modern manuals on physics. As a matter of fact, it brought to simplistic understanding of the notion of 'electric field', as a force, which acts on the test charge. Let us start from the very beginning.

The Weber's formula for the case of two charges is [31]:

$$\mathbf{F}_{21} = \frac{q_1 q_2 \mathbf{r}_{21}}{4\pi\varepsilon_0 r^3} - \frac{q_1 q_2 \mathbf{r}_{21}}{8\pi\varepsilon_0 r^3 c^2}\left(\frac{dr}{dt}\right)^2 + \frac{q_1 q_2 \mathbf{r}_{21}}{4\pi\varepsilon_0 r^2 c^2}\left(\frac{d^2 r}{dt^2}\right) \tag{1.5}$$

where

$$r = \sqrt{(x_1^1 - x_1^2)^2 + (x_2^1 - x_2^2)^2 + (x_3^1 - x_3^2)^2} \tag{1.6}$$

Already in the second part of the 20th century a new force formula called 'New Gaussian' was proposed by Moon, Spencer, Mirchandaney, Shama and Mann [3]:

$$\mathbf{F}_G = \frac{q_1 q_2}{4\pi\varepsilon_0}\left\{\frac{1}{r_{\mathrm{III}}^3}\left[\mathbf{r}_{21} - \frac{[\mathbf{v}_2(\tau_{\mathrm{III}}) - \mathbf{v}_1]\times[(\mathbf{v}_2(\tau_{\mathrm{III}}) - \mathbf{v}_1]\times\mathbf{r}_{21}}{2c^2}\right] - \right.$$
$$\left. - \frac{1}{c^2 r_{\mathrm{III}}^2}\left[\frac{d\mathbf{v}_2(\tau_{\mathrm{III}})}{d\tau_{\mathrm{III}}} + \frac{\mathbf{v}_2(\tau_{\mathrm{III}}) - \mathbf{v}_1}{2c}\times\left(\frac{d\mathbf{v}_2(\tau_{\mathrm{III}})}{d\tau_{\mathrm{III}}\cdot r}\times\mathbf{r}_{21}\right)\right]\right\} \tag{1.7}$$

Here τ_{III} is the time defined by *universal time postulate* proposed by the authors.

Like (1.5), formula (1.7) depends on relative velocities of the charges but it is based on another postulate on light velocity.

Let us summarize what is said above:

1. The force (1.5) is radial. It is clear psychologically because all of the fundamental forces that were known at that time were radial.
2. The force, which was added to the Coulomb's force, depends on the relative velocities and accelerations of the charges; that is, formulae (1.5) and (1.7) both predict the presence of a force in addition to Coulomb's force, even if one of the charges (for example the 'test charge' 1) is at rest.
3. Formula (1.5) satisfies Newton's third law: the force with which charge 2 acts on the charge 1 is of magnitude equal to and direction opposite to the force with which the charge 1 acts on charge 2.
4. Formula (1.5) accounts for interaction of charges, saying nothing about the mechanism of propagation of such interaction in space.

The last statement made physicists at the middle of the 19th century feel rather ambivalent, because interaction had 'contact character' in mechanics – the queen of science in that day. This statement is a matter of discussion for scientists nowadays though.

In 1782, in order to overcome difficulties of long-range interaction, Laplace suggested replacing gravitation law with the differential equation for some parameter, named the "field". Under such an approach, one can consider that the differential equation describes the short distance interaction between the neighboring elements of the field.

The introduction of this field substitutes the problem of 'long-range interaction' between the real charges by the problem of 'short-range' interaction between the neighboring regions of space, which is filled in with some artificially invented field. We are obliged to Laplace for the idea of introducing the equations of the field - equations that act everywhere outside the points at which the charges are placed.

Maxwell suggested his famous system of equations for electromagnetic field, having used the idea of field for the problems of electrodynamics and generalizing the results of experiments, accomplished first of all by Faraday in terms of the field.

These equations are:

$$\mathrm{div}\mathbf{E} = \rho / \varepsilon \tag{1.8}$$

$$\mathrm{rot}\mathbf{E} = -\partial\mathbf{B} / \partial t \tag{1.9}$$

$$\mathrm{div}\mathbf{B} = 0 \tag{1.10}$$

$$c^2\mathrm{rot}\mathbf{B} = \mathbf{j} / \varepsilon_0 + \partial\mathbf{E} / \partial t \tag{1.11}$$

Here $\mathbf{E}$ and $\mathbf{B}$ are fields called electric and magnetic ones, ρ is electric charges' density, $\mathbf{j} = \rho\mathbf{v}$ is electric current density, *i.e*. the charges' density propagation with velocity $\mathbf{v}$, ε_0 is previously mentioned electric constant. It will be shown that ε_0 means free ether density. But what is the physical meaning of the $\mathbf{E}$ and $\mathbf{B}$ fields?

A partial answer is obtained when (1.8) is integrated under condition

$$\mathrm{rot}\mathbf{E} = 0 \tag{1.9a}$$

One obtains having integrated (1.8)

$$\mathbf{E} = \frac{q_2}{4\pi\varepsilon_0 r^3}\mathbf{r} \tag{1.12}$$

where q_2 is the charge quantity in the integration volume and $\mathbf{r}$ is radius-vector from charge 2 to the observation point.

This correlation is very similar to Coulomb's law (1.1). It is just supposed in Coulomb law that charge q_1 is situated in the observation point. We shall obtain force from (1.12) if multiply it by charge q_1, *i.e.* $\mathbf{E}\ q_1$ is the force with which static charge q_2 acts on static charge q_1.

But Eqs. (1.8)-(1.11) contain in addition the magnetic field $\mathbf{B}$ which must also somehow influence on the test charge q_1. Apparently, Heaviside was the first person to propose the formula later called Lorentz force. Here is the force:

$$\mathbf{F}_{21} = q_1\mathbf{E}_2 + q_1\mathbf{v}_1 \times \mathbf{B}_2 \tag{1.13}$$

with which moving charge q_2 is said to act on moving charge q_1. Here test charge q_1 appears explicitly. The charge q_2 action is concealed in the fields $\mathbf{E}_2$ and $\mathbf{B}_2$ that it creates.

What do these fields look like? In order to answer this question we must solve equations (1.8)-(1.11) for q_2 and substitute these solutions into (1.13). But we do not know Maxwell's system solution for separate charges. We can find them in some special partial cases. One of such cases is the case of long beam of moving electrons. In this case

$$\mathbf{B}_2 = \frac{\mathbf{I}_2 \times \mathbf{r}_{21}}{2\pi\varepsilon_0 c^2 r^2} \tag{1.14}$$

where $\mathbf{I}_2$ is current, *i.e.* the charge quantity intersecting the beam transverse section per second, c is light speed. Eq. (1.14) may be transformed if the charges' velocity in the beam $\mathbf{v}_2$ is written explicitly.

$$\mathbf{B}_2 = \frac{\lambda_2(\mathbf{v}_2 \times \mathbf{r}_{21})}{2\pi\varepsilon_0 c^2 r^2} \tag{1.15}$$

Here λ_2 is linear charge density in the beam. Eq. (1.13) for this case looks as follows:

$$\mathbf{F}_{21} = \frac{q_1\lambda_2}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} + \frac{q_1\lambda_2}{2\pi\varepsilon_0 r^2 c^2}\left[\mathbf{v}_1\times(\mathbf{v}_2\times\mathbf{r}_{21})\right]$$
$$= \frac{q_1\lambda_2}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} + \frac{q_1\lambda_2}{2\pi\varepsilon_0 c^2 r^2}\left[\mathbf{v}_2(\mathbf{r}_{21}\bullet\mathbf{v}_1) - \mathbf{r}_{21}(\mathbf{v}_1\bullet\mathbf{v}_2)\right] \quad (1.16)$$

Let us compare this formula with the Weber's (1.5).

1. Force (1.16) has not only force directed along the radius $\mathbf{r}_{21}$, but also force directed along the velocity $\mathbf{v}_2$.
2. The radial force additional to Coulomb's force depends on the velocity product $\mathbf{v}_1\bullet\mathbf{v}_2$. Therefore it is zero if at least one charge is at rest. This conclusion compels modern physics, which limits itself with this formula, and asserts that only Coulomb force acts between a moving charge and a charge at rest, even though simple experiments show the invalidity of such an assertion.
3. (1.16) does not satisfy Newton's third law. If for instance $\mathbf{r}_{21} \parallel \mathbf{v}_1, \mathbf{r}_{21} \perp \mathbf{v}_2, \mathbf{v}_1 \perp \mathbf{v}_2$, *i.e.* $\mathbf{v}_2(\mathbf{r}_{21}\bullet\mathbf{v}_1) \neq 0$, $\mathbf{r}_{21}(\mathbf{v}_1\bullet\mathbf{v}_2) = 0$, then changing indicies we obtain expression for the reaction force: $\mathbf{v}_1(\mathbf{r}_{12}\bullet\mathbf{v}_2) = 0$, $\mathbf{r}_{12}(\mathbf{v}_1\bullet\mathbf{v}_2) = 0$, *i.e.* in this case the action force is non-zero and the reaction force is zero.
4. The interaction between charges in (1.13) is explained in terms of the fields $\mathbf{E}_2$ and $\mathbf{B}_2$ that charge q_2 creates in the surrounding space. For all this $\mathbf{E}_2$ acts on the 'static part' of the test charge, and $\mathbf{B}_2$ acts on the component depending on the test charge velocity. Let us note that this means that the test charge is as if it does not have fields of its own. The external fields act directly on it. But this short-range action disappears in formula (1.16), which is equivalent to (1.13). In other words, a question appears: isn't it our wrong intuition that leads us to the problem of long- and short-range action?
5. Eq. (1.16) does not predict a force induced by the charge's acceleration, but the Eq. (1.5) force depends upon it.

Let us repeat once more that the very idea of formula (1.16) is to find interaction force knowing the fields created by charge q_2 and the characteristics of the charge q_1.

But the problems with finding solutions to the Maxwell to the system made it necessary to reverse the situation. There is a characteristic example in the textbook by Prof. E.M. Purcell ([4], p.182, Russian version). Having written our equation (1.13) he writes: "…we accept it (formula 1.13) as a definition of Electric and Magnetic field in this space point."

In other words, we are proposed, not interaction force to define with the help of the fields (the idea initially incorporated into the formula), but rather, having adopted the formula to be universal and exhaustive, to define fields with the help of measured force. But such an attempt meets many problems. Let us pin-point some of them.

Generally speaking, four unknown variables appear in formula (1.13):

1. The first two are the value and velocity of the test charge. Usually (but not always) the way out is found accepting that test charge is unit and the velocity is known.
2. The second two are fields $\mathbf{E}_2$ and $\mathbf{B}_2$ created by charge q_2.

Purcell writes further: "We have proved that the force acting on the test charge is completely independent with respect to its velocity if the other charges are at rest. This means that Eq. (1.13) is valid everywhere that $\mathbf{B}_2 = 0$".

But even if we accept the proof, which is very non-evident because it incorporates many unnatural assumptions, the problem is that Eq. (1.13) must be valid also in the case when $\mathbf{B}_2 \neq 0$, because $\mathbf{E}_2$ changes as well when $\mathbf{B}_2$ changes. But in accord with the idea of Purcell himself, immobility of the charge q_2, *i.e.* condition $\mathbf{B}_2 = 0$, is a necessary condition for the validity of the first item.

But perhaps the greatest problem is that formula (1.13) is not universal. Therefore we loose many very important partial cases incorporated into Maxwell equations if we define the field with the help of (1.13).

In practice, this means that $\mathbf{E}_2$ is understood as the charge q_2 static field (the dynamic part of $\mathbf{E}_2$ is lost); *i.e.*, the special case (1.9a), but not general case (1.9), is considered.

Thus the Lorentz force formula cannot replace Maxwell equations and asymmetic definitions proposed in text-books can not describe Electric and

Magnetic fields which we must obtain as solutions of the Maxwell system. Therefore they often strive to obtain force manipulating with (1.8)-(1.11) equations in particular integrating them over volumes or surfaces.

But let us try to understand the mathematical meaning of the system (1.8)-(1.11).

If these are the equations, then what do they determine? It is usually assumed that charge and current densities are known. The answer looks evident: this is equation system in which **E** and **B** are unknown. But in order to find two vector-functions we need two vector equations [(1.9) and (1.11)], not more, and not less. But system (1.8)-(1.11) incorporates two scalar equations in addition. Does this mean that the system (1.8)-(1.11) is over determined?

It is strange, but the only book in which I found a certain perplexity inspired by this fact is the magnificent monograph on continuous media mechanics by L.I. Sedov [5]. In all other books I read, including books written by mathematicians, such a strange fact astonishes nobody. Rushing a little bit forward, one can say that when system (1.8)-(1.11) is generalized it becomes clear that the equations, *i.e*. equalities valid only with some values of the unknown variables, are vector correlations (1.9) and (1.11). Equalities (1.8) and (1.10) define initial conditions, *i.e*. they are definitions or identities.

Let us note that accurate following of this understanding meets a certain problem: the right hand part of the divergent correlations must describe the process of ‘charge generation’ by ether particles. Mathematically, this means that angular velocity of the ether particles must appear there.

The author tried to construct such a theory in paper [20]. This led to a necessity to describe fields in terms of complex functions. The field energy turned out to be equally distributed between real and imaginary parts of the field. In particular, just because of this elementary particles energy is equal mc^2 and not $\frac{1}{2}mc^2$. Some other useful results were obtained, and I am sure others can be obtained in addition. But this needs quite a new theory.

Here we limit ourselves with only real functions. Therefore the following interpretation of (1.8)-(1.11) is possible here. In accordance with the well known theorem by Helmholtz, any field consists of a divergent part and a curl part. Thus scalar correlations (1.8), (1.10) define the divergent part, and (1.9), (1.11) define the curl part. But purely a mathematical problem appears here: how to find a vector function with the help of a scalar equation.

Actually we have got the vector function (1.12) from the scalar correlation (1.8) with the help of mathematical forgery. We cannot do this strictly logically. Physical textbooks obtain this result 'repeating some physical words'. We are not going to devote too much space to this problem here. But, dear reader, try to calculate the divergence of the vector function (1.12) in order to evaluate reliability of such 'physical words' in general. Have you got zero? But let us return to our narration.

Historically, many formulas for interaction force between charges were proposed as generalizations of some experimental facts, without any concept of field. One of them, the Weber one, was mentioned above. Weber's formula (1.5), just as the New Gaussian formula (1.7) proposed by Spencer and her colleagues, depends on relative velocities and accelerations of the charges. Formulas depending on the product of absolute velocities of the charges were also proposed. All of them were based on experiments with currents in neutral conductors and formulated in terms of current differentials. For reference, we reproduce them below in terms of separate charges and their velocities, which will be used in Section 2.

Neumann formula [10]:

$$\mathbf{F}_{21} = +\frac{q_1 q_2}{4\pi\varepsilon_0 c^2 r^3}\mathbf{r}_{21}(\mathbf{v}_1 \bullet \mathbf{v}_2) \tag{1.16a}$$

Grassman formula [11]:

$$\mathbf{F}_{21} = -\frac{q_1 q_2}{4\pi\varepsilon_0 c^2 r^3}\left[\mathbf{v}_2(\mathbf{r}_{21} \bullet \mathbf{v}_1) - \mathbf{r}_{21}(\mathbf{v}_1 \bullet \mathbf{v}_2)\right] \tag{1.16b}$$

Ampere formula [12]:

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 c^2 r^5}\left[3(\mathbf{r}_{21} \bullet \mathbf{v}_1)(\mathbf{r}_{21} \bullet \mathbf{v}_2) - 2(\mathbf{v}_1 \bullet \mathbf{v}_2) r^2\right]\mathbf{r}_{21} \tag{1.16c}$$

Whittaker formula [13]:

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 c^2 r^3}\left[\mathbf{v}_1(\mathbf{r}_{21} \bullet \mathbf{v}_2) + \mathbf{v}_2(\mathbf{r}_{21} \bullet \mathbf{v}_1) - \mathbf{r}_{21}(\mathbf{v}_1 \bullet \mathbf{v}_2)\right] \tag{1.16d}$$

1. HISTORICAL REVIEW

But let us return to the problem of how system (1.8)-(1.11) is used, and for explanation of what phenomena. Eq. (1.9) is usually used to explain induction. Its integral form is often used:

$$\int_L \mathbf{E}dl = -\frac{\partial}{\partial t}\iint_S \mathbf{B}ds \qquad (1.9b)$$

Here L is a certain closed contour, and S is an arbitrary surface bounded by L.

To my regret, we are compelled to concentrate on the mathematical side of integral transformations. In order not to burden our conversation with distracting details, we shall not consider formulas for spatial integrals; they can be found in any textbook on mathematical analyses and physics. But we must pay attention to some peculiarities of differential and integral transformation. We must remember that we have no right to differentiate or integrate equations under equivalent transformations. For instance equation $2x+1=0$ is the derivative of the equation $x^2+x+5=0$. But not many physicists would dare say that they are equivalent.

We have right to differentiate and integrate such equations only when we substituted solutions in them, *i.e.* converted them into identities. Therefore we do not need any additional suppositions in order to come from (1.8) to (1.12). But in order to come from (1.9) to (1.9b), we are compelled to suppose that already solutions of the system (1.8)-(1.11) figure in (1.9b). For better understanding, $\mathbf{E}$ and $\mathbf{B}$ in (1.9b) should be marked somehow to emphasize that they are already-known functions, in contrast to $\mathbf{E}$ and $\mathbf{B}$ in (1.9), which are unknown, and must be found.

This is said in order to stress that $\mathbf{E}$ and $\mathbf{B}$ in (1.9b) are certain functions determined by charge density ρ and current density $\mathbf{j}$. The problem of how other charges react on such fields must be solved by some additional axiom; for instance, the Lorentz force formula. We shall see that this formula is not universal enough, and it must be generalized, but in principle it plays role of such an axiom that defines the rule of interaction between the fields induced by two different charges. But the Lorentz force formula does not cover some important cases. Therefore the idea has appeared to describe interaction between two charges with the help of so called ‘flow rule’.

That very rule is described in every textbook. We shall not spare time for it. It appeared as an attempt to describe the case when a loop moves in constant magnetic field or is at rest in alternating one.

The left hand part of equality (1.9b) is believed to be determined by the charges in the loop, and the right hand part by the external charges, creating external magnetic field.

Let us repeat once more: *such a partition of the fields contradicts the essence of equality (1.9b), which actually just informs us about identity of the electric field circulation and time derivative of the magnetic field flow, created by the same charge distribution.*

The Lorentz force formula (1.13) works correctly when the current loop moves in constant magnetic field. But it fails to describe the effect observed when current loop is at rest in an alternative magnetic field. To explain just this case equality (1.9b) was used. It helped to obtain the necessary result, and logical jumps on this way were not noticed. But not by all; some felt certain discomfort here. Let us cite the corresponding discourse by R. Feynman [6, p.53]:

“The two possibilities – “circuit moves” or “field changes” are not distinguished in the statement of the rules. Yet in our explanation of the rule we have used two completely distinct laws for the two cases - $\mathbf{v}\times\mathbf{B}$ for “circuit moves” and $\mathrm{rot}\,\mathbf{E}=-\partial\mathbf{B}/\partial\mathbf{t}$ for “field changes”. “We know of no other place in physics where such a simple and accurate general principle requires for its real understanding an analysis in terms of two different phenomena. Usually such a beautiful generalization is found to stem from a single deep underlying principle. Nevertheless, in this case there does not appear to be any profound implication. We have to understand the rules as the combined effects of two quite separate phenomena.”

No, Mr. Feynman, we should not combine two separate phenomena; we had better use the generalized Lorentz force formula, which will appear in this book, Section 2, because the phenomena are really different.

But why does correlation (1.9b) in modern-day interpretation so luckily bridge the gaps in Lorentz force formula (1.13)? We shall see below that generalized Lorentz force formula in the case of changing fields comes to very similar correlation, but for two different charge distributions; *i.e.* $\mathbf{E}$ in the left hand part of (1.9b) is determined by one distribution and $\mathbf{B}$ in the right hand part by another one.

Not aiming to investigate the problem of the Poynting vector, let us mention it as an example of a symmetric logical mistake. The Lorentz force formula is used to deduce Poynting formula [- 6, p. 289]. We have already said that this formula describes interaction of the fields originated by two different charges distributions. But these fields are identified when the Poynting formula is obtained; therefore, using the Poynting vector sometimes leads us to very strange conclusions.

The Poynting vector was introduced to describe the flow of energy density in an electromagnetic wave. And there it works quite satisfactorily because it links electric and magnetic fields of photons. Certainly it is applicable to fields created by a separate charge or set of charges. But its application to the interaction of the fields created by different charges is wrong. Such interaction will be defined in Section 2, and we shall need special axioms for that.

Therefore, complaints that the Poynting vector does not describe, for instance, a static case seem strange. It would be surprising if the Poynting vector described a static case; the magnetic field of static charge is zero, and only a devoted relativist can create it by running around with tremendous speed!

Therefore Feynman is not right when he comes to conclusion [Chapt.6, p. 289] that the Poynting vector is directed from outside imto a conductor with current, and predicts energy influx into it through a lateral area. The mistake is that he calculates a Poynting vector by substituting into it the external electric field that is directed along the conductor and pushes electrons in it. The electrons' electric field should be substituted into corresponding product. This is the electrons' Coulomb force directed along the radius. And such a flow is directed along conductor, just as Feynman's intuition tells him.

One more strange conclusion is made when it is asserted that (1.9b) predicts "energy pumping in light wave from electric field to magnetic one and *vice versa*", and that this allegedly sustains the fields vectors' rotation in the light wave. We are compelled to declare that (1.9b) cannot predict such a pumping because this is an identity in any space-time point; *i.e.*, this description is just different names for the same physical reality. This assertion certainly does not mean that we object that energy is pumped from one field to another one in light wave. We just declare that it cannot be the consequence of the (1.9b) identity.

Another mathematical mistake became foundation for the theory of retarded potentials. Accurate analysis of the all problems would take too much time for our introductory part. Therefore we pinpoint the very mistake and leave the problem for specialists.

The theory of retarded potentials strives to take into account the very fact that light signal needs some time to pass from source to receiver. And sometimes it is really essential. But already at first glance it becomes clear that this is important only for some very rapidly changing processes, or for very distantly situated objects. But the theory declares result to be essential for all cases. Therefore the question appears: isn't there some mistake?

Such a mistake is really found. Let us demonstrate this citing an abstract from Feynman textbook [6, eq.21.20 and 21.22].

Feynman considers the velocity of dipole moment $\dot{\mathbf{p}}$ changing not in the current time t, but in the previous moment ($t-r/c$), where r is the distance from the source, $r=\sqrt{x^2+y^2+z^2}$, and c is light speed. He calculates derivative of $\dot{\mathbf{p}}(t-r/c)$ with respect to spatial coordinate y and does this in the following way:

$$\frac{\partial}{\partial y}\dot{\mathbf{p}}(t-r/c)=-\frac{y}{cr}\ddot{\mathbf{p}}(t-r/c) \tag{1.17}$$

where $\ddot{\mathbf{p}}$ is time derivative of $\dot{\mathbf{p}}$.

But this is wrong. And the mistake is seen immediately: the author calculates partial derivative with respect to spatial coordinate but obtains time derivative. This could be valid if time were a function of spatial coordinates and total derivative were calculated. The correct result is

$$\frac{\partial}{\partial y}\dot{\mathbf{p}}(t-r/c)=+\frac{y}{r}\frac{\partial}{\partial r}\dot{\mathbf{p}}(t-r/c) \tag{1.18}$$

See when partial derivative is calculated the other parameters should be fixed. This becomes especiall clear if initial definition is used: let us fix time t_0, spatial coordinates x_0 and z_0, then partial derivative of ρ with respect to y is the limit

$$\lim_{\Delta y\to 0}\frac{p(t_0-\sqrt{x_0^2+(y+\Delta y)^2+z_0^2}/c)-p(t_0-\sqrt{x_0^2+y^2+z_0^2}/c)}{\Delta y} \tag{1.19}$$

It is clear that time derivative here can appear from nowhere.

Nevertheless why does the retarded potentials theory work in many cases? We can answer: because (1.17) actually calculates a certain substitute for total time derivative, and such a derivative, as we shall see below, is essential for correct and universal description of electrodynamics.

1. HISTORICAL REVIEW

To the point: some words about the partial time derivative in (1.9b). It is written because today orthodox theory demands this. But when we are really drawing the conclusion we are compelled to write total time derivative. Wise Prof. Feynman finds a very good and simple way out: somewhere he writes total and somewhere partial time derivative, leaving the problem to the reader: either this is typesetter misprint or the author's mistake.

The authors of other textbooks are more straightforward. We cite Purcell's textbook here only because it is at hand. One can find similar assertions in many others. On page 233 in his textbook [4], Purcell comes to his formula 29, which coincides with (1.9b), but total time derivative. Then he writes word for word: "Because $\mathbf{B}$ may depend on position and time we write $\partial\mathbf{B}/\partial t$ instead of $d\mathbf{B}/dt$". And that's all, no explanation in addition. And this is for all that some lines earlier he writes down different combinations of partial derivatives with respect to spatial coordinates. And here he proposes to exclude these coordinates and limit with only time, which was not even mentioned explicitly before. It is typical: the necessity to get the desired answer compels one to constrain logic.

Coming to the end of this historical part, let us say some words about Relativity Theory, because it dominates today's physics and our results will be compared with its predictions. I shall not reproduce all indistinct and paradoxical considerations on which it is based, but only dare declare my deep belief that the "king is nude", and note that many serious scientists in the USA, Russia, and other countries, pinpoint multiple logical contradictions in it. Let us also note that direct experiments to verify the main its assumptions, time dilation and space contraction, showed negative results [7,8].

But certainly RT could not exist so long if it did not predict correct results at least in some cases. One could note here that Ptolemaic astronomy based on the idea of 7 crystal spheres had existed for almost two millennia, certainly because it correctly predicted many observable facts. Really, Copernicus and Galileo had already said their words, the three Kepler laws had already been well known, but the majority of astronomers were going on calculating in accord with Ptolemaic astronomy. And, by the way, they got better results. I believe no comments are needed here.

Let us finish this Section with some deductions:

1. Different, non-coincident formulas were proposed to describe electrodynamic forces, and all of them were based on the experiments. One can find the review of these formulae in Marinov paper

[10,p.186]. Does this not mean that a general formula incorporating all these force laws exists?

2. The force interpretation of the Maxwell system is invalid. Therefore, the field explanation of induction, “flow rule”, the very concept of field, turn out to be suspended. Apparently, fields must be understood just as Maxwell equations’ solutions. There should be proposed additional axiom (formula) that constructs interaction force from such solutions.
3. Theories of Poynting vector, retarded potentials, are based on logical mistakes, incorrect calculations, or, as in the case of Relativity Theory, on indistinct initial definitions of fundamental notions of space and time. But all of them successfully explain some experimental facts. Any theory claiming to substitute for them must explain all these experiments and propose explanation of many others that are today explained *ad hoc*, or are not explained at all.

J.G. KLYUSHIN
FUNDAMENTAL PROBLEMS IN
ELECTRODYNAMICS AND GRAVIDYNAMICS

2. WHAT CAN BE DONE?

An approach that the author believes could overcome the drawbacks of present-day electrodynamics that were mentioned in the previous Section is proposed in the present Section.

Let a rectangular right hand coordinate triple be defined in three-dimensional Euclidian space. Let $\mathbf{x}=(x_1,x_2,x_3)$ be a point in this space, t be time and $\mathbf{i},\mathbf{j},\mathbf{k}$ be unit vectors. Let q_1,q_2 be electric charges 1 and 2, $\mathbf{v}_1,\mathbf{v}_2$ and $\mathbf{a}_1,\mathbf{a}_2$ be their velocities and accelerations. For simplicity, assume the charges to be distributed evenly in a ball of radius r_0. Let $\mathbf{E}_1,\mathbf{E}_2,\mathbf{B}_1,\mathbf{B}_2$ be electric and magnetic field intensities generated by the charges in space (ether). In the development below, a double index means field intensity created by the charge whose index goes first evaluated at the point where the charge whose index goes second is situated. For instance, $\mathbf{E}_{21}$ means the electric field intensity created by the second charge at the point where the first charge is situated. Let $\mathbf{r}_{21}$ be the radius vector from charge 2 to charge 1, r be its modulus, with $r>>r_0$, and let ε_0 be the dielectric constant.

GENERALIZED FORMULA FOR LORENTZ FORCE

Charge 2 produces the following force on charge 1

$$\mathbf{F}_{21}=-\mathrm{grad}\left[4\pi\varepsilon_0 cr^3(\mathbf{B}_{12}\bullet\mathbf{E}_{21})\right]+\frac{d}{dt}\left[4\pi\varepsilon_0 cr^3(\mathbf{B}_{12}\times\mathbf{B}_{21})\right] \qquad (2.1)$$

Here and everywhere below $c=c_0(\mathbf{i}\times\mathbf{j})\bullet\mathbf{k}$, where c_0 is light speed. This quantity is called ‘pseudo-scalar light velocity’.

Two notions of force are used in modern physics: the idea inherited from Newton and Descartes as an impulse derivative with respect to time, and the idea inherited from Huygens and Leibnitz as energy gradient. It is believed that these definitions are equivalent. And this is really so if we mean a separate body of constant mass, as it was in the discussed above force definition in the second Newton law. We came to the conclusion there that it was not a law but force definition. We are compelled to assert now that such a definition is, for some reasons, not satisfactory. One of them is the following: the very notion of force means interaction between at least two objects. We cannot describe collision force between two cars while limiting ourselves with the characteristics of only one of them. Therefore, we must acknowledge force definition in the static law of gravity, where two masses participate, or of Coulomb law, where two charges are used, to be natural and understandable. For the same reason, the force definition with the help of Newton's second law must be admitted to be non-satisfactory. Apparently Newton himself felt this, and therefore supplemented it with the third law, which include the second object.

The meaning of formula (2.1) is the following: each of the charges moves, creating fields in the surrounding space (ether). Any of these fields depends on some charge's value, its velocity, and its radius vector. The fields may be found as solutions of some equations (for instance Maxwell's system). We construct interaction energy and interaction impulse as a certain combination of these fields. Such combination depends already on two charges' values, their velocities, and the distance between them. The gradient of the interaction energy supplies us with Huygens interaction force, and the total time derivative of the interaction impulse supplies us with the Newton dynamic force, already including Newton's third law in explicit form: the force with which the charge 1 acts on the charge 2 is equal in magnitude and opposite in direction to the force with which the charge 2 acts on the charge 1.

Perhaps it is useful to note that those forces are directed not only along radius-vector but along charges' velocities as well. So constructed forces are not equivalent, but are two items in a generalized understanding of force. Formula (2.1) unites these two concepts. The scalar product of the passive charge 1 magnetic field and the active charge 2 electric field describes their interaction energy density, which is written under the gradient symbol. The vector product of the passive charge 1 magnetic field and the active charge 2 magnetic field describes their interaction impulse, which is written under the total time derivative symbol.

To realize this approach, we need certain system of equations. The Maxwell system is used to describe fields in traditional theory. Here, we are compelled to modify Maxwell system in order to coordinate it to formula (2.1).

GENERALIZED MAXWELL EQUATIONS

Electric charge q, distributed in the space with density ρ, originates electric and magnetic fields that are solutions of following system:

$$\mathrm{div}\mathbf{E} = \rho / \varepsilon_0 \tag{2.2}$$

2. WHAT CAN BE DONE?

$$\mathrm{rot}\mathbf{E} = -d\mathbf{B} / dt \qquad (2.3)$$

$$\mathrm{div}\mathbf{B} = -\rho / c\varepsilon_0 \qquad (2.4)$$

$$c^2\mathrm{rot}\mathbf{B} = d\mathbf{E} / dt \qquad (2.5)$$

Let us begin our explanations with the equation (2.5)

$$d\mathbf{E} / dt = (\mathbf{v}\bullet\mathrm{grad})\mathbf{E} + \partial\mathbf{E} / \partial t \qquad (2.6)$$

where $\mathbf{v}$ is the charge velocity and d / dt is total time derivative. We assume that velocity depends only on time, and does not depend on spatial coordinates. The first item in the right hand part of (2.6) generalizes the idea of a current in classical theory and comes to it if $\mathbf{E}$ satisfies some additional conditions

$$(\mathbf{v}\bullet\mathrm{grad})\mathbf{E} = \mathbf{v}\mathrm{div}\mathbf{E} + \mathrm{rot}(\mathbf{E}\times\mathbf{v}) = \mathbf{j} / \varepsilon_0 + \mathrm{rot}(\mathbf{E}\times\mathbf{v}) \qquad (2.6\ a)$$

where $\mathbf{j}$ is current density, $\mathbf{j} = \rho\mathbf{v}$. So the right hand part of (2.5) contains a curl component in addition to the classical one. This item is manifested for instance in a light wave.

Equation (2.4) means that equations (2.3)-(2.5) generalize the idea of magnetic field. A magnetic field $\mathbf{B}$ that is the solution of (2.3)-(2.5) possesses not only a curl but also a divergence component as well. The divergence component of $\mathbf{B}$ is defined by pseudo-scalar electric charge (defined as usual electric charge divided by a mixed product of unit vectors and light velocity). The $\mathbf{B}$ appears to be a pseudo-vector, just as in classical theory.

The right hand part of (2.4) may be considered as another ‘incarnation’ for electric charge, because the existence of electric charge is both necessary and sufficient for its existence.

One may consider it as a ‘magnetic charge’ as well. But it is necessary to emphasize that such a ‘magnetic charge’ does not coincide with Dirac’s monopole. Let us pinpoint some of the differences.

1. Such a magnetic charge is a pseudo-scalar, *i.e*. its sign changes when a right-handed coordinate triple is changed for a left-handed one.
2. It is c times less than electric charge; correspondingly its dimension differs from the electric charge dimension.

3. And last but not least, (2.1) implies that two static ‘magnetic charges’ do not interact, because the second term in (2.1) responsible for magnetic interaction is zero in this case. I ask the reader to pay attention to this fact because ‘ordinary physical mentality’ usually identifies field and force, two charges and their inevitable static interaction. We shall see that Newtonian (second) part in (2.1) does not contain a static item.

Equality (2.2) coincides with the classical equation, but (2.3) expands as

$$d\mathbf{B}/dt = (\mathbf{v}\bullet \text{grad})\mathbf{B} + \partial \mathbf{B}/\partial t \tag{2.7}$$

So it includes a conventional derivative of $\mathbf{B}$ originated by electric charge (and correspondingly ‘magnetic charge’) movement with velocity $\mathbf{v}$. Classical theory associates the appearance of magnetic field just with the movement of electric charges, but does not include the originating movement into (2.3) equation.

The $\mathbf{E}$ and the $\mathbf{B}$ in (2.2)-(2.3) may be defined by means of potentials. Let $\mathbf{A}$ and ϕ be the vector and scalar potentials of the electric field, and let them satisfy the following equations

$$\text{divgrad}\mathbf{A} - \frac{1}{c^2}\frac{d^2\mathbf{A}}{dt^2} = 0 \tag{2.8}$$

$$\text{divgrad}\varphi = -\rho/\varepsilon_0 \tag{2.9}$$

Let us assume the following gauge conditions

$$\text{div}\mathbf{A} = -\frac{1}{c^2}\frac{d\varphi}{dt} = 0 \tag{2.10}$$

Equations (2.10) means that $\mathbf{A}$ is the curl of a certain vector function. If φ is imagined as a density of a certain ‘electric liquid’, and $\mathbf{A}$ determines the velocity of such a liquid, then the first part of (2.10) is revealed to be a continuity equation for φ and the second part of (2.10) becomes a condition of incompressibility for φ.

If we define

$$\mathbf{B} = +\mathrm{grad}\varphi / c + \mathrm{rot}\mathbf{A} \tag{2.11}$$

$$\mathbf{E} = -\mathrm{grad}\varphi - d\mathbf{A} / dt \tag{2.12}$$

then (2.8)-(2.10) comes to (2.3)-(2.5).

Now we are compelled to concentrate on the point to which modern physics prescribes great importance. This is Maxwell equations invariance with respect to Galilean and Lorentz transformation.

Equations (1.8)-(1.11) are non-invariant under the Galilean transformation. The letter asserts that

$$\mathbf{r}' = \mathbf{r} - \mathbf{u}t \ , \ t' = t \tag{2.13}$$

for inertial transformation between unprimed and primed system which moves with constant velocity $\mathbf{u}$ with respect to the unprimed one

What is the physical meaning of this velocity $\mathbf{u}$? The most typical case in hydrodynamics is media movement: previously we observed water particle in a lake (and partial time derivative was enough for us) and we now strive to obtain the same picture in a river where water moves with velocity $\mathbf{u}$. Certainly we can observe not only water movement but for instance sand particles which water carries. In the last case $\mathbf{u}$ will be sand particles velocity in the water with respect to the bank and not water velocity.

How does hydrodynamics take this problem into account? When the process is described in Euler coordinates (as it is in Electrodynamics) total time derivative (2.6) is calculated instead of the partial one. We interpreted $\mathbf{v}$ in (2.6) as charge velocity in stationary ether. And what to do if the ether moves as well ? Then we assume that the charge will move with velocity $\mathbf{v} + \mathbf{u}$.

About 10 years before Lorentz used his transformation in electrodynamics, Voigt [26] proposed the same transformation in hydrodynamics.

Let us return to water movement in a river. Voigt proposed not to calculate total time derivative, but to come to new reference frame linked not with the bank but rather with the water in the river. Really, if we produce our experiments on a raft moving with velocity of river water, we can limit ourselves with only partial derivatives. It is clear that everything said above is applicable to the movement of sand particles: their velocity in the lake is $\mathbf{v}$ with respect to as water as bank, and their velocity in the river is $\mathbf{v} + \mathbf{u}$ with respect to bank and $\mathbf{v}$ with respect to water.

But what will observer on the bank see? He will see the picture so scrupulously described in physical textbooks when Lorentz transformation is commented: he will see that bodies on the raft are contracted in the movement direction and time is dilated. Of course, no a sober hydrodynamist believes that persons on the raft have lost their flesh and their dying day has been put off. Any sane person understands that this is just a ‘mathematical mirage’. But for believers of relativity theory, such an idea not only does not seem insane, but they declare *in*sane everybody who does not agree with it. God save their mentality!

Therefore let us return to electrodynamics. System (1.8)-(1.11) is not invariant with respect to Galilean transformation (2.13). All the textbooks known to the author declare but do not explain this fact. Therefore, let us say some explanatory words. In the time of Maxwell, the magnetic field was believed to be connected only with the movement of electric charges. Maxwell introduced the partial time derivative of the electric field into the right-hand part of Eq. (1.11) apparently based only on mathematical reasoning. The charges movement was introduced ‘by hand’, based on experimental reasoning. The connection of the charges movement with convective part of the total time derivative was not understood. No kind of current was introduced into Eq. (1.9) because nothing that could be interpreted as magnetic charge was observed in experiments of that time. Therefore, the appearance of the magnetic field was linked with electric charges movement only. The existence of magnetic charges was negated. This negation was manifested in correlations (1.9) and (1.10). Dirac’s failure to introduce such charges finally burried the idea. Summing up, one can say that Maxwell formulated his equations for the case of stable ether, and electric current was introduced into it as an axiom based on experiment.

Therefore, when experiments that could be interpreted as ether movement were produced, a problem of generalizing the Maxwell system appeared. Hertz was apparently the first one who thought about it. He solved the problem by introducing the total time derivative into Maxwell’s system. Velocity $\mathbf{v}$ in its convective part was interpreted by him as velocity of ether movement. [24] Thus he had to assume some ether qualities in his model. In particular, he supposed that any ether movement must induce electric phenomena. The ether at that time was believed to be barely connected with electrodynamics, and was even called ‘light-carrying’: the media in which light propagates. Only today we begin understanding that ether determines gravi- and thermodynamic phenomena as well.

2. WHAT CAN BE DONE?

But this Hertz idea was not lucky. Soon after his early death, Eichenwald [27] produced an experiment with rotating capacitors that he interpreted as a proof of Lorentz theory of stable ether, and correspondingly refutation of Hertz concept of moving ether, and correspondingly the uselessness of total time derivatives in Maxwell system.

We shall return to Eichenwald's experiments and their interpretation in Section 8. Here we just repeat the assertion formulated above: total time derivatives are useful not only for description of moving ether, but also in the case of stable ether. With their help, we not only naturally introduce conductivity current, but also obtain curl current. We shall see that this current is very essential for explanation of many electrodynamic phenomena.

But this or that way, the fact is that concept of total time derivatives was buried, and the relativistic approach triumphed. Hydrodynamically, this meant that movement of a medium and of particles in this medium were taken into account not with the help of convective derivative but rather with the Voigt method: coming to a moving reference frame.

Everything said above helps us to go to the mathematical side of the problem. System (1.8)-(1.11) is not Galileo invariant because the partial time derivative in (2.13) does not conserve $\mathbf{r}$ and $\mathbf{r}'$, but conserves velocity $\mathbf{u}$. Therefore, it is impossible to obtain equality in (1.9) and (1.11) for moving media, and it is necessary to use the Voigt-Lorentz method, which gives us the desired result by 'scratching the left ear with the right hand'.

Let us show that system (2.2)-(2.5) is Galileo invariant (and certainly Lorentz non-invariant). Not to forget, let us mention that system (2.2)-(2.5) is non-linear, and generally speaking it does not satisfy superposition principle. But we shall not go too far with this question, and postpone it for a separate discussion. Let us come to mathematics. We shall do this following T. Phipps, Jr. [25]

The electric and magnetic fields are:

$$\mathbf{E} = \mathbf{E}(x_1, x_2, x_3, t) \tag{2.14}$$

$$\mathbf{B} = \mathbf{B}(x_1, x_2, x_3, t) \tag{2.15}$$

If (2.13) is valid, how are derivatives in primed and unprimed system connected? We are going to show that

$$\text{grad}' = \text{grad} \ , \ \partial / \partial t' = \partial / \partial t + (\mathbf{u} \bullet \text{grad}) \tag{2.16}$$

Really one obtains using the chain rule:

$$\frac{d}{dx_1} = \frac{dx_1'}{dx_1}\frac{d}{dx_1'} + \frac{dx_2'}{dx_1}\frac{d}{dx_2'} + \frac{dx_3'}{dx_1}\frac{d}{dx_3'} + \frac{dt'}{dx_1}\frac{d}{dt'} = \frac{d}{dx_1'} \qquad (2.16a)$$

After repeating the procedure for other coordinates, one obtains

$$\text{grad}' = \text{grad} \qquad (2.17)$$

if (2.13) is valid.

Simularly, since $x_1' = x_1 - u_{x_1}t$, $\partial x_1' / \partial t = -\mathbf{u}_{x_1}$, *etc*, we have

$$\partial / \partial t = \partial / \partial t' - (\mathbf{u} \cdot \text{grad}') = \partial / \partial t' - (\mathbf{u} \cdot \text{grad}) \qquad (2.18)$$

One can see that traditional Maxwell system (1.8)-(1.11) is not invariant under Galilean transformation. For instance, when we have come to anothet inertial system moving with constant velocity $\mathbf{u}$, the additional term $\mathbf{u}$•grad appears in the right hand part of (1.9), and this term is not compensated in the left hand part of (1.9). In today's physics, the problem was solved by usage of Lorentz transformation. Identity (2.6) shows that this problem also disappears if total time derivative is used: additional terms are annihilated.

Vector $\mathbf{v}$ in (2.6) is interpreted as charge velocity. It appears even in immovable media, *i.e*. in the fixed frame reference. And it remains invariant if we come to another inertial frame moving with constant velocity $\mathbf{u}$. In this case (2.6) will look as follows

$$d\mathbf{E} / dt = \left[(\mathbf{u} + \mathbf{v})\bullet\text{grad}\right]\mathbf{E} - (\mathbf{u}\bullet\text{grad})\mathbf{E} + \partial\mathbf{E} / \partial t = (\mathbf{v}\bullet\text{grad})\mathbf{E} + \partial\mathbf{E} / \partial t \qquad (2.19)$$

But we cannot agree with the Dr. Phipps' idea that field equations must include sink or detector velocity. Another charge plays role of sink, or detector. How this sinking and detection takes place must de defined by special additional postulate and can not be obtained from the equations describing fields originated by one charge. Therefore we can not obtain charges' interaction formulas (either Lorentz or any other) from Maxwell equations. Formula (2.1) is just such an axiom that describes the interaction between 'source' and 'sink'. The following Sections will be devoted to revealing it.

2. WHAT CAN BE DONE?

Based on purely mathematical reasoning, the right hand part of (2.4) must be a pseudoscalar. But what is physical essence of this demand?

It will be shown in Appendix 1 that the dielectric constant ε_0 means free ether mass density, and the magnetic constant μ_0 means free ether compressibility. Therefore, it is more natural to speak not only about light speed, but also about the whole coefficient $1/\varepsilon_0 c$; *i.e.*, about free ether impedance.

The equality $c^2 = 1/\varepsilon_0\mu_0$ means that we can write $\sqrt{\mu_0/\varepsilon_0}$ instead of $1/\varepsilon_0 c$. Thus the magnetic field divergence is proportional to free ether impedance, in contrast to electric field divergence, which is ε_0 inverse, and does not depend on μ_0. The pseudoscalar character of the $\sqrt{\mu_0/\varepsilon_0}$ coefficient means that if we use right hand coordinate triple, we must take the radical sign minus in the right hand part of (2.4), and in the opposite case, we must take plus. The only explanation of this fact that I can imagine is that ether polarization is manifested when a magnetic field extends. And this polarization makes left hand and right hand rotations non-equivalent. This non-equivalence does not influence electric field divergence. The situation is *vise versa* for rotational parts of the fields: ether polarization influences the electric field and does not influence magnetic field.

3. THE FIELD FORMULA

Equations (2.2)-(2.5) define in differential form the fields $\mathbf{E}$ and $\mathbf{B}$ originated by moving charges. They are just the fields one needs in order to use formula (2.1).

Mathematically, the system (2.2)-(2.5) dissociates into two groups. Equations (2.3) and (2.5) define the $\mathbf{E}$ and the $\mathbf{B}$ fields that are their solutions. And this is enough: in order to find two vector-functions $\mathbf{E}$ and $\mathbf{B}$ we need only two vector equations, not more, and not less. But system (2.2)-(2.5) contains two scalar (divergence) equations in addition. Does this mean that system (2.2)-(2.5) is over-determined? Accurate analysis shows that correlations (2.2) and (2.4) are actually initial conditions for $\mathbf{E}$ and $\mathbf{B}$; *i.e.*, (2.2) and (2.4) may by written:

$$\mathbf{E}(0,\mathbf{r}) = (\rho/3\varepsilon_0)\mathbf{r} \tag{3.1}$$

$$\mathbf{B}(0,\mathbf{r}) = -(\rho/3\varepsilon_0 c)\mathbf{r} \tag{3.2}$$

$$\mathrm{div}\mathbf{E}(0,\mathbf{r}) = (\rho/\varepsilon_0) + (1/3\varepsilon_0)(\mathrm{grad}\rho)\bullet\mathbf{r} \tag{3.3}$$

$$\mathrm{div}\,\mathbf{B}(0,\mathbf{r}) = -(\rho/\varepsilon_0 c) - (1/3\varepsilon_0 c)(\mathrm{grad}\,\rho)\bullet\mathbf{r} \tag{3.4}$$

We assumed above that charge q was evenly distributed in a ball of radius r_0; *i.e.*,

$$\mathrm{grad}\,\rho = 0 \tag{3.4a}$$

We have thus come to (2.2) and (2.4). One can verify that (2.2) and (2.5) imply that

$$d\rho/dt = \partial\rho/\partial t + \mathbf{v}\bullet(\mathrm{grad}\,\rho) = 0 \tag{3.5}$$

In other words, our assumption concerning ρ yields in addition that the partial time derivative

$$\partial\rho/\partial t = 0 \tag{3.6}$$

We also assume that $\mathbf{v}$ is independent of spatial coordinates; *i.e.*,

$$\mathbf{v} = \mathbf{v}(t) \tag{3.7}$$

Under conditions (3.4a)-(3.7) one can find a partial solution of (2.2)-(2.5). This is

$$\mathbf{E} = (\rho / 3\varepsilon_0)\left[-(\mathbf{r}\times\mathbf{v}) / c + \mathbf{r}\right] \tag{3.8}$$

$$\mathbf{B} = -(\rho / 3\varepsilon_0)\left[(\mathbf{r}\times\mathbf{v}) / c + \mathbf{r}\right] \tag{3.9}$$

where $\mathbf{r}$ is the radius-vector from the charge to the observation point. Let us verify (3.8) and (3.9) by direct substitution, and show that they are really solutions of the modified Maxwell's equations (2.2)-(2.5)

$$\mathrm{div}\,\mathbf{E} = \frac{\mathrm{grad}\rho}{3\varepsilon_0}\left[-(\mathbf{r}\times\mathbf{v}) / c + \mathbf{r}\right] + \frac{\rho}{3\varepsilon_0}\mathrm{div}\left[-(\mathbf{r}\times\mathbf{v}) / c + \mathbf{r}\right] = \frac{\rho}{\varepsilon_0} \tag{3.10}$$

In just the same way

$$\mathrm{div}\,\mathbf{B} = -\rho / \varepsilon_0 c \tag{3.11}$$

Let us calculate left and right hand parts of (2.3)

$$\varepsilon_0 \frac{d}{dt}\mathbf{B} = -\frac{1}{3}\frac{d\rho}{dt}\left[\frac{\mathbf{r}\times\mathbf{v}}{c^2} + \frac{\mathbf{r}}{c}\right] - \frac{\rho}{3c}\left[\frac{\mathbf{v}\times\mathbf{v}}{c} + \frac{\mathbf{r}\times\mathbf{a}}{c} + \mathbf{v}\right] = -\frac{\rho}{3c}\left[\frac{\mathbf{r}\times\mathbf{a}}{c} + \mathbf{v}\right] \tag{3.12}$$

In the text below we assume that the first item in the last expression here is zero; *i.e.*, we assume that either the radius vector is perpendicular to the acceleration $\mathbf{a}$, or else $\mathbf{a}$ is zero; *i.e.*, the velocity is constant. One obtains finally

$$d\mathbf{B} / dt = -\rho\mathbf{v} / 3c\varepsilon_0 \tag{3.13}$$

On the other hand

$$\varepsilon_0 \mathrm{rot}\mathbf{E} = \frac{1}{2}\left\{\mathrm{grad}\frac{\rho}{3}\times\left[-\mathbf{r}\times\mathbf{v} / c + \mathbf{r}\right] + \right.$$
$$\left. + \frac{\rho}{3c}\left[-(\mathbf{v}\bullet\mathrm{grad})\mathbf{r} + (\mathbf{r}\bullet\mathrm{grad})\mathbf{v} - (\mathrm{div}\mathbf{v})\mathbf{r} + (\mathrm{div}\mathbf{r})\mathbf{v}\right]\right\} = +\frac{\rho\mathbf{v}}{3c} \tag{3.14}$$

Here we have assumed the definition of 'rot' as one half of the corresponding combination of partial derivatives because such definition is adopted in the Russian Mathematical Encyclopedia. [34] Equation (2.5) is verified in the same way. If ‘rot’ is defined without this factor of one half, a 2 appears in vector product items in (3.8) and (3.9). Equations (2.5) is verified in the same way.

4. THE FINAL CORRELATION

Let us write down in explicit form the items appearing in the formula (2.1):

1. $\mathbf{B}_{12} = -\dfrac{q_1}{4\pi\varepsilon_0 r^3 c}\left[(\mathbf{r}_{12}\times\mathbf{v}_1)/c+\mathbf{r}_{12}\right] = \dfrac{q_1}{4\pi\varepsilon_0 r^3}\left[(\mathbf{r}_{21}\times\mathbf{v}_1)/c+\mathbf{r}_{21}\right]$

2. $\mathbf{E}_{21} = \dfrac{q_2}{4\pi\varepsilon_0 r^3 c}\left[-(\mathbf{r}_{21}\times\mathbf{v}_2)/c+\mathbf{r}_{21}\right]$

Let us find the gradient of the scalar product of these fields:

3. $-\mathbf{B}_{12}\bullet\mathbf{E}_{21} = \dfrac{q_1 q_2}{16\pi^2\varepsilon_0^2 r^6 c}\left[(\mathbf{r}_{21}\times\mathbf{v}_1)\bullet(\mathbf{r}_{21}\times\mathbf{v}_2)/c^2 - r^2\right]$

4. $-\text{grad}[4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\bullet\mathbf{E}_{21})] = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r^3}\times$

$$\times\left[\mathbf{r}_{21} - \frac{3\mathbf{r}_{21}(\mathbf{r}_{21}\times\mathbf{v}_1)\bullet(\mathbf{r}_{21}\times\mathbf{v}_2)}{r^2c^2} - \frac{(\mathbf{r}_{21}\bullet\mathbf{v}_1)\mathbf{v}_2 + (\mathbf{r}_{21}\bullet\mathbf{v}_2)\mathbf{v}_1}{c^2} + \frac{2\mathbf{r}_{21}(\mathbf{v}_1\bullet\mathbf{v}_2)}{c^2}\right]$$

Now the second item in (1.1) is found

5. $\mathbf{B}_{21} = -\dfrac{q_2}{4\pi\varepsilon_0 r^3 c}\left[(\mathbf{r}_{21}\times\mathbf{v}_2)/c+\mathbf{r}_{21}\right]$

6. $\mathbf{B}_{12} = \dfrac{q_1}{4\pi\varepsilon_0 r^3 c}\left[(\mathbf{r}_{21}\times\mathbf{v}_1)/c+\mathbf{r}_{21}\right]$

7. $4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\times\mathbf{B}_{21}) =$

$$= \frac{q_1 q_2}{4\pi\varepsilon_0 r^3 c}\left[\frac{1}{c^2}(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{v}_1) + \mathbf{r}_{21}\times\frac{1}{c}[\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2)]\right]$$

The first and second time derivatives of the radius vector are

$$d\mathbf{r}_{21}/dt = \mathbf{v}_1 - \mathbf{v}_2\ ,\ d^2\mathbf{r}_{21}/dt^2 = \mathbf{a}_1 - \mathbf{a}_2\,.$$

If the problem conditions are essentially independent of the signal retardation, the derivatives are calculated at the time t. If retardation is essential, the derivatives are calculated at the previous time $\tau = t - r/c_0$.

The second term in (1.1) appears as follows

$$\frac{d}{dt}\left[4\pi\varepsilon_0 r^3 c(\mathbf{B}_{12}\times\mathbf{B}_{21})\right]=\frac{q_1q_2}{4\pi\varepsilon_0 r^3c^2}\left\{-\left[(\mathbf{v}_1-\mathbf{v}_2)\times[\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2)]\right]-\right.$$
$$-\frac{3\mathbf{r}_{21}\bullet(\mathbf{v}_1-\mathbf{v}_2)}{r^2}\left[\mathbf{r}_{21}\times[\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2)]\right]+\mathbf{r}_{21}\times[\mathbf{r}_{21}\times(\mathbf{a}_1-\mathbf{a}_2)]+$$
$$+\frac{1}{c}(\mathbf{v}_1\times\mathbf{v}_2)\times\left[(\mathbf{r}_{21}\times\mathbf{v}_1)-(\mathbf{r}_{21}\times\mathbf{v}_2)\right]+$$
$$+\frac{1}{c}\left[(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{a}_1)-(\mathbf{r}_{21}\times\mathbf{v}_1)\times(\mathbf{r}_{21}\times\mathbf{a}_2)\right]-$$
$$\left.-\frac{1}{r^2c}3\mathbf{r}_{21}\bullet(\mathbf{v}_1-\mathbf{v}_2)\bullet\left[(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{v}_1)\right]\right\}$$

Finally one obtains the force the second charge exerts on the first one:

$$\mathbf{F}_{21}=\frac{q_1q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}+\frac{q_1q_2}{4\pi\varepsilon_0 r^3c^2}\left\{\left[\mathbf{v}_1\times(\mathbf{r}_{21}\times\mathbf{v}_2)+\mathbf{v}_2\times(\mathbf{r}_{21}\times\mathbf{v}_1)-\right.\right.$$
$$\left.-\frac{3}{r^2}\mathbf{r}_{21}(\mathbf{r}_{21}\times\mathbf{v}_1)\bullet(\mathbf{r}_{21}\times\mathbf{v}_2)\right]+\left[(\mathbf{v}_1-\mathbf{v}_2)\times[\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2)]-\right.$$
$$-\frac{3}{r^2}\mathbf{r}_{21}\bullet(\mathbf{v}_1-\mathbf{v}_2)\left[\mathbf{r}_{21}\times[\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2)]+\mathbf{r}_{21}\times[\mathbf{r}_{21}\times(\mathbf{a}_1-\mathbf{a}_2)]\right]+ \qquad (4.1)$$
$$+\frac{1}{c}(\mathbf{v}_1\times\mathbf{v}_2)\times[(\mathbf{r}_{21}\times\mathbf{v}_1)-(\mathbf{r}_{21}\times\mathbf{v}_2)]+\frac{1}{c}\left[(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{a}_1)-\right.$$
$$\left.\left.-(\mathbf{r}_{21}\times\mathbf{v}_1)\times(\mathbf{r}_{21}\times\mathbf{a}_2)\right]-\frac{1}{r^2c}3\mathbf{r}_{21}\bullet(\mathbf{v}_1-\mathbf{v}_2)\left[(\mathbf{r}_{21}\times\mathbf{v}_1)\times(\mathbf{r}_{21}\times\mathbf{v}_2)\right]\right\}$$

By revealing triple vector products one obtains another expression for the same force

4. THE FINAL CORRELATION

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21} + \frac{q_1 q_2}{4\pi\varepsilon_0 r^3 c^2}\cdot$$

$$\cdot\left\{\left[\mathbf{r}_{21}(\mathbf{v}_1 \bullet \mathbf{v}_2) - \mathbf{v}_1(\mathbf{r}_{21} \bullet \mathbf{v}_2) - \mathbf{v}_2(\mathbf{r}_{21} \bullet \mathbf{v}_1) + \frac{3}{r^2}\mathbf{r}_{21}[(\mathbf{r}_{21} \bullet \mathbf{v}_1)(\mathbf{r}_{21} \bullet \mathbf{v}_2)\right] + \right.$$

$$+\left[\mathbf{r}_{21}(\mathbf{v}_1 - \mathbf{v}_2)^2 - (\mathbf{v}_1 - \mathbf{v}_2)[\mathbf{r}_{21} \bullet (\mathbf{v}_1 - \mathbf{v}_2)]\right] -$$

$$-\frac{3\mathbf{r}_{21}(\mathbf{v}_1 - \mathbf{v}_2)}{r^{\mathbf{2}}}\left[\mathbf{r}_{21}[\mathbf{r}_{21} \bullet (\mathbf{v}_1 - \mathbf{v}_2)] - (\mathbf{v}_1 - \mathbf{v}_2) r^2\right] + \qquad (4.2)$$

$$+\left[\mathbf{r}_{21}[\mathbf{r}_{21} \bullet (\mathbf{a}_1 - \mathbf{a}_2)] - (\mathbf{a}_1 - \mathbf{a}_2) r^2\right] +$$

$$+\frac{1}{c}(\mathbf{v}_2 - \mathbf{v}_1)[\mathbf{r}_{21} \bullet (\mathbf{v}_1 \times \mathbf{v}_2)] + \frac{1}{c}\mathbf{r}_{21}[(\mathbf{r}_{21} \times \mathbf{v}_2) \bullet \mathbf{a}_1 - (\mathbf{r}_{21} \times \mathbf{v}_1) \bullet \mathbf{a}_2] +$$

$$\left. + \frac{3}{r^2 c}\mathbf{r}_{21}[\mathbf{r}_{21} \bullet (\mathbf{v}_1 - \mathbf{v}_2)] \bullet [\mathbf{r}_{21} \bullet (\mathbf{v}_1 \times \mathbf{v}_2)]\right\}$$

Let us find another form of the force (4.2) explicitely introducing the angles between the vectors.

Let:

Q_1 be the angle between $\mathbf{r}_{21}$ and $\mathbf{v}_1$
Q_2 be the angle between $\mathbf{r}_{21}$ and $\mathbf{v}_2$
Q_3 be the angle between $\mathbf{v}_1$ and $\mathbf{v}_2$
Q_4 be the angle between $\mathbf{r}_{21}$ and $(\mathbf{v}_1 - \mathbf{v}_2)$
Q_5 be the angle between $\mathbf{r}_{21}$ and $(\mathbf{a}_1 - \mathbf{a}_2)$
Q_6 be the angle between $\mathbf{r}_{21}$ and $(\mathbf{v}_1 \times \mathbf{v}_2)$
Q_7 be the angle between $(\mathbf{r}_{21} \times \mathbf{v}_2)$ and $\mathbf{a}_1$
Q_8 be the angle between $(\mathbf{r}_{21} \times \mathbf{v}_1)$ and $\mathbf{a}_2$

Then (4.2) appears as follows

$$\mathbf{F}_{21}=\frac{q_1q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21}+\frac{q_1q_2}{4\pi\varepsilon_0 r^3c^2}\cdot$$

$$\cdot\Big\{-[\mathbf{v}_2v_1r\cos\theta_1+\mathbf{v}_1v_2r\cos\theta_2+\mathbf{r}_{21}v_1v_2(\cos\theta_3+3\cos\theta_1\cos\theta_2)]+$$

$$+[\mathbf{r}_{21}(\mathbf{v}_1-\mathbf{v}_2)^2(1-3\cos^2\theta_4)+2(\mathbf{v}_1-\mathbf{v}_2)r\,|\,\mathbf{v}_1-\mathbf{v}_2\,|\cos\theta_4]+$$

$$+[\mathbf{r}_{21}r\,|\,\mathbf{a}_1-\mathbf{a}_2\,|\cos\theta_5-(\mathbf{a}_1-\mathbf{a}_2)r^2]+ \qquad (4.3)$$

$$+\frac{1}{c}(\mathbf{v}_1-\mathbf{v}_2)rv_1v_2\cos\theta_6\cos\theta_3+$$

$$+\frac{1}{c}\mathbf{r}_{21}[ra_1v_2\sin\theta_2\cos\theta_7-ra_2v_1\sin\theta_1\cos\theta_8]+$$

$$+\frac{3}{c}\mathbf{r}_{21}\cdot[(\mathbf{v}_1-\mathbf{v}_2)\bullet(\mathbf{v}_1\times\mathbf{v}_2)]\cos\theta_4\cos\theta_6\Big\}$$

One can see that Neumann, Grassman, Ampere and Whittaker formulas mentioned in paragraph 1 are special cases of the gradient part of formula (4.2). They are all terms in the first square brackets. Really (1.16a) is just the first item there, (1.16b) is the first and the third items, (1.16c) is the doubled first and the forth ones, (1.16d) is the first, the second and the third items. It is worthwhile to note that Grassman's formula (1.16b) accurately coincides with Lorentz's formula (1.16) when integrated over current contour. It is understandable that all the above mentioned authors proposed terms from the first square bracket in (4.2). They all experimented with current loops, *i.e.* with neutral currents, for which as we shall see the second, third and forth square brackets in (4.2) are zero.

But Weber [27] somehow managed to come to the items in the second, the third and the forth brackets in (4.2). Perhaps he experimented just with charged currents, but he came to the radial items in the brackets. The first square bracket coincides with New Gaussian formula (1.7) if time is calculated in accord with *universal time postulate*. In contrast to Weber's formula, it contains not only radial terms, but also terms directed along the velocity difference.

Let us try to clarify the physical essence of the formula obtained. All the derivatives here are calculated with respect to the laboratory frame of reference.

4. THE FINAL CORRELATION

Let us return to functions (3.8) and (3.9). The second terms in their right hand sides define static components that are manifested only for 'bare charges':

The first terms define dynamic components, and they are manifested not only for charged currents but for neutral ones as well. This quality is inherited when these components are multiplied and when derivatives are calculated in formula (2.1). For instance the first item in (4.1)-(4.3) in obtained as a gradient of the static components' product. Therefore it is valid only for 'bare charges' (Coulomb law). On the contrary, the first square bracket is a result of the product of dynamic components. So it is valid for neutral currents' as well. One can easily see that this square bracket is a symmetrization of the classical Lorentz force in a way such that it begins satisfying the third Newtonian law plus Ampere force.

The second square bracket in (4.1)-(4.3) is a product of dynamic and static components. So it is equal to zero between two neutral currents. It is valid if at least one of the currents is charged. This square bracket depends on the difference between charges velocities, and predicts all experimrntaly verified effects of Relativity Theory without 'time dilation' and 'space contraction'. It also predicts a force produced on a 'bare charge' at rest near a neutral current.

The third square bracket depends on the charges accelerations and describes field radiation. It is valid for all kinds of currents because the radiated field should be considered as a "nude" one. It often predicts the same result as classical theory, but Example 2 in Section 5 shows that it predicts no radiation for an electron rotating around positive charge.

The last three terms in braces are proportional to inverse c^3. They are apparently essential in electro-weak interactions.

5. EXAMPLE APPLICATIONS

EXAMPLE 1. COMPARISON WITH RELATIVITY THEORY

Let test charge q_1 be evenly distributed along the circumference of a circle of radius R_0 situated in the (x_1, x_2) plane at the center in the coordinate system origin. The charge q_2 is at rest in the center of the circle. The classical Lorentz formula and the formula (4.3) predict only a Coulomb force directed along the radius. Let q_2 move with constant velocity **v** along the x_1 axis. Today theory predicts that relativistic effects exist in this case. They are believed to change the Coulomb force magnitude but to preserve its radial character. This force is considered to be

$$F_{\mathbf{e}} = \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} \cdot \frac{(1-\beta^2)}{(1-\beta^2 \sin^2\theta)^{3/2}}\,, \tag{5.1}$$

where $\beta = v/c$, and θ is the angle between $\mathbf{v}$ the and radius-vector to q_1.

When β is small enough that it is possible to expand (5.1) in a series, one gets

$$F_{\mathbf{e}} = \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} + \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} \cdot \frac{\beta^2}{2}(1-3\cos^2\theta)\ . \tag{5.1a}$$

When $\theta = 0$, (5.1a) predicts Coulomb force multiplication by a factor of $(1-\beta^2)$; *i.e*., force decrease. When $(1-\cos^2\theta) = 0$ (at about 55^0 and 125^0), the second term in (5.1a) is zero. The Coulomb force acts on the points where the additional force changes its sign. When $\theta = 90^0$ (5.1a) predicts force factor $(1+\beta^2/2)$; *i.e*., overall force increase. When β increases, other terms in the series expansion become essential, so (5.1a) becomes incorrect and we must use (5.1).

Let us see predictions of the (4.3) formula. Only the second square bracket in (4.3) is nonzero for the small β case. The bracket predicts two forces: a force $\mathbf{F}_r$ that is radial, and a force $\mathbf{F}_v$ that is directed along the velocity.

One obtains for the radial force magnitude:

$$F_r = \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} + \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} \cdot \beta^2 (1 - 3\cos^2\theta) \qquad (5.2)$$

One can see that, in comparison with (5.1a), (5.2) predicts for small β a result that is qualitatively similar, but twice greater. The difference with (5.1) in the transverse direction ($\theta = 90^0$) decreases with increasing β. When $\beta^2 = 3/4$, (5.1) is already bigger than (5.2). And when β→1, $F_e \to \infty$ and F_r approaches double the Coulomb force in the direction perpendicular to $\mathbf{v}$ ($\theta = 90^0$). Let us note that (5.2) is also valid when one of the currents is neutral (for instance, q_1 is distributed in a neutral conductor).

The velocity force has magnitude

$$F_v = \frac{q_1 q_2}{4\pi\varepsilon_0 R_0^2} \cdot \beta^2 \cos\theta \qquad (5.3)$$

The force is maximum when $\theta = 0$ (longitudinal direction). When θ is in the interval (0^0,90^0), the force decreases from $q_1 q_2 \beta^2 / 4\pi\varepsilon_0 R_0^2$ to zero, and when θ is in the interval (90^0,180^0), F_v goes on decreasing from zero to $-q_1 q_2 \beta^2 / 4\pi\varepsilon_0 R_0^2$. The overall force produced on a charged circumference is the sum

$$\mathbf{F}_k = \mathbf{F}_v + \mathbf{F}_r \qquad (5.4)$$

$\mathbf{F}_v$ originates tangential to the circumferential force. If q_2 is a negative charge and the circumference is a neutral conductor, then free electrons gather in the region where the circumference crosses x_1 axis. Correspondingly, the x_3 axis and the circumference intersection are charged positively. This charging goes on until the mechanical moment due to the Coulomb force balances the moment transferred to the system by the external forces that give velocity '$\mathbf{v}$' to the charge (see details in Sect. 10). If the velocity of charge q_2 is not constant, *i.e.* q_2 has some acceleration $\mathbf{a}$, an additional force [the third square bracket in (4.3)] is produced on the circumferential charges. Its magnitude is

5. EXAMPLE APPLICATIOINS

$$F_a = \frac{q_1 q_2 a}{4\pi\varepsilon_0 c^2 R_0^2} \cdot \sin\theta \tag{5.5}$$

If the directions of velocity and acceleration coincide, then this force is maximal at the intersection of the circumference and the x_3 axis ($\theta = 90^0$). On the intervals (90^0,0^0), (90^0,180^0), it decreases without changing its sign. One can compare it with the F_v, which decreases on the interval (0^0,180^0), and has different signs on the intervals mentioned.

Some deductions follow:

1. Formula (4.3) predicts two (or in the case of accelerated movement - three) forces produced on a test charge.
2. The acceleration force coincides with the classical one. The radial force is close to relativity theory predictions in a wide range of velocities. But the velocity force is not predicted by to-day electrodynamics, and may be used for experimental verification of the proposed scheme.

EXAMPLE 2. A ROTATING CHARGE DOES NOT RADIATE

Let a positive charge q_2 be al rest, *i.e.* $\mathbf{v}_2 = 0$, $\mathbf{a}_2 = 0$. A negative charge q_1 rotates around q_2 with constant speed v_1 and correspondingly with constant centripetal acceleration magnitude a_1. What effects does (4.3) predict?

The first square bracket in (4.3) is zero because $\mathbf{v}_2 = 0$. The third square bracket is zero because $\mathbf{a}_1$ is parallel to $\mathbf{r}_{21}$. (One can see this especially clearly in (4.1)), $\theta_4 = 90^0$, *i.e.* $\cos\theta_4 = 0$. One gets finally

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21} + \frac{q_1 q_2 v_1^2}{4\pi\varepsilon_0 r^3 c^2}\mathbf{r}_{21} \tag{5.5}$$

Formula (5.5) predicts no force produced on q_1 because of centripetal acceleration, hence q_1 does not radiate. Such radiation takes place only if q_1 is accelerated tangentially.

Eq. (5.5) predicts radial force that augments the Coulomb force. In the case of an elliptic orbit, this force leads to orbit rotation as a unit (pericenter shift). It is just an accurate analogue to the case of pericenter shift of the planetary orbits in gravity.

EXAMPLE 3. A NON-TRADITIONAL FORCE ARISES

Let two charges of the same sign, q_1 and q_2, move along parallel straight lines with equal constant velocities; *i.e.*, $\mathbf{v}_1 = \mathbf{v}_2 = \mathbf{v}$, $\theta_1 = \theta_2 = \theta$, $\cos\theta_3 = 1$, and only the first bracket is nonzero

$$\mathbf{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^3}\mathbf{r}_{21} - \frac{q_1 q_2 v^2 (1-3\cos^2\theta)}{4\pi\varepsilon_0 r^3 c^2}\mathbf{r}_{21} - \frac{2 q_1 q_2 v \cos\theta}{4\pi\varepsilon_0 r^2 c^2}\mathbf{v} \qquad (5.6)$$

Force (5.6) implies that in addition to the Coulomb force (the second term) the radial force $\mathbf{F}_r$ directed along radius $\mathbf{r}$ and the force $\mathbf{F}_v$ directed along velocity (the third term) are produced on charge 1.

When $(1-3\cos^2\theta) = 0$ (approximately 55° and 125°), the radial force $\mathbf{F}_r$ is zero. When θ is in the interval $[0°, 55°)$ and θ is in the iinterval $(125°, 180°]$ $\mathbf{F}_r$ is positive and augments the Coulomb force. When θ is in the interval $(55°, 125°)$, $\mathbf{F}_r$ is negative, and 'weakens' the Coulomb force. The velocity force is equal to zero when $\theta = 90°$, *i.e.* charges fly 'side by side'. When θ is in the interval $(180°, 90°)$ (the first charge is behind the second one), $\mathbf{F}_v$ is directed along the first charge velocity and accelerates it (the second charge 'helps' its partner to fly). When θ is in the interval $(90°, 0°)$ (the first charge is before the second one), $\mathbf{F}_v$ is directed against the velocity of the first charge (the second charge brakes the first one movement). A force equal in magnitude and opposite in direction is produced on the second charge. So the equilibrium point for the charge is going 'side by side'.

If there are two beams instead of two separate charges, the velocity force $\mathbf{F}_v$ separates the beams into clusters that strive to move 'side by side'. We observe a 'cluster effect'. The force $\mathbf{F}_r$ weakens the Coulomb force between charges.

6. CHARGE 2 DISTRIBUTED ALONG INFINITE STRAIGHT LINE

Let q_2 be distributed with constant density λ along the x_3 axis. This means that boundary conditions (2.2) and (2.4) must be changed. We assume that initial condition (2.2) is

$$\operatorname{div}\mathbf{E}_2 = +\lambda / 2\pi\varepsilon_0 r^2 \text{ for } r > r_0 \tag{6.1}$$

where

$$E_2 = -\lambda / 2\pi\varepsilon_0 r \text{ and } r = \sqrt{x_1^2 + x_2^2}\ ,$$

and r_0 is the wire radius. Instead of item 2 of Sect. 4, one obtains

$$E_{21} = -\frac{\lambda}{2\pi\varepsilon_0 r}\left[\mathbf{r}_{21} \times \mathbf{v}_2 / c - \mathbf{r}_{21}\right]$$

In the same way

$$\mathbf{B}_{21} = -\frac{\lambda}{2\pi\varepsilon_0 r^2 c}\left[\mathbf{r}_{21} \times \mathbf{v}_2 / c + \mathbf{r}_{21}\right]$$

If the calculations of Section 4 are repeated for the charge q_1, one finds

$$\mathbf{F_{21}} = \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} - \frac{q_1\lambda}{2\pi\varepsilon_0 r^2 c^2}\cdot\left\{\left[\mathbf{v}_1\bullet\mathbf{v}_2 + \frac{2(\mathbf{r}_{21}\bullet\mathbf{v}_1)(\mathbf{r}_{21}\bullet\mathbf{v}_2)}{r^2} - \frac{(\mathbf{r}_{21}\bullet\mathbf{v}_1)(\mathbf{r}_{21}\bullet\mathbf{v}_2)}{r^2}\right]\mathbf{r_{21}} - \right.$$
$$-\mathbf{v}_1(\mathbf{r}_{21}\bullet\mathbf{v}_2) - \mathbf{v}_2(\mathbf{r}_{21}\bullet\mathbf{v}_1) + \left[(\mathbf{v}_1 - \mathbf{v}_2)\times(\mathbf{r}_{21}\times(\mathbf{v}_1 - \mathbf{v}_2))\right] +$$
$$\left. -\frac{2}{r^2}\mathbf{r_{21}}\bullet(\mathbf{v_1} - \mathbf{v_2})\left[\mathbf{r}_{21}\times[\mathbf{r}_{21}\times(\mathbf{v}_1 - \mathbf{v}_2)]\right] + \left[\mathbf{r}_{21}\times[\mathbf{r}_{21}\times(\mathbf{a}_1 - \mathbf{a}_2)]\right]\right\}$$

(6.2)

Let us assume that the charged straight wire (axis x_3) does not move as a unit, *i.e.* $\mathbf{v}_2 = 0$, $\mathbf{a}_2 = 0$, so $\mathbf{r}_{21}\bullet\mathbf{v}_2 = 0\mathbf{v}$, $\mathbf{r}_{21}\bullet\mathbf{a}_2 = 0$. And let us reveal the triple vector product in (6.2) while taking this condition into account

$$\mathbf{F}_{21} = \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} - \frac{q_1\lambda}{2\pi\varepsilon_0 r^2 c^2}\cdot\Big\{\big[v_1 v_2\cos\theta_3\mathbf{r}_{21} - \mathbf{v}_2 r v_1\cos\theta_1\big] + $$
$$+[|\mathbf{v}_1 - \mathbf{v}_2|^2\cdot(1 - 2\cos^2\theta_4)]\mathbf{r}_{21} - [2r|\mathbf{v}_1 - \mathbf{v}_2|\cos\theta_1)](\mathbf{v}_1 - \mathbf{v}_2) + \tag{6.3}$$
$$+\Big[ra_1\cos\theta_5\mathbf{r}_{21} - (\mathbf{a}_1 - \mathbf{a}_2)r^2\Big]\Big\}$$

Let us note that the first square bracket in (6.3) coincides with dynamic part of traditional Lorentz force, if the magnetic field of the charged straight line (charged wire) is revealed with respect to velocities of charges creating it.

7. MORE EXAMPLES OF GE VS. TRADITIONAL RESULTS

EXAMPLE 1. THE LORENTZ FORCE IS A SPECIAL CASE OF GE.

The Lorentz force law is a special case of Generalized Electrodynamics (GE). Let charge q_1 move parallel to x_3 with the same velocity as charge q_2 along x_3, *i.e.* $\mathbf{v}_1 = \mathbf{v}_2 = \mathbf{v}$.

All the square brackets in (6.4) are equal to zero except for the first one, in which $\cos\theta_1 = 0$, $\cos\theta_3 = 1$. One obtains finally

$$\mathbf{F}_{21} = \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} - \frac{q_1\lambda v^2}{2\pi\varepsilon_0 r^2 c^2}\mathbf{r}_{21} \qquad (7.1)$$

This formula coincides with the prediction of the Lorentz force formula.

EXAMPLE 2. GE PREDICTS THE TRADITIONAL EFFECT AGAIN.

In the previous Example 1, let $\mathbf{v}_1 = -\mathbf{v}_2 = \mathbf{v}$, *i.e.* let q_1 move anti-parallel to the charges in the wire. The first and the second square brackets in (6.3) are nonzero for the case that $\cos\theta_1 = 0$, $\cos\theta_3 = -1$

$$\mathbf{F}_{\mathbf{21}} = \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} + \frac{q_1\lambda v^2}{2\pi\varepsilon_0 r c^2} \qquad (7.2)$$

again we have got coincidence with classical case.

EXAMPLE 3. A NEW FORCE APPEARS.

Let the first charge move perpendicular to the x_3 axis, going away from the wire along a radius vector. The first two square brackets in (6.3) are nonzero, $\cos\theta_1 = 1, \cos\theta_3 = 0$, $\cos\theta_4 = \cos\theta_1 = 1$. The force produced on q_1 is

$$\mathbf{F_{21}} = \frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} - \frac{q_1\lambda\,|\,\mathbf{v}_1 - \mathbf{v}_2\,|^2}{2\pi\varepsilon_0 r^2 c^2}\mathbf{r}_{21} - \\ -\frac{2q_1\lambda|\mathbf{v}_1 - \mathbf{v}_2|}{2\pi\varepsilon_0 c^2 r}(\mathbf{v}_1 - \mathbf{v}_2) + \frac{q_1\lambda v_1}{2\pi\varepsilon_0 r c^2}\mathbf{v}_2 \tag{7.3}$$

The last two terms here are not predicted by the Lorentz formula. Let us investigate more deeply the physical meaning of these terms for the case when the speed v_2 of the charge in the beam is much less than the speed of the separate charge v_1, *i.e* $v_2 << v_1$. Then the force

$$\mathbf{F_k} = -\frac{q_1\lambda}{2\pi\varepsilon_0 r^2}\left\{\mathbf{r}_{21} - \frac{q_1\lambda v_1^2}{2\pi\varepsilon_0 c^2}\mathbf{r}_{21} - \frac{q_1\lambda v_1 r}{\pi\varepsilon_0 c^2}\mathbf{v}_1\right\} \tag{7.3a}$$

But $\mathbf{r}_{21}$ and $\mathbf{v}_1$ are parallel. Therefore one obtains in this case that if $v_2 << v_1$ the force (7.3a) is directed along the radius and

$$\mathbf{F}_{21} = \frac{q_1\lambda(1-3\beta^2)}{2\pi\varepsilon_0 r^2}\mathbf{r}_{21} \tag{7.3b}$$

where $\beta^2 = v_1^2 / c^2$. Let us note that when $v_1^2 = c^2/3$, force (7.3b) changes its sign; *i.e.*, when velocity $\mathbf{v}_1$ is big enough, repulsion of the charges of the same sign changes to attraction.

EXAMPLE 4. GE CONTRADICTS TRADITIONAL PREDICTIONS

Let $\lambda\mathbf{v}_2$ be a steady neutral current and let ‘bare’ charge q_1 be at rest in the laboratory reference frame; *i.e.* $\mathbf{v}_1 = \mathbf{a}_1 = 0$. Traditional theory predicts no force produced on q_1, but the second square bracket in (6.3) is nonzero, and it predicts

$$\mathbf{F}_{21} = -\frac{3q_1\lambda v_2^2}{2\pi\varepsilon_0 r^2 c^2}\mathbf{r}_{21} \tag{7.4}$$

MORE EXAMPLES OF GE VS. TRADITIONAL RESULTS

Eqs. (7.3) and (7.4) may be used for experimental testing of the proposed theory. The velocities of electrons in conductors are small. Therefore in order to test (7.4), it is more convenient to use a beam of rapid charges than to observe electrons' behavior in a conductor.

8. CHARGED PLANE – ETHER APPEARS ON THE SCENE

Let the plane (x_1, x_2) be charged with density σ. Generally speaking, these charges can move with velocity $\mathbf{v}_2$ and acceleration $\mathbf{a}_2$. The static part of the electric field satisfying the initial condition

$$\mathrm{div}\mathbf{E}_2 |_{x_3=0} = 0 \tag{8.1}$$

appears as follows

$$E_2 = -\sigma / 2\varepsilon , \tag{8.2}$$

and the electric field created by the charged plane in the vicinity of the charge q_1 is

$$\mathbf{E}_{21} = \frac{\sigma}{2\varepsilon r}\left[\mathbf{r}_{21} \times \mathbf{v}_2 / c - \mathbf{r}_{21}\right] \tag{8.3}$$

where $\mathbf{r}_{21}$ is the radius-vector from plane (x_1, x_2) to the point nearest to the charge q_1.

In just the same way

$$\mathbf{B}_{21} = \frac{-\sigma}{2\varepsilon rc}\left[\mathbf{r}_{21} \times \mathbf{v}_2 / c + \mathbf{r}_{21}\right] \tag{8.4}$$

The formula for the magnetic field of the passive charge q_1 is preserved:

$$\mathbf{B}_{12} = \frac{q_1}{4\pi\varepsilon r^3 c}\left[\frac{1}{c}\mathbf{r}_{21} \times \mathbf{v}_1 + \mathbf{r}_{21}\right] \tag{8.5}$$

The ε that appears in (8.1)-(8.5) is assumed to be function of space and time coordinates, $\varepsilon(x_1, x_2, x_3, t)$, and not the constant ε_0. It is shown in **Appendix 1** that ε_0 characterizes the density of free ether. In our case it is natural to understand ε as ether density in a substance. We are interested here in the analyses of the behavior of $\varepsilon(x_1, x_2, x_3, t)$ on boundaries between two substances, and especially in the transition space between substance and free ether, or to be more accurate, in the ε gradient function near static or moving bodies. In using $\varepsilon(x_1, x_2, x_3, t)$ instead of ε_0 we aim to take into account the case when a dielectric is introduced between the charged plane and q_1. Thus we strive to investigate the cases that are explained in present-day physics by the polarization of dielectrics. The proposed theory links $\varepsilon(x_1, x_2, x_3, t)$ with different ether density in different substances, thus overcoming many problems of present-day theory of electric fields in media.

We must also take into account the fact that the magnetic constant μ_0, which has meaning of free ether compressibility [Appendix 1], also becomes a function of space and time coordinates $\mu(x_1, x_2, x_3, t)$. The speed of light in matter $c^2 = 1/\varepsilon\mu$ also turns out to be function of spatial coordinates.

Taking into account that $\mu = 1/\varepsilon c^2$, one obtains

$$-\text{grad}\left[4\pi\varepsilon r^2 c(\mathbf{B}_{12}\bullet\mathbf{E}_{21})\right] = \frac{q_1\sigma}{2\varepsilon r}\left[\mathbf{r}_{21} + \frac{r^2}{\varepsilon^2}\text{grad}\,\varepsilon\right] + \frac{\mu q_1\sigma}{2r}\cdot$$
$$\cdot\left\{\mathbf{r_{21}}\left[2(\mathbf{v_1}\bullet\mathbf{v_2}) - \frac{1}{r^2}(\mathbf{r_{21}}\times\mathbf{v_1})\bullet(\mathbf{r_{21}}\times\mathbf{v_2})\right] - \mathbf{v}_1(\mathbf{r}_{21}\bullet\mathbf{v}_2) - \mathbf{v}_2(\mathbf{r}_{21}\bullet\mathbf{v}_1)\right\} + \quad (8.6)$$
$$+\frac{q_1\sigma}{2r}\text{grad}\mu\left[(\mathbf{r_{21}}\times\mathbf{v_1})\bullet(\mathbf{r_{21}}\times\mathbf{v_2})\right]$$

A peculiarity of formula (8.6) is that the second item in the first square bracket and the last item depend on the distribution in space of ether mass density and compressibility. The gradient term in the first bracket predicts the appearance of force directed along the gradient of ether density. Therefore a dielectric plate is drawn into capacitors: ether density ε_0 in a hollow capacitor is bigger than ε in dielectric. This force grows with r: distance of q_1 from the charged plane. In the case of a capacitor, this means that force is bigger when the dielectric plate is thicker.

These effects are observed only when the charges are ‘bare’. It is well known that when a dielectric is brought between capacitor’s plates, its capacity is enlarged or, which is the same, the strength of attraction between plates is lowered. What is the cause of this effect?

Today this effect is explained by ‘polarization of the dielectrics’. It is believed that molecular dipoles are shifted as a reaction to the external field action. Such a shift partly neutralizes the charge on the plates and thus weakens the Coulomb force.

Let us investigate this problem in greater detail, returning to the views of the physicists of the 19th century, and discussing Eichenwald's experiments. As was mentioned in Section 2, those experiments are believed to disprove Hertz electrodynamics, which include total time derivatives. At that time physicists believed that ether polarization between the capacitor plates led to the observed effects. They often spoke about one Eichenwald's experiment, although he set up a lot of different experiments, and many conclusions were deduced from his experiments. We shall consider some of them referring to our discussion.

In the first experiment, round capacitors plates were rotated. The induced magnetic field was measured. The experiment showed that such movement of electrons creates the same magnetic field as their movement in a conductor.

In the second experiment, the same capacitor with dielectric between the plates was rotated. Such rotation created the same magnetic field as in the first experiment, *i.e* the same as without dielectric.

In the third experiment, the capacitor plates were immovable, but the dielectric was rotated. Such rotation also induced a magnetic field. Its direction did not change when the rotation direction changed, but it did change when the plates were charged oppositely.

Let us consider the conclusions that were drawn from these experiments. These conclusions were incorporated into the foundation of modern physics.

There was also another question that excited physicists at that time. This was the problem of the physical meaning of the displacement current introduced by Maxwell into his equations in addition to conductivity current. Displacement current was mathematically realized as the electric field partial time derivative. Displacement current was used to explain the fact that the magnetic field does not end on one of the capacitor's plates, but overcomes the space between plates even though electrons do not travel from one plate to the other.

The following explanation was proposed. Ether particles between the plates are polarized by the electric field and displaced. This polarization creates in the ether the conductivity that is manifested as the electric field partial time derivative.

It is interesting that present-day physics denying ether actually preserves this explanation just as the very name of the current. And today it becomes completely inexplicable that electric field changes independently of space coordinates, and dependence on time manifests only between capacitor plates, and does not manifest along conductors and in substance.

But let us return to Eichenwald's first experiment. If such a polarization of the ether particles takes place, it must lessen the charge on the plates, and correspondingly the magnetic field created by rotating the capacitor should be less than the magnetic field created by a conductivity current. But the experiment showed complete equivalence of these fields.

Eichenwald himself [27], and some other scientists, interpreted this fact as stability of ether and its polarized particles: the capacitor's rotation does not carry them along.

It is impossible to understand today how Eichenwald could come to such a conclusion. Certainly it is difficult to come to any conclusion about behavior of such a substance as exotic as ether on the basis of only one experiment, and Eichenwald's second experiment shows that ether contained in dielectric is carried along, but the effect remains.

In one way or in another, Eichenwald supported Lorentz' theory of stable ether and declared that his experiment refutes Hertz's idea of moving ether. Today one can hear for the very same experiment an interpretation very different from its interpretation by Eichenwald. Many educated persons assert that Eichenwald showed that it is prohibited to use total time derivatives in electrodynamics. Some very educated persons, for instance [25], believe that Eichenwald proves ether nonexistence, but that total time derivatives in electrodynamics are necessary.

Let us consider Phipps' monograph [25] in greater detail. I recommend the reader to read this book if possible. This is sum total of many years of meditation on electrodynamics problems written by a very clever man with very keen insight. Therefore his even erroneous, as we believe, ideas characterize the scatter coefficient in the interpretation of Eichenwald's experiments.

Dr. Phipps is a supporter of the idea of introducing total time derivatives into Maxwell equations. He scrupulously investigates how Hertz did this [25, p. 24] : "He (Hertz) conceived of his theory…as describing an electrodynamics of "moving media," and interpreted his new velocity parameter (appearing in total time derivative) as ether velocity. This was a serious mistake, a false interpretation. He compounded that error by postulating a Stokesian ether 100% convected by ponderable matter. This made his theory testable, because it reified the ether - giving it ‘hooks’ to observable matter…Soon after Hertz death an experimentalist, Eichenwald went into his laboratory and disconfirmed Hertz’s predictions. The invariant theory was thus discredited and relegated to history’s trash bin.”

Such an understanding of Eichenwald’s experiments leads Dr. Phipps to negation of ether altogether, and to his semi-relativistic theory, although, we repeat, he insists on total time derivatives in electrodynamics.

We here cite Dr. Phipps only to illustrate that Eichenwald’s experiment can be interpreted very differently, and to propose our own interpretation. First of all, let me express my deep conviction that the main problem of experimental physics during this millennium will be ascertaining the qualities of ether. Therefore, we cannot be completely certain in declaring its qualities today. Nevertheless, we have some foundation for some conclusions.

We cannot say for sure if ether is carried along in the first experiment. But we are sure that ether in dielectric is carried along with it, because the dielectric’s ether density ρ and compressibility μ are not changed. And this urges us to the conclusion that ether is carried along in the first experiment as well.

But the most interesting point for us here is that, in contrast to Mr. Phipps interpretation, we need total time derivatives in electrodynamics not only to describe ether movement, but also to describe conductivity current without having to introduce it axiomatically. And the main result of their usage is introduction of the curl current [second item in Eq. (2.6a)]. This current moves in the conductor as well, and not with the speed of electrons, but with the speed of light. Therefore, a knife-switch switched on in Europe lights a lamp in America immediately, and not some years later when electrons arrive there over a cable.

Just this curl current overcomes the space between the capacitor plates and extends, moving along the conductor, carrying electrons along and creating magnetic field. Just this curl current is responsible for all the effects attributed to current nowadays. Just this curl current induces ether rotation in the dielectric while electrons cannot penetrate dielectric. And the electrons’ movement in conductor is rather a consequence of curl current in the same way in which sand’s movement in river is a consequence of water movement in it.

Let us note that a partial time derivative cannot be a cause for current to overcome space between capacitor’s plates, just because there is no time dependence in the changes of the fields between capacitor's plates, in comparison with the fields in a conductor. These changes depend only on space coordinates.

But let us return to the second of Eichenwald's experiments, where the capacitor rotates together with the dielectric, and correspondingly the ether filling the dielectric also rotates. We need more accurate consideration of this experiment because modern physics, in this case not hindered by disbelief in ether, accurately reproduces for the dielectric the ideas of the 19th century concerning ether.

They already did not speak about polarization of ether particles, but rather attributed this idea to molecules. They believed that charges in the dielectric are shifted, and the shift enlarges the capacitance, and partly neutralizes the charges on the capacitor plates, thus lessening attraction between them.

But why does the dielectric influence the capacitance? And what is the essence of capacitance? And is capacitance linked with polarization of the dielectrics? And why doesn't this shift neutralize all the charges on the capacitor plates?

They usually answer that there are not enough dipoles in dielectric. But if so, when there are a small number of charges on the plates, for which there are enough dipoles in dielectric, all such charges should be neutralized. But experience does not show such an effect. Coulomb's force is just lessened in $\varepsilon / \varepsilon_0$ times, either for a small or for a large amount of charges. And let us note that direct measurements to determine the shift of dipoles in the dielectrics were not produced, to the best of this author's knowledge.

What explanation for the corresponding experiments can be proposed? Let us begin with capacitance. It was mentioned that the physical meaning of free ether dielectric permeability ε_0 is free ether mass density. Correspondingly, we interpret absolute dielectric permeability ε as ether density in dielectric. This means that the introduction of dielectric between the capacitor plates just changes the ether density between them. Correspondingly, the Coulomb force is lessened: it depends not only on the value of charges but also on the quality of the substance filling the space separating them. Therefore, the dielectric between plates does not influence the magnetic field of the rotating capacitor: its introduction conserves charges on the plates. Thus we could predict the result of the second Eichenwald's experiment.

8. CHARGED PLANE – ETHER APPEARS ON THE SCENE

And what is the physical meaning of the capacitance? If C is the capacitance, d is the distance between the plates, and A is the area of the plates, then

$$C = \varepsilon A / d \ ,$$

i.e., the capacitance is the average surface mass density of the ether in the dielectric.

What other effects detected in Eichenwald's experiments does formula (8.6) predict? Ether density between the capacitor plates does not change. This means that Coulomb force is ε_0 inverse in the first experiment and ε inverse in the second one, although charges on the plates are conserved. Ether densities ε_0 and ε are constant, and therefore the second item in the first square bracket in (8.6) is zero, because $\text{grad}\,\varepsilon = 0$.

The velocities of the charges on the plates are parallel. These velocities are perpendicular to the radius vector. This means that only radial force remains in braces. This force is μ proportional; *i.e.*, it is v^2 / c^2 weaker than the Coulomb force, but is co-directed with it and enlarges it. Eichenwald did not measure it, but it would be interesting to produce the corresponding experiment and answer the question: "Is it correct that the attraction force between rotating plates of a capacitor is greater than between stable ones?"

We have analyzed the effects predicted by the first item in Eq. (8.6). The physical meaning of the third, gradient item in (8.6) (the second square brackets in braces is analogous to the physical meaning of the gradient item in the static part. But it is linked with another ether characteristic: its compressibility. We observe its action when paramagnetics are pulled in and diamagnetics are pushed out of a solenoid. The force is directed along the gradient of the ether compressibility μ, which increases from the solenoid's ends to its midpoint. The static gradient part is also directed along the gradient of ε. This force always expels dielectric from free ether because ε_0 is always less than the ether density in substance. But in the case of a capacitor, charges of opposite sign are induced on its plates. Therefore $\text{grad}\,\varepsilon$ is directed into the capacitor.

Current in the solenoid's coils are induced by charges of the same sign. And ether compressibility in different substances can be bigger than in free ether (paramagnetics), or smaller (diamagnetics). Therefore, paramagnetics are pulled into, and diamagnetics are pushed out of, the solenoid.

What does the first Eichenwald's experiment shows us in this respect? Let us note that square brackets in the third item in (8.6) is always positive because $\mathbf{v}_1$ and $\mathbf{v}_2$ (tangential velocities of the charges on the rotating plates) are co-directed. Charges opposite sign are induced on the plates. Therefore the third item produces force directed against $-\mathrm{grad}\,\mu$, *i.e* in the direction of magnetic field decrease.

Charges' velocities increase along the radius of the plates, but magnetic fields may overcross each other. Therefore, we cannot assert that the magnetic field also increases along the radius. This should be determined by experiment. But we can assert that paramagnetics will be pulled into the capacitor, and diamagnetics pushed out of it, if the magnetic field inside the capacitor increases along the radius. The sign of the assertion is opposite in the opposite case. It is also opposite if the charges on the plates are of the same sign. In the last case, a picture similar to that of solenoid is predicted.

We observe here just an accurate analog to the electric field. Rotation of two plates charged with the charges of the same sign will induce a traditional effect: diamagnetics will be pushed out and paramagnetics pulled in.

Let us formulate the main result of our consideration of formula (8.6). Although apparently a certain polarization of dielectrics in capacitors takes place, the main effects are determined by the fall of ether mass density ε and ether compressibility μ on the boundary between different matterials, or free-space ether and ether in substance

If the charged plane is immovable, then the following correlations are valid:

$$\mathbf{r}_{21} \perp \mathbf{v}_2 \ , \ \mathbf{r}_{21} \perp \mathbf{a}_2 \ \ i.e. \ (\mathbf{r}_{21} \bullet \mathbf{v}_2) = 0 \ , \ (\mathbf{r}_{21} \cdot \mathbf{a}_2) = 0$$

In this case (8.6) grows simpler

$$-\mathrm{grad}\left[4\pi\varepsilon r^3 c(\mathbf{B}_{12} \bullet \mathbf{E}_{21})\right] = \\ = \frac{q_1\sigma}{2\varepsilon r}\left[\mathbf{r}_{21} + (r^2/\varepsilon)\mathrm{grad}\,\varepsilon\right] + \frac{\mu q_1 \sigma}{2r}\left[2\mathbf{r}_{21}(\mathbf{v}_1 \bullet \mathbf{v}_2) - \mathbf{v}_2(\mathbf{r}_{21} \bullet \mathbf{v}_1)\right] \qquad (8.7)$$

We have calculated the Huygens part of the force. The Newton part appears as follows:

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$$\frac{d}{dt}[4\pi\varepsilon\ r^3 c(\mathbf{B}_{12}\times\mathbf{B}_{21})]=$$
$$=\frac{q_1\sigma\mu}{2r}\Big[-\mathbf{r}_{21}\,|\,\mathbf{v}_1-\mathbf{v}_2\,|^2+(\mathbf{v}_1-\mathbf{v}_2)[\mathbf{r}_{21}\bullet(\mathbf{v}_1-\mathbf{v}_2)]-$$
$$-\mathbf{r}_{21}[\mathbf{r}_{21}\bullet(\mathbf{a}_1-\mathbf{a}_2)]-(\mathbf{a}_1-\mathbf{a}_2)r^2\Big]+$$
$$+\frac{q_1\sigma}{2r}[\mathbf{r}_{21}\bullet(\mathbf{v}_1-\mathbf{v}_2)]\varepsilon^{1/2}\mu^{3/2}\big[(\mathbf{v}_2-\mathbf{v}_1)[\mathbf{r}_{21}\bullet(\mathbf{v}_1\times\mathbf{v}_2)]\big]+ \tag{8.8}$$
$$+\frac{q_1\sigma}{2r}\frac{d\mu}{dt}\Big[\mathbf{r}_{21}[\mathbf{r}_{21}\bullet(\mathbf{v}_1-\mathbf{v}_2)]-(\mathbf{v}_1-\mathbf{v}_2)r^2\Big]+$$
$$+\frac{q_1\sigma}{2r}\frac{d}{dt}\left(\varepsilon^{1/2}\mu^{3/2}\right)\big[(\mathbf{r}_{21}\times\mathbf{v}_2)\times(\mathbf{r}_{21}\times\mathbf{v}_1)\big]$$

The static part is absent from this formula, and consequently force depending on ε gradient is absent as well. The whole part depends not on velocities' product but on their difference product. Therefore it is null in the first and the second Eichenwald experiments : the plates' velocities are modulo equal and codirected. Let us suppose the following modification of the second Eichenwald experiment : capacitor's plates uniformly rotate in opposite directions around dielectric. Radius-vector in such experiment is perpendicular to velocities. Therefore all the items containing $(\mathbf{r_{21}}\cdot(\mathbf{v_1}-\mathbf{v_2}))$, all the item containing accelerations and the last item in (8.8) will be zero. Only radial force is preserved in (8.8). Thus Newton's part of force density

$$\mathbf{F}_{\mathrm{N}}=-\frac{4\sigma^2\mu v^2}{2r}\mathbf{r}_{21} \tag{8.9}$$

The velocities in the experiment are oppositely directed. Therefore the braces in (8.6) for the case will appear as follows

$$\mathbf{F}_{\mathrm{H}}=-\frac{\sigma^2\mu v^2}{2r}\mathbf{r}_{21} \tag{8.10}$$

i.e. for this case, Huygens' and Newtons' surface force density are directed against the Coulomb surface force density, and the sum surface force density appears as follows:

$$\mathbf{F}_N + \mathbf{F}_H = -\frac{5\sigma^2 \mu v^2}{2r} \mathbf{r}_{21} \tag{8.11}$$

Below we shall use term ‘force’ instead of ‘surface force density’ to simplify the narration.

The forces defined by the second and the fourth square brackets are c times less than the other forces here. They could be essential in the processes combined by the idea of ‘electroweak interaction’. They need special investigation, which we postpone. Let us investigate the force defined by the third square bracket. Its coefficient depends on time derivative of μ, *i.e.* ether compressibility in dielectric. We can detect this force if, for instance, we put a substance with periodically changing ether compressibility among oppositely rotating plates of a capacitor. Let

$$\mu = \mu_0 \cos \omega t \tag{8.12}$$

i.e.

$$d\mu / dt = -\omega \mu_0 \sin \omega t \tag{8.13}$$

Here μ_0 is average ether compressibility in the substance, ω is frequency.

Then the force appearing between the capacitor plates because of μ changing in time and acting from plate 2 on plate 1 is

$$\mathbf{F}_{21} = \sigma^2 \omega \mu_0 r \sin \omega t \, \mathbf{v}_1 \tag{8.14}$$

This force is proportional to square surface charges density σ^2 on the plates and linear on ω, μ_0, r; *i.e.* it increases with increase of these parameters. It periodically untwists and brakes plate 1 in accordance with the sin law. The force with which plate 1 acts on plate 2 is:

$$\mathbf{F}_{12} = -\mathbf{F}_{21} \tag{8.15}$$

Plate 1 acts on plate 2 in the same way.

Let us consider an additional modification of this experiment: the dielectric does not rest between oppositely rotating plates, but rotates with one of them. In this case, μ does not depend on time explicitly, but, generally speaking, the convective part of the total time derivative $(\mathbf{v}_1 \bullet \text{grad})\mu$ is not null. Under what conditions? Apparently when tangential velocity $\mathbf{v}_1$ and $\text{grad}\,\mu$ are not perpendicular. Is this condition valid for this case? Perhaps not. Note that in the static case $\text{grad}\,\mu$ is apparently directed perpendicular to the dielectric surface. We know too little about ether qualities to assert something with certainty. But we can adopt the following:

> *Assumption: grad μ near the surface of a rotating dielectric is directed along tangential velocity, i.e μ increases in this direction.*

The adopted assumption means that total time derivative convective part $(\mathbf{v}_1 \bullet \text{grad})\mu$ is always positive and does not depend on the direction of the dielectric rotation. The force with which the plates act on each other

$$\mathbf{F}_{21} = \frac{1}{2}\sigma^2 r(\mathbf{v}_1 \bullet \text{grad})\mu \mathbf{v}_1 \tag{8.16}$$

$$\mathbf{F}_{12} = -\mathbf{F}_{21} = \frac{1}{2}\sigma^2 r(\mathbf{v}_2 \bullet \text{grad})\mu \mathbf{v}_2 \tag{8.17}$$

Let us return to the third Eichenwald experiment. In this experiment the capacitor plates were at rest, and only an ebonite disc rotated. Sudden for Eichenwald and expected for us was that the magnetic field direction did not depend on the rotation direction. Eichenwald himself explained this by invoking qualities of ebonite. We are sure that it is really the ether qualities: when ether jumps from its more dense state in dielectric into its more rarefied state in free space, the rotation movement drags it. Therefore, its compressibility gradient vector is directed along the tangential velocity vector, and their scalar product is always positive.

The last two items here are non-zero if μ and ε depend on time. The previous items are consequences of general formulas (4.1)-(4.3). The general formula is the sum of the Huygens and Newton forces

$$\mathbf{F}_{21} = \mathbf{F}_{\text{H}} + \mathbf{F}_{\text{N}} \,. \tag{8.18}$$

9. FIELDS THAT EXIST INSIDE A CHARGED SPHERE

Our aim in this Section is to find force that acts on charge q_1 inside sphere of radius R_0 charged with density σ. The initial condition

$$\mathrm{div}\mathbf{E}_2 = \sigma r \big/ \varepsilon_0 R_0^2 \ \text{ for } r = R_0 \tag{9.1}$$

supplies us with the static part of the field inside the sphere

$$\mathbf{E}_2 = \mathbf{r}_{21} \sigma r \big/ \varepsilon_0 R_0^2 \ \text{ for } r \le R_0 \tag{9.2}$$

One can see that the field (9.2) is proportional to r^2; *i.e.*, it decreases to zero when r decreases to zero. This means that the field is not constant and not zero, as is believed nowadays, because ‘electric field’ is defined as ‘a force acting on a charge’. It has been said already that such a definition is not satisfactory. Does this mean that our conclusion contradicts well-known experimental facts? We shall see below that there is really no force acting on a charge inside a charged sphere in the static case, but not because there is no field inside the sphere, but rather because the interaction energy inside such a sphere is constant, and therefore its gradient is zero.

If the charges on the sphere move with velocity $\mathbf{v}_2$, they create the following field at the point where charge q_1 is situated:

$$\mathbf{E}_{21} = \frac{\sigma r}{\varepsilon_0 R_0^2}\left[-\frac{1}{c}(\mathbf{r}_{21} \times \mathbf{v}_2) + \mathbf{r}_{\mathbf{21}}\right], \ r \le R_0 \tag{9.3}$$

In just the same way

$$\mathbf{B}_{21} = -\frac{\sigma r}{\varepsilon_0 R_0^2 c}\left[\frac{1}{c}\mathbf{r}_{21} \times \mathbf{v}_2 + \mathbf{r}_{21}\right], \ r \le R_0 \tag{9.4}$$

The magnetic field created by moving charge q_1 is traditional:

$$\mathbf{B}_{12} = \frac{q_1}{4\pi\varepsilon_0 r^3 c}\left[\frac{1}{c}\mathbf{r}_{21} \times \mathbf{v}_1 + \mathbf{r}_{21}\right], \ r \le R_0 \tag{9.5}$$

The Huygens force acting on q_1 inside the sphere is

$$-\text{grad}\left[4\pi\varepsilon_0 R_0^2 c(\mathbf{B}_{12}\bullet\mathbf{E}_{21})\right]=$$

$$=\frac{q_1\sigma R_0}{\varepsilon_0 rc^2}\left[\mathbf{r}_{21}v_1v_2(\cos\theta_3+\cos\theta_1\cdot\cos\theta_2)-\mathbf{v}_1v_2r\cos\theta_2-\mathbf{v}_2v_1r\cos\theta_1\right] \qquad (9.6)$$

$$\text{for } r<R_0$$

Here θ_1 is the angle between radius vector $\mathbf{r}_{21}$ and velocity $\mathbf{v}_1$, θ_2 is the angle between $\mathbf{r}_{21}$ and $\mathbf{v}_2$, θ_3 is the angle between $\mathbf{v}_1$ and $\mathbf{v}_2$.

This force acts on q_1 from every point of the charged sphere. Let us note that the Coulomb force is absent: its contribution into the interaction energy between the charge and the sphere is constant, and so its energy gradient is zero.

This example shows the problems of the present-day understanding of the electric field as a force acting on a charge. Such a definition compels us to believe that the field inside the sphere is zero. Because the field exists outside the sphere, it must be discontinuous at the surface of the sphere. And what is going on at the surface of the sphere? And will any force act on a charge moving inside a static charged sphere?

Let us demonstrate that we can obtain reasonable answers on all these questions within the framework of the proposed approach. Charge density on the sphere is $\sigma=q_2/4\pi R_0^2$, where q_2 is the common charge of the sphere. Having integrated over the sphere, we obtain from (9.2)

$$E_2\big|_{r=R_0}=q_2\big/4\pi\varepsilon_0 R_0^2 \qquad (9.7)$$

And without any discontinuity,

$$E_2=q_2\big/4\pi\varepsilon_0 r^2 \text{ for } r\geq R_0 \qquad (9.8)$$

Let us return to Eq. (9.6). It does not exhaust the forces acting on charge inside the sphere. In addition we must find the Newtonian part of the force; *i.e.*, the time derivative of the vector product of the magnetic fields:

FIELDS THAT EXIST INSIDE A CHARGED SPHERE

The coefficient before the square bracket in Eq. (9.6) can create the impression that the force is proportional to the sphere radius R_0. But charge density σ is R_0^2 inverse; therefore, the force (9.6) is R_0 inverse. All the terms in the square bracket depend on the product of the velocities of charges on sphere and the charge inside the sphere. Therefore the whole force is zero if at least one of the charges is at rest. The radius vector inside the square bracket links any charge on the sphere with the charge q_1 inside. This bracket coefficient radius vector is modulo inverse, *i.e* the whole force does not depend on the distance between q_1 and particular charges on the sphere. But it essentially depends on the angles between the radius vector and the charges' velocities and on the angle between velocities of the charges on the sphere and q_1.

Usually we are interested not in the interaction force between q_1 and any particular point on the sphere. We usually want to understand how the whole sphere influences q_1. In this case we must integrate (9.6) over the whole sphere.

Let us find Newton's force in our case:

$$\frac{d}{dt}\left[4\pi\varepsilon_0 R_0^2 c(\mathbf{B}_{12}\times\mathbf{B}_{21})\right]=$$
$$=\frac{q_1\sigma R_0}{\varepsilon_0 rc^2}\left\{\mathbf{r}_{21}\left[|\mathbf{v}_1-\mathbf{v}_2|^2(1-\cos\theta_4)\right]+\left[\mathbf{r}_{21}r\,|\mathbf{a}_1-\mathbf{a}_2|\cos\theta_5-(\mathbf{a}_1-\mathbf{a}_2)r^2\right]\right\} \quad (9.9)$$

for $r\le R_0$

Here θ_4 is the angle between $\mathbf{r}_{21}$ and $(\mathbf{v}_1-\mathbf{v}_2)$, θ_5 is the angle between $\mathbf{r}_{21}$ and $(\mathbf{a}_1-\mathbf{a}_2)$. One can see that the velocity-dependent part of the formula does not depend on the distance from q_1 to the points on the sphere, but the acceleration dependent part increases with this distance. This force is not zero even if the charges on the sphere or q_1 are at rest.

Let us consider the case of stable current on the sphere and constant velocity of q_1; *i.e.*, we put to zero the second square bracket in (9.9). The angle between $\mathbf{r}_{21}$ and $(\mathbf{v}_1-\mathbf{v}_2)$ is never null for any movement of q_1, *i.e.* $\cos\theta_4$ is never equal to 1. This means that radial force directed from sphere must be observed because $|\mathbf{v}_1 - \mathbf{v}_2|^2$ and $(1-\cos\theta_4)$ are always positive. In other terms, there is a magnetic field inside the charged sphere. This contradicts the well-known theorem that magnetic field circulation over a curve not enveloping current is zero. The cause is that present-day electrodynamics does not take into account the curl current [Eq. (2.6a)] and the radial part of magnetic field [Eq. (2.4)]. Formula (9.4) shows that in a charged sphere, magnetic field decreases as r^2 to the center of the sphere, and is directed from this center to the sphere along the radius. Concentric spheres are level surfaces of the field. This field exists even if the charges on the sphere are at rest: the static part of (9.4) and magnetic field of moving charge q_1 interact and create observable effects contradicting present-day theory. The general formula of force acting on q_1 inside charged sphere appears as follows

$$\mathbf{F}_{21} = \frac{q_1\sigma R_0}{\varepsilon_0 rc}\Big\{\mathbf{r}_{21}\Big[|\mathbf{v}_1 - \mathbf{v}_2|^2(1-\cos\theta_4) + v_1 v_2\cos\theta_1\cos\theta_2\Big] - \\ -\mathbf{v}_1 r v_2\cos\theta_2 - \mathbf{v}_2 r v_1\cos\theta_1 + \Big[\mathbf{r}_{21} r\,|\mathbf{a}_1 - \mathbf{a}_2|\cos\theta_5 - (\mathbf{a}_1 - \mathbf{a}_2)r^2\Big]\Big\} \tag{9.10}$$

In particular when the charge q_1 inside the sphere is at rest, *i.e.* when $\mathbf{v}_1 = 0$ and $\mathbf{a}_1 = 0$

$$\mathbf{F}_{21} = \frac{q_1\sigma R_0}{\varepsilon_0 rc^2}\Big\{\Big[\mathbf{r}_{21}|\mathbf{v}_2|^2(1-\cos\theta_2)\Big] + \mathbf{a}_2 r^2 - \mathbf{r}_{21} r a_2\cos\theta_2\Big\} \tag{9.11}$$

If the charges in and on the sphere are immovable, (9.10) is zero. There is an electric field inside the sphere but there is no force acting on the charge.

Let us illustrate (9.10) by the example of when direct current is brought to a diameter end of the sphere (the first pole) and drawn aside from the other end of the diameter (the second pole). The current flows over the sphere between these points. How will force lines look?

Present-day physics asserts that the circulation of the magnetic field over a curve that does not envelop the current is zero. But formula (9.10) predicts that a force acts on a charge in our case; *i.e.*, it predicts a magnetic field inside the sphere. Not going into mathematical details, I just pinpoint the cause of this contradiction. The cause is that Eq. (1.11) contains only conductivity current, and does not contain curl item $\text{rot}(\mathbf{E}\times\mathbf{v})$ that appears in Eq. (2.6a). Just this item creates a magnetic field and a corresponding force (9.11) inside the sphere.

The magnetic field (9.4) is proportional r^2, *i.e.* the squared distance from any point on the sphere to the point inside it. It is minimal and equal to zero when $\mathbf{r}_{21}\perp\mathbf{v}_2$; i.e., it is minimal at the center of the sphere. It increases along the radius. Small spheres with centers coinciding with the center of the big one are level curves for magnetic field created by current over the sphere. The magnetic field comes to maximum on the big sphere; *i.e.*, it enlarges with the distance from the big circumference center.

The situation with the force is different. Formula (9.10) shows that it does not depend on the distance from the sphere, but rather essentially depends on the angle between velocities and the radius vector from points on the surface to the point inside (we assume acceleration equal to zero). One force is radial. It depends on squared difference between velocities of the charge on the surface and inside, the product of these velocities, and angles between the radius vector and these velocities. The second force is directed along velocities. If the charge inside is at rest, the force is proportional v_2^2, and is maximal at the center, where $\cos\theta_2 = 0$ because $\mathbf{r}_{21}\perp\mathbf{v}_2$ there.

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Let us clear up mechanical qualities of the two-charges system under consideration. Let us emphasize that (4.1)-(4.3) suppose that external forces which induce charges' velocities and accelerations acts on the system. Formulas for $\mathbf{F_{12}}$ and $\mathbf{F_{21}}$ contain non-central terms, and therefore classical mechanical theorems cannot be transferred directly on the system under our consideration. The aim of this section is to show that all these theorems are valid in our case as well.

The principle force vector

$$\mathbf{F}_{\text{int}} = \mathbf{F}_{12} + \mathbf{F}_{21} \equiv 0 \tag{10.1}$$

Integrating this identity with respect to time and along an arbitrary trajectory in space, one obtains

$$\int_A \mathbf{F}_{\text{int}} dt = \text{const.} \tag{10.2}$$

$$\int_B \mathbf{F}_{\text{int}} dx = 0 \tag{10.3}$$

Equalities (10.2) and (10.3) imply the validity of two theorems:

Theorem 1. *Internal forces do not change the system impulse.*
Theorem 2. *Internal forces do not produce work.*

Let us find the moment of internal forces. Let O be an arbitrary point in space, $\mathbf{r}_1$ be radius vector from O to q_1 and $\mathbf{r}_2$ be radiusvector from O to q_2. The internal forces' principal moment with respect to O is

$$\begin{aligned}\mathbf{M}_{\text{int}} &= \mathbf{r}_1 \times \mathbf{F}_{21} + \mathbf{r}_2 \times \mathbf{F}_{12} = (\mathbf{r}_1 - \mathbf{r}_2) \times \mathbf{F}_{21} = \\ &= (\mathbf{r}_2 - \mathbf{r}_1) \times \mathbf{F}_{12} = \mathbf{r}_{21} \times \mathbf{F}_{21} = \mathbf{r}_{12} \times \mathbf{F}_{12}\end{aligned} \tag{10.4}$$

Eq. (10.4) implies the validity of:

Theorem 3. *A moment of force transferred to the system by external forces does not depend on the point of its application, and creates two moments of* *force acting on the charges. These moments are modulo equal and codirected. They can be considered as a force couple applied to radius vector.*

The notion of 'force couple' is used in mechanics to describe solid body movement. It determines solid body rotation if the couple arm is not zero. Zero occurs only if the forces in the couple are directed along lines that are not just parallel, but *identical*. Only the special case of a zero couple does not influence solid body movement.

We can interpret **Theorem 3** as application of the force couple idea to radius vector, or to be more accurate to its ends. This force couple not only rotates the radius vector, but also deforms it: expands or compress it when the forces are directed along the same straight line. Just this case corresponds radial forces. This means that in our case, a force couple with zero arm also has understandable physical meaning.

Charges are situated on the ends of a radius vector. Thus we come to the connection between **Theorem 3** and Newton's third law in mechanics.

It is widely accepted that the assertion that action and counteraction forces are directed oppositely means that they are directed along the same straight line. The author has heard such assertions from mechanics professors. Therefore, they believe that all non-radial forces cannot satisfy Newton's third law. They assert that, for instance, the Lorentz force formula cannot satisfy Newton's third law because it contains a non-radial term (look for instance in [13]). Certainly when we speak about point-like masses, we have no other choice. But the situation essentially changes when we speak about real physical bodies.

It was mentioned in Section 1 that all the forces in 18th and-19th century physics were radial. This tradition comes to us as we see. But it is difficult to agree with such an understanding of Newton's third law. If that understanding were correct, then, for instance, the billiard game could not exist. The passive ball would just continue the trajectory of the active one, not changing it. In other words, such an understanding for interaction of mechanical bodies leaves only head-on collision, and excludes oblique collisions.

At first I thought that **Theorem 3** generalized the third Newton law for general electrodynamics. But recently I read its formulation in a textbook [28]. The author Putilov just stresses that in general the action and counteraction forces in the third Newton law are directed along parallel straight lines. As an example, he proposes interaction of 'magnetic poles'. Thus we can assert now that **Theorem 3** just corroborates validity of Newton's third law in general electrodynamics.

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But the very law should be formulated as follows: in collisions of real mechanical bodies, action and counteraction moments of force are modulo equal and co-directed.

Example 1. Let us find the force moment produced on the charge in **Example 3** of **Section 5**. The force $\mathbf{F}_{21}$ is defined by (4.6)

$$\mathbf{r}_{21}\times\mathbf{F}_{21}=\frac{-2q_1q_2v\cos\theta}{2\pi\varepsilon_0 r^2c^2}(\mathbf{r}_{21}\times\mathbf{v})=\mathbf{r}_{12}\times\mathbf{F}_{12} \qquad (10.5)$$

Eq. (10.5) means that both arms work the same.

Example 2. Let us find the force moment produced on the charges in Example 3 of Section 7. The force $\mathbf{F}_{21}$ is defined by (7.3).

$$\mathbf{r}_{21}\times\mathbf{F}_{21}=\frac{q_1\lambda}{2\pi\varepsilon_0 rc^2}\left[(\mathbf{r}_{21}\times\mathbf{v}_2)-[\mathbf{r}_{21}\times(\mathbf{v}_1-\mathbf{v}_2)]\right]=\mathbf{r}_{12}\times\mathbf{F}_{12} \qquad (10.6)$$

Only the first equality here is valid in accordance to Lorentz force, *i.e*. only one arm works if we limit ourselves with present-day electrodynamics.

The Lorentz force predicts appearance of not only radial force, but also force directed along velocity as well; *i.e*., mechanically it describes oblique impact, but predicts rotation of only one of the interacting bodies, and not of the second one.

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CONCLUSION

Let us briefly repeat the main points to which we have come above:

1. Certain generalizations of the traditional Maxwell equations have been proposed here. The new aspects of these generalizations are:

a) The divergence of the magnetic field is assumed to be non-zero; *i.e.*, the existence of magnetic charge is accepted. But such charge does not coincide with Dirac's monopole in many aspects. It is closely connected with the magnetic moment of the electrically charged particles, and in this sense it may be considered as another incarnation of the electric charge. But in contrast to electric charges, no force similar to the Coulomb one appears between two magnetic charges at rest. They begin interact only in motion.

b) Total time derivatives instead of the partial ones are used in the equations. Physically this means that we can take into account the ether, *i.e*. the medium in which electromagnetic waves propagate. For this, the direct current that is introduced into the traditional Maxwell equations 'by hand' turns out to be one of the two items forming the convective part of the total time derivative. The second part of it is a curl expression that appears when an electric wave is described, and which was not explicitly a subject of investigation in the Maxwell system.

Mathematically, this means that the generalized Maxwell system is Galileo invariant, and we do not need to use Lorentz transformations: the total time derivatives take it into consideration automatically. In addition, the generalized Maxwell equations have a good mathematical peculiarity: in contrast to traditional equations, they have solution in the case of 'bare' charge.

2. The last mathematical peculiarity of the Generalized Maxwell equations enables us to propose some new approaches to the concepts of the fields and their interaction.

a) Fields are defined not in terms of a force acting on a charge, but rather just as a solution of the Generalized system. It is shown in Appendix 1 that the electric field has the mechanical dimension of velocity, and the magnetic field is non-dimensional and means rotation angle.

b) Thus we turn out to be able to describe the interaction between charges with the help of interaction between fields induced by these charges. Interaction energy and interaction impulse are constructed with the help of the fields. The gradient of interaction energy supplies us with the Huygens part of the force, and the time derivative of the interaction impulse gives us the Newtonian part of it. The formula obtained describes all the experimental results known to the author.

3. Some examples are investigated.

a) A case usually investigated nowadays within the framework of Relativity theory is examined. An alternative formula is proposed.

b) A peculiarity of the interaction between two electrically charged beams is investigated. The existance of a 'cluster effect' is predicted.

c) It is shown in Appendix 1 that the electric permittivity constant ε_0 means free ether mass density, and the magnetic permeability constant μ_0 means free ether compressibility. Both are different in different substances. Examples are proposed to show that many qualities of capacitors, solenoids, diamagnetics and paramagnetics are determined by ε and μ in these bodies.

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REFERENCES

1. H. Poincaré, **On the Science**, p. 68-69 (Russian edition, Nauka, Moscow, 1983).
2. Z.I. Doctorovich. **Electromagnetic Paradoxes and the Ways to Avoid them**. Natural Sciences, vol. 1, no. 3, pp. 15-27, 1996 (in Russian).
3. D.E.Spencer, U.Y.Shama, **Gauss and Electrodynamic Force**, The mathematical Heritage of C.F.Gauss, World Scientific, Conference Singapore, 1991, p.693-694.
4. E. Purcell, **Electricity and Magnetism** (Russian edition, Nauka, Moscow, 1983).
5. L.I. Sedov, **Mechanics of Continious Media**, vol. 1, p. 307-308 (in Russian, Nauka, Moscow, 1976),
6. R. Feynman, R, Leighlon, M. Sands, **Feynman Lectures on Physics**, vol. 6 (Russian edition, Mir, Moscow, 1977)
7. D.E.Spencer, U.Y.Shama, **A New Interpretation of the Hafele-Keating Experiment**, p. 250 in Proceedings of International Conference **Fundamental Problems of Natural Sciences** (St. Petersburg, Russia, 1998),
8. C.E. Renshaw, **A Direct Test of the Lorentz Length Contraction**, Ibid, p.278.
9. **New Ideas in Natural Sciences**, Proceedings of the III International Conference **Space, Time, Gravity**, vol. 1, part 1 (St. Petersburg, Russia, 1995).
10. S. Marinov, **Divine Electromagnetism**, p. 82 (Eeast-West, Graz, 1993)
11. H. Grassman, **Eine Theorie der Elektrodynamik**. Annalen der Physik und Chemic 64, 1-18 (1845)
12. A.A.Ampere, **Memoires de I'Academi de Paris** 6, 175 (1823)
13. E.T. Whittaker, A. **History of the Theories of Aether&Electricity**, p.91 (Longman, Green and Co.London, 1910)
14. P.D. Prussov, **Ether Occurrence**, part 2, p. 35 (in Russian, Nikolaev, 1994).
15. Ju.K.Saharov. **Contradictions Between Modern Concepts of the Charged Particles Radiation and Atom Construction**, Proceedings of International Conference **Space, Time, Gravity** (Polytechnica, St. Petersburg, 1997).

16. R.Feynman, R.Leighton, M.Sands. **Feynman Lectures on Physics**, vol. 5, p. 99 (Russian edition, Mir, Moscow, 1997).
17. J.G.Klyushin, **Proton Structure: an Experimental Approach**, Proceedings of the Natural Philosophy Alliance, vol. 1, no. 1, p. 51 (Spring 2004).
18. J.G.Klyushin, **Electro-and-Gravi-dynamics**, Journal of New Energy, vol. 7, no. 3, p. 57 (2000).
19. J.G.Klyushin. **Mechanical Dimensionality for Electrodynamic Quantities**, Ibid, p. 53.
20. J.G. Klyushin, **Wave solution of generalized Maxwell equations and quantum mechanics**, Part 1, Galilean Electrodynamics **15**, Special Issues, Number 2 (2004).
21. J.G.Klyushin, **Hydrogen Atom Construction: Non-Bohr Approach**, Ibid, p. 45.
22. J.G.Klyushin, **A Field Generalization for the Lorentz Force Formula**, Galilean electrodynamics, vol. 11, no. 5, p. 83 (2000).
23. www.physical-congress.spb.ru
24. H.R.Hertz, **Electric Waves**, chap. 14 (Dover, NY, 1962,)
25. T.E. Phipps, Jr,, **Old Physics for New** (Apeiron Montreal, 2006).
26. W. Voigt, II, Goett.Nachr.-1887.-S. 41 (1887).
27. A.A. Eichenwald, Ann. Phys. (Leipzig), vol. 11, No. 1 (1903).
28. A.A. Eichenwald, **Selected Papers**.-M.:Znanie, 1956.-p.9-109
29. A.A. Eichenwald, **About Magnetical Action of Bodies, Moving in Electrostatic Field**.- M.:University, 1904.-p.144.
30. M. Born, **Einstein Relativity Theory and it's Physical Foundation**. L.-M.: ONTI, 1938.-p.268.
31. W. Weber, **Werke**, vol. 3, pp. 25-214 (Springer, Berlin, 1893).
32. P. Graneau, **Ampere-Newton Electrodynamics of Metals**, 2nd ed (Hadronic Press, Palm Harbor, F11, 1994).
33. P. and N. Graneau, **Newtonian Electrodynamics** (World Scientific, Singapore, 1996).
34. **Mathematical Encyclopedia**, "Sovetskaya Encyclopedia", p. 715 (Mir, Moscow, 1977).
35. K.A.Putivol, **Physics Course** (in Russian, Physmathgiz, 1963).
36. J.G. Klyushin, Principles of Modern Electrodynamics. S-Pb, Russia, 2006.

37. J.G. Klyushin, **Wave Solution of Generalized Maxwell Equations and Quantum Mechanics**, Part 1, Galilean Electrodynamics **15**, Special Issues, Number 2 (2004).

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APPENDIX 1

Mechanical Dimensionalities of Electro- and Gravidynamic Fields

The Static law of gravity means that mass M at distance r creates the static gravitational field:

$$G = \gamma \cdot M / r^2$$

Taking into account that the gravitational constant γ has mechanical dimensionality $m^3/kg\ s^2$, one obtains that gravitational field has dimensionality of acceleration m/s^2.

The Electric charge at distance r creates static Coulomb field:

$$E = q / 4 \cdot \pi \cdot \varepsilon_0 \cdot r^2$$

where ε_0 is electric 'permittivity' constant.

But we can say nothing about the mechanical dimensionality of E until the mechanical dimensionality of electric charge q is defined. If we could do this, we would obtain a clear formal relationship with mechanics, and between gravity and electricity.

In this author's papers [2] and [6], it is shown that the electric charge has dimensionality kg/s, and the electric field has dimensionality of velocity, *i.e.* m/s. The electric constant ε_0 has dimensionality of mass density, *i.e.* kg/m^3. Its physical meaning is mass density of free ether. The aim of this Appendix is to extend these results on electrodynamic and gravidynamic fields.

In papers [1] and [2], it was proposed to describe the gravity field with the help of Maxwell type equations in which the first time derivatives are changed for the second time derivatives. This means, in particular, that gravitation is understood as a field of accelerations, in contrast to electricity, which is a field of velocities. Respectively, these fields are characterized with constants that have the dimensionality of acceleration for gravity and the dimensionality of velocity (light speed *c*) for electricity.

Gravity preserves its one natural mechanical dimensionality. It has dimensionality of acceleration, and its charge is mass. But several dimensionality systems are used in electrodynamics. To my knowledge, scientists who use a certain system are its devoted supporters, and do not see any problems with its usage.

All can agree on the following point. Really, physics in general, and electricity in particular, may be studied in any language: in English, Chinese, or even Russian. But for every individual, there is among all of them a unique, preferred language. In this language, our intuition works better, we understand the interdependence of different phenomena better, we better express our ideas better, and we understand other persons better. This is our native language.

Do physicists have such a language? I am sure they have. This language is language of mechanics. Therefore, the method of gravity description mentioned above should be considered natural and understandable, and all dimensionality systems used in modern electrodynamics should be recognized as artificial and inconvenient. If the electric field has dimensionality of velocity, then all electrodynamic values obtain mechanical dimensionalities. In particular, electric charge has dimensionality kg/s, *i.e*. mass time derivative.

In different times, different authors have come to this conclusion, although starting from different concepts. Papers by Aszukovsky [3] and Prussov [4] must be mentioned in this connection. But it is not enough for us to know dimensionalities of the described objects. We must translate electrodynamic values used in present-day terms into terms of mechanics.

That is what V.A. Aszukovsky writes in discussing this problem in his paper [3] (page 49). He comes to conclusion that the electric constant ε_0 means mass density ρ of ether, and that dimensionality 'Farad' corresponds mechanical dimensionality kg/m^2. He concludes from here that ether mass density must be equal to 8.85×10^{-12} kg/m^3 because $\varepsilon_0 =$ 8.85×10^{-12} F/m. But this conclusion is wrong because it rests on a logical flaw. The fact that capacitance is measured in Farad and kg/m^2 does not mean that 1F = 1kg/m^2. And just such a correlation between units we must find in order to transform one dimensionality into another one. One easily sees that the assertion that mass may be measured in grams and kilograms does not mean that 1g = 1kg. Therefore, other quantitative evaluations in Aszukovsky book [3] seem to be unnatural.

An experiment in which electric and gravitational forces are compared is needed to answer our question. The best-known one is the experiment in which gravitational attraction and electric repulsion between two electrons is compared.

(A1.1)

APPENDIX 1. DIMENSIONALITIES

This number is taken from Feynman lectures [9]. Here q is electron charge, m is electron mass, ε_0 and γ are electric and gravitational constants.

In order to use this equality, we must adopt a certain model of elementary particles in general, and of the electron in particular. Some authors (in addition to above-mentioned Aszukovsky and Prussov, F.M. Kanarev [5] should be mentioned) proposed models of elementary particles as follows: ether particles form a torus performing two curling movements: in equatorial and meridional planes. The Similarity between models of this author and the above-mentioned authors stop here, as these rotations are prescribed different physical meanings. The present author believes that the equatorial rotation determines electric charge, and the meridional rotation determines the spin of the particle.

The electron's charge is:

$$q = m\omega \; F_{\text{elec.}} / F_{\text{grav.}} = q^2 / \gamma \cdot \varepsilon_0 m^2 = 4.17 \times 10^{42} \quad \text{(A1.2)}$$

where m is its mass and ω is the equatorial rotation angular velocity.

Such a description of the charge is a natural consequence of the idea of translational movement in kinematics. As my reader may remember, the velocity of translational movement of a massive point is linked with rotation, and described there with the help of vector product of the radius vector and the angular velocity vector. This author used exactly this idea in paper [6].

Substituting (A1.2) into (A1.1) one obtains:

$$\omega^2 / 4\pi \cdot \gamma \cdot \varepsilon_0 = 4.17 \times 10^{42} \quad \text{(A1.3)}$$

We are compelled now to adopt some suppositions linking the gravitational constant γ and electric constant ε_0. Paper [2] yields that the electric field is a special case of the gravitational one. This means that ε_0 and $1/\gamma$ must be numerically equal (perhaps with the accuracy of 2π). The difference in dimensionalities is a consequence of the dimensionality difference between electric charge and mass. The difference in static gravitational and electric forces is determined by the angular velocity value ω in (2). $1/\gamma$ has dimension kg/m^{3}s^2, and the mechanical dimension of ε_0 is kg/m^3.

Assumption: $$8\pi \cdot \gamma \cdot \varepsilon_0 = 1\,\text{rad}^2/\text{s}^2 \quad \text{(A1.4)}$$

Angular velocity squared unit is in the right hand part here. In other words, we suppose that $1/4\pi\gamma$ and ε_0 are numerically equal with the accuracy of 2π .

Taking (A1.4) and (A1.3) into account, one obtains

$$\omega = 8.1 \times 10^{20}\,\text{rad/s} \quad \text{(A1.5)}$$

This number is close to the Compton electron angular velocity

$$\omega_S = 7.8 \times 10^{20}\,\text{rad/s} \quad \text{(A1.6)}$$

We can take (A1.6) as accurate equatorial angular velocity for electron taking experimental errors into account. This number is in accord with the spectral analyses data in the framework of ethereal (non Bohr) model of elementary particles ([7], [8]). The author does not know any experimental facts contradicting evaluation (6).

Equality (A1.6) enables us to express all electrodynamic units in mechanical terms. Some of them are reproduced below:

Electric charge: $$e = 7.1 \times 10^{-10}\,\text{kg/s} \quad \text{(A1.7)}$$

Correspondingly: $$1K = 4.44 \times 10^{9}\,\text{kg/s} \quad \text{(A1.8)}$$

Electric constant: $$\varepsilon_0 = 1.9 \times 10^{8}\,\text{kg/m}^3 \quad \text{(A1.9)}$$

Magnetic constant: $$\mu_0 = 5{,}84\ 10^{-26}\ \text{ms}^2/\text{kg} \quad \text{(A1.10)}$$

Note that ‘electric constant’ means ‘free ether mass density’ and ‘magnetic constant’ means ‘free ether compressibility’.

Free ether impedance: $$1/\varepsilon_0 e = 1.75 \times 10^{-17}\,\text{m}^2\text{s/kg} \quad \text{(A1.11)}$$

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It is known that it is equal to 377Ohm. Thus:

$$1\text{Ohm}=4.65\times10^{20}\,\text{m}^2\text{s/kg} \tag{A1.12}$$

$$1\text{Ampere}=4.44\times10^{9}\,\text{kg/s}^2 \tag{A1.13}$$

$$1\text{Volt}=1\text{Ohm}\times1\text{Ampere}=2.07\times10^{-10}\,\text{m}^2\text{/s} \tag{A1.14}$$

Aszukovsky [3] was right: the mechanical dimensionality of capacitance is kg/m^2. But

$$1\text{Farad}=1K/1\text{Volt}=2.14\times10^{19}\,\text{kg/m}^2 \tag{A1.15}$$

One can express other electrodynamic values in mechanic terms in the same way.

There is no dimensionality problem for gravidynamic field. Just as in the static case, the gravidynamic field has dimension of acceleration, and is characterized with a certain acceleration constant a that plays the same role for it that light speed c plays for the electrodynamic field.

Let us note that the static gravitational force $m\mathbf{G}$ and static electric force $q\mathbf{E}$ may be considered as two items in the Newtonian definition of the force as impulse time derivative.

$$d(m\mathbf{V})/dt=m\mathbf{G}+q\mathbf{E}\ . \tag{16}$$

Here $\mathbf{G}=d\mathbf{V}/dt$, and $q=dm/dt$, $\mathbf{E}=\mathbf{V}$.

Links between electricity and gravity are investigated in greater details in paper [2].

References to Appendix 1

1. J.G. Klyushin, “On the Maxwell Approach to Gravity”, Report in seminar of St. Petersburg Physical Society (St. Petersburg, Russia, 1993).
2. J.G. Klyushin, “Electro- and Gravidynamics”, Journal of New Energy, Vol. 7, No. 3, p. 57 (2003).

3. V.A. Aszukovsky. **General Etherodynamics**, (Russian, Energoizdat, Moscow, 1990).
4. P.D. Prussov, **Physics of the Ether** (Russian, Nikolaev, 2003).
5. F.M. Kanarev. **Principles of Microworld Physchemics** (Russian Krasnodar, 2002).
6. J.G. Klyushin. "Mechanical Dimensionality for Electrodynamic Quantities", Journal of New Energy, Vol. 7, No. 3, p. 51 (2003).
7. J.G. Klyushin, "Proton Structure: an Experimental Approach", Proceedings of the NPA, Vol. 1, No. 1, p. 51 (Spring.2004).
8. J.G. Klyushin, "Hydrogen Atom Construction: a Non-Bohr Approach", Ibid, p.45.
9. R. Feynman. R. Leighton. M. Sands, **Feynman Lectures on Physics**,Vol. 1, p. 138 (Russian Edition, Mir, Moscow, 1977) .

APPENDIX 2

On the Connection between Electricity and Gravity.

When Einstein moved from analyses of Electricity to analysis of Gravity, he adopted as a first postulate the concept of equivalence of gravitational field and acceleration. This means that he considered Gravity as a field of acceleration, in contrast to Electricity, which is the field of velocities. The next natural step would have been to introduce a new constant with the dimension of acceleration, which had to somehow characterize Gravity in the same sense as the speed of light characterizes Electricity.

Einstein did not go this way. We know the result: General Relativity Theoty (GRT) has very limited applications.

In 1993 the author proposed to describe Gravity by equations of the Maxwell type in which first time derivatives are replaced by second ones. This approach leads to predictions of perihelia shifts of planets, differential rotation of the Sun and gaseous-liquid planets, the proximity of natural satellites' orbits to equatorial plane of their central body, the Earth's continental drift, the observed type of atmosphere and ocean currents, *etc*.

1. Historical Review

When Gauss and his assistant Weber proposed their generalization of Coulomb's law for the case of moving charges, many investigators immediately tried to apply the Gauss and Weber law to gravity. Such an approach looks quite natural because the static law of Gravity and the Coulomb formula look so similar.

The dynamic part of the Gauss and Weber law depends on the difference between velocities of electric charges. The calculations were first applied to explain the perihelion advance of Mercury's orbit. This problem was very acute at that time. Observations showed that Mercury's perihelion mysteriously shifts approximately 43" per century beyond the much larger amount that can be accounted for by Newtonian interactions with the other planets. All earlier attempts to explain the 43" discrepancy within the framework of the Newtonian gravitational law had no success.

But the new attempts were also unsuccessful. Weber's formula predicted 14" per century and Gauss' formula gave 28" per century. These attempts have been renewed recently in connection with the new wave of interest to Gauss and Weber works [1,2]. Historically, the first one who obtained the desired 43" was Gerber [3]. His paper was recollected [4] when Einstein also obtained 43” within the framework of GRT. Fierce discussion followed this publication. Unfortunately, the interests of different nations and financial and scientific circles influenced the final scientific outcome of the dispute. More unfortunately, we observe something like this nowadays as well.

At last it was decided that Gerber’s formula was just an adjustment to a preliminary known fact. There were two additional arguments on the side of GRT. It predicted ‘gravitational red shift’ and ‘double deviation’ of star light in the field of the Sun. It soon became clear that the ‘red shift’ was actually predicted within the framework of Newtonian mechanics. But the double deviation was not, and was ‘confirmed’ by experiment. Only nowadays do certain doubts appear. The problem is that it is impossible, even today, to clearly identify this effect against the background of non-calm Sun. The question is how Eddington and others were so lucky as to do this at the beginning of the 20th century.

But the main problem of GRT today is lack of any practical application.

When the new Maxwell field theory eclipsed the Gauss approach, attempts to apply the electromagnetic approach to gravity renewed.

The first one who made an attempt was Maxwell himself. But soon he came to the conclusion that any direct analogy contradicts the law of energy conservation. He concluded this mainly because opposite signs appear in Newton and Coulomb laws: two electric charges of the same sign are repulsed and two masses are attracted.

Despite this, such attempts continued in different countries: England, France, Russia, and others. The best was the one by Heaviside [5]. It was unsuccessful, just as others, including recent ones. There are many causes for this. We mention here the one that is related to Maxwell’s objections.

Field equations do not describe interactions, neither of charges nor of fields. Therefore, modern electrodynamics consist of two parts: Maxwell’s equations, which describe fields, and the Lorentz formula, which describes interactions. The formulas of Gauss and Weber ([1],[2]), as well as the ones of Grassman [6], Ampère [7], and Whittaker [8], describe interaction of current differentials. They do not need fields. It would be natural if field theory supplied us with a formula describing interaction of fields. But the Lorentz force formula takes an intermediate position. It takes one charge, called the ‘test charge’, whose field is ignored, and defines the interaction of this test charge with the fields induced in accord with Maxwell’s equations by other ‘ordinary’ charges.

Such an approach has many drawbacks. One of them is the following: the Lorentz force formula is asymmetric. It predicts situations when charge no. 1 affects charge no. 2, but not *vice-versa*; *i.e*., Newton's third law is violated.

One can express the idea of the Lorentz force formula differently. If, in accord with Maxwell equations, we express fields by means of charges, and put them into the Lorentz force formula, we obtain the Grassman formula [6]. This means that if we limit ourselves to the Lorentz force formula, the entire Maxwell system becomes unnecessary, and one can always use Grassman's formula instead of modern electrodynamics. But Grassman's formula covers very specific cases of charge interactions. Other cases are described by other formulas, the above mentioned ones in particular.

But why was no formula describing interaction of fields proposed? I believe there were historical causes. I would mention one frequently used argument in support of the Lorentz formula. It is alleged that two fields do not interact. Example: two light beams freely intersect each other. And photons are believed to be the transmitters of fields. One objection to this assertion was mentioned above: any field induced by a charge can be expressed by means of this charge in accord with Maxwell equations. We shall come to the second objection below.

Thus we can assert that we must re-examine electrodynamics problems before we try to apply this approach to gravity.

2. Generalized Electrodynamics

The author proposed a certain generalization of Maxwell's equations whose solutions were found for the case of charges and photons [9,10]. It turned out that photons were described with functions of complex variables, with the part of photon energy defined by the imaginary part. Solutions for charges and photons correspond to different initial conditions. Thus the fields generated by photons and charges are partial solutions of generalized Maxwell equations. Therefore, the interaction formula for photons differs from that for charges.

A formula describing fields' interaction was proposed within the framework of Generalized Electrodynamics. It covered the Lorentz and other above-mentioned force formulas. It also contained additional terms, which predicted new effects, the charge cluster effect in particular.

Two concepts of force are used when the generalized interaction formula is constructed. The first one is Huygens' idea that force is energy gradient. The second one is the Newtonian understanding of force as an impulse time derivative. Modern mechanics uses both approaches to analyze the movement of isolated bodies, although the very idea of force implies interaction. These approaches are believed to be equivalent. And this is indeed so, provided the bodies' masses are constant.

The picture essentially changes if interaction between fields is taken into account. Electrodynamic fields generated by two charges depend on the charges' value, their velocities and distances between them. We obtain the interaction energy by taking the scalar product of electric fields, and interaction impulse by taking the vector product of magnetic fields. But we come to different expressions when we calculate corresponding derivatives.

The idea of energy-gradient force incorporates Coulomb, Lorentz (Grassman), Ampère and Whittaker forces. The dynamic part of this energy-gradient force depends on the product of velocities, and is zero if at least one of the above discussed charges does not move. Uncritical use of the Lorentz force formula in modern physics resulted in a strange assertion that interaction forces between two charges at rest, *vs*. one charge moving and other one at rest, are equal. This is certainly wrong, and a simple experiment shows that in the latter case an extra force appears in addition to Coulomb's force. In particular, this additional force is predicted by the second, Newtonian, part of the generalized force.

This second part of the generalized force depends on differences between velocities and between accelerations. It covers the Gauss and Weber formulas, and adds new terms to them, which symmetrize them in the same sense as the gradient part symmetrizes Lorentz force formula. The Newtonian part of the generalized force does not contain static terms analogous to Coulomb force; *i.e.*, it does not predict interaction between 'static magnetic fields'.

3. On the Gravidynamic Field and Force

In the early 1980's, the author proposed a variational 'Logarithm Principle', in which fields, in particular the gravitational field, are described by Maxwell type equations in which first time derivatives are replaced by second time derivatives, and constant acceleration a plays the role of light speed c in electrodynamics. In the first version, a certain analog of the Lorentz force formula was adopted [11], but instead of electric charges and their velocities, masses and their accelerations appeared. This scheme was presented at St. Petersburg Physical Society meeting in 1993 [11].

APPENDIX 2. ELECTRICITY-GRAVITY CONNECTIONS

Already at this stage, it became possible to explain many gravity phenomena. They were well known, but to the best of our knowledge, no attempts had been made to explain them.

Most of the proposed explanations were essentially related to the gravimagnetic field that appears in the equations. For instance, movement of planets in the Sun's gravimagnetic field leads to the emergence of several forces. One force is radial, and defines planets orbits displacement. The second one is directed towards Sun equatorial plane, and drives orbits into this plane. That is why most of the orbits of natural satellites are close to the equatorial plane of the central body. Orbits behave like a current loop in an electromagnetic field. The main difference is that the forces are small and process is slow.

The third force is directed tangentially, and either enhances or counteracts the planet's movement. This very force increases or decreases the angular velocity of the planets' own rotation, depending of the sign of gravimagnetic field. Apparently, these forces produce effects in galaxies that are today ascribed to 'dark mass', and they explain the following observed fact: young stars in our Galaxy rotate slowly, mature stars rotate fast enough, and old stars again rotate slowly. And the gravimagnetic field distribution in the Earth controls atmospheric and ocean currents and continental drift. The same force leads to differential rotation of the Sun and gaseous-liquid planets: equatorial regions rotate faster than polar ones.

It was clear from the very beginning that the gravimagnetic field is closely related to the electromagnetic field. Today, we understand that the magnetic and electric fields are just special cases of gravity. Thus we can discuss the magnetic field only in all the cases.

It is known that Earth's magnetic field oscillates, and even changes sign. To-day we do not know the cause of such behavior, but we can state that the rate of Earth's rotation, continental drift and ocean currents are closely linked to the behavior of Earth's magnetic field.

Generalization of gravimagnetics in the way electrodynamics was generalized shows that the interaction of masses depends not only on accelerations, but also on the third and forth time derivatives as well. Newtonian attraction appears with the correct sign in such a generalization, and predicts attraction of two masses.

References to Appendix 2

[1] Andre K.T. Assis, **Relational Mechanics** (Apeiron, Montreal, 1999)

[2] D.E. Spencer, G. Coutu, W.W. Bowley, U.Y. Shama, P.J. Mann. “The Experimental Verification of the New Gaussian Equation for the Force between Moving Charges : Overhead Welding”, International Conference on Space, Time and Motion, September 23-29, 1996, St. Petersburg, Russia.

[3] P. Gerber Die r**ä**umliche und zeitliche Ausberichtung der Gravitation, ztschr., math. und phys., 1898, Bd. 43, s. 93-103.

[4] Gerber P. Die r**ä**umliche und zeitliche Ausbertung der Gravitation. – Ann.Phys., 1917, bd. 52, s. 415-422.

[5] O.A. Heaviside, “Gravitational and Electromagnetic Analogy”, The Electrican, p. 281-282, 359 (1893).

[6] H. Grassman. “Eine Theorie der Elektrodynamik”, Annalen der Physic und Chemic **64**, 1-18 (1845).

[7] A.A. Ampère, Memories de l’Academic de Paris **6**, 175 (1823).

[8] E.T. Whittaker, **A History of the Theories of Aether & Electricity**, p. 91 (Longman, Green and Co., London, 1910)

[9] J.G. Klyushin. “A field Generalization for the Lorentz Force Formula”, Galilean Electrodynamics **11** (5) 90 (2000).

[10] J.G. Klyushin. “Wave solution of Generalized Maxwell Equations and Quantum Mechanics, Part 1”, Galilean Electrodynamics **15**, Special Issues 2, GED-East, Fall 2004.

[11] J.G.Klyushin. “On the Maxwell Approach to Gravity”, Report in seminar of St.Petersburg Physical Society. St.Petersburg, Russia, 1995.

[12] J.G.Klyushin. “Electro- and Gravidynamics”, Journal of New Energy, vol. 7, no. 3, p. 57.

[13]. J.G.Klyushin. “Mechanical Dimensionality for Electrodynamic Quantities”, Journal of New Energy, vol. 7, No. 3, p. 51.

APPENDIX 3

On Gravidynamic Forces

A certain generalization of Maxwell equations was proposed in paper [1]. It implies the use of total time derivatives instead of the partial ones. A partial solution of this system was found for the case of the fields induced by electric charges.

The scalar product of electric fields created by different charges determines their interaction energy, and the vector product of their magnetic fields determines their interaction impulse. Having calculated interaction energy gradient, we obtain interaction force as Huygens understood it, and having calculated impulse total time derivative, we obtain Newton's interaction force.

It turns out that these forces' physical meaning and mathematical description essentially differ.

The gradient part depends on the product of charges' velocities, and is equal to zero if at least one of the charges is at rest. This part incorporates force formulas proposed earlier by Ampere, Whittaker and Lorentz. The last one is usually defined by interaction of a certain charge, called 'test charge'. and the fields induced by the other charge. Actually it coincides with force formula proposed earlier by Grassman. The proposed formula, in contrast to Lorentz formula, satisfies Newton's third law.

The second Newtonian part of the force formula depends on the product of the differences of the charge velocities and accelerations. Therefore it predicts interaction, in particular, between moving and standing charges, in addition to Coulomb force. It contains terms proposed earlier for force description by Gauss and Weber. As in the case of the Lorentz force formula, it adds terms that make the Gauss and Weber force symmetric. A certain part of this force is inverse in squared light velocity c^2 and a part of it is inverse in c^3. Apparently these items are essential for the electroweak interaction.

This Appendix is devoted to a similar investigation of gravitational forces created by moving masses. Corresponding fields are described by Maxwell type equations in which first time derivatives are changed for the second ones. One can say that Electricity is a field of velocities and gravity is a field of accelerations. Solutions of such a system are used to construct interaction energy and interaction impulse. The gradient of the scalar product of corresponding gravitational fields, and second time derivative of vector product of gravimagnetic fields, turn out to give accurate analogs of electrodynamic interaction. But here forces depend not only on velocities and accelerations, but also on third and fourth derivatives as well.

Equations of Gravidynamic field

Let $\mathbf{G}$ be the gravidynamic field, and $\mathbf{D}$ be the gravimagnetic field, both of which are induced by moving mass m that is distributed in space with density ρ. We assume that functions describing these fields satisfy the following equations:

$$\mathrm{div}\mathbf{G} = \gamma\rho \tag{A3.1}$$

$$\mathrm{div}\mathbf{D} = -\gamma\rho / a \tag{A3.2}$$

$$\mathrm{rot}\mathbf{G} = -d^2\mathbf{D} / dt^2 \tag{A3.3}$$

$$a^2\mathrm{rot}\mathbf{D} = d^2 G / dt^2 \tag{A3.4}$$

where γ is gravitational constant, and a is constant acceleration, playing in gravidynamics the same role that light speeed c plays in electrodynamics. Thus we consider gravity as a field of accelerations, in contrast to electricity, which is a field of velocities.

System (A3.1)-(A3.4) is similar to generalized Maxwell equations [1]. It provokes the same questions as the traditional Maxwell system does. Thequestions are: in order to find two vector-functions **G** and **D** that are unknown in system (A3.1)-(A3.4), we need two vector equations, not more and not less. But system (A3.1)-(A3.4) contains two divergence equations in addition. Accurate analysis shows that divergence correlations, as in the Maxwell system (A3.1)-(A3.4), are actually not equations, but initial conditions for $\mathbf{G}$ and $\mathbf{D}$ written in divergence form. Therefore, instead of (A3.1) and (A3.2) we shall write

$$\mathbf{G}(0, r) = (\gamma\rho / 3)\mathbf{r} \tag{A3.5}$$

$$\mathbf{D}(0, r) = -(\gamma\rho / 3a)\mathbf{r} \tag{A3.6}$$

We come to (A3.1) and (A3.2) having calculated the divergence of (A3.5) and (A3.6). If we want to obtain for system (A3.3)-(A3.4) a partial solution, we must determine initial conditions not only for the fields (A3.5) and (A3.6) but also initial conditions for their time derivatives. These are determined by the physical essence of the problem. We accept here zero initial conditions for them, *i.e.*

$$\mathbf{G}'(0,\mathbf{r}) = 0 \tag{A3.7}$$

$$\mathbf{D}'(0,\mathbf{r}) = 0 \tag{A3.8}$$

In other terms we assume that initial impulse of the investigated mass is null. Mathematically this means that its initial velocity $d\mathbf{r}/dt$ and the initial velocity of its density change .. are zero.

Let $\mathbf{r}_0$ be the radius of the minimal sphere containing the mass m. We assume the following boundary conditions for this sphere

$$\mathbf{G}(t,\mathbf{r}_0) = -\frac{\gamma m}{4\pi r_0{}^3}\left(\mathbf{r}_0 \times \mathbf{w}/a - \mathbf{r}_0\right) \tag{A3.9}$$

$$\mathbf{D}(t,\mathbf{r}_0) = -\frac{\gamma m}{4\pi r_0{}^3 a}\left(\mathbf{r}_0 \times \mathbf{w}/a + \mathbf{r}_0\right) \tag{A3.10}$$

where t is in the interval $[0,\infty]$, $\mathbf{w}$ is acceleration of the mass m**,** which is obtained by integrating ρ over a sphere of radius $\mathbf{r}_0$ that contains it.

Conditions (A3.9)-(A3.10) fix the fields translational and rotational movement on the minimal sphere containing m.

$\mathbf{G}(t,\mathbf{r})$ and $\mathbf{D}(t,\mathbf{r})$ are functions of time and space coordinates (x_1, x_2, x_3) which we express with the help of radius-vector **r**. Thus we search for system (1.3)-(1.4) solution with initial conditions (1.5)-(1.6), (1.7)-(1.8) and boundary conditions (1.9)-(1.10).

Let mass m, which we obtain integrating density ρ over the volume inside of which this mass is distributed, move with velocity $\mathbf{v}$ and acceleration $\mathbf{w}$. Time derivatives will be designated by dot over the corresponding letter. Thus $\dot{\mathbf{w}}$ and $\ddot{\mathbf{w}}$ are the third and the forth time derivatives of radius vector $\mathbf{r}$. We assume the following limitation on the character of the movement of mass m

$$2(\mathbf{v}\times\dot{\mathbf{w}})+\mathbf{r}\times\ddot{\mathbf{w}}=0 \tag{A3.11}$$

This condition holds for an instant in the case of motion with constant acceleration $\mathbf{w}$ or when vector $\mathbf{v}$ is collinear to $\dot{\mathbf{w}}$ and $\mathbf{r}$ is collinear to $\ddot{\mathbf{w}}$. Condition (A3.11) holds in particular when two masses oscillate along parallel straight lines. When condition (A3.11) holds, the system (A3.3)-(A3.10) has the following solution

$$\mathbf{G}=\frac{\gamma m}{4\pi r^3}\left[-(\mathbf{r}\times\mathbf{w})/a+\mathbf{r}\right] \tag{A3.12}$$

$$\mathbf{D}=-\frac{\gamma m}{4\pi r^3 a}\left[(\mathbf{r}\times\mathbf{w})/a+\mathbf{r}\right] \tag{A3.13}$$

Eqs. (A3.12) and (A3.13) show that the gravidynamic field consists of not only a static part (the second part in square brackets), but also of the dynamic curl part (the first item in square brackets).

Let two masses m_1 and m_2 move inducing fields $\mathbf{G}_1,\mathbf{D}_1$ and $\mathbf{G}_2,\mathbf{D}_2$, and let their accelerations be $\mathbf{w}_1$ and $\mathbf{w}_2$. Let $\mathbf{r}_{21}=\mathbf{r}_1-\mathbf{r}_2$ be the radius vector from mass m_2 to mass m_1, $\mathbf{r}_1$ and $\mathbf{r}_2$ be radius vectors to masses m_1 and m_2, and $r=|\mathbf{r}_{21}|$.

We assume the following formula, which describes the forces with which fields $\mathbf{G}_2,\mathbf{D}_2$ act on fields $\mathbf{G}_1,\mathbf{D}_1$:

$$\mathbf{F}_{21}=-\mathrm{grad}\left[\frac{1}{\gamma}4\pi a r^3(\mathbf{G}_1\bullet\mathbf{G}_2)\right]+\frac{d^2}{dt^2}\left[\frac{1}{\gamma}4\pi a r^3(\mathbf{D}_1\times\mathbf{D}_2)\right] \tag{A3.14}$$

When (A3.12)-(A3.13) are substituted into (A3.14), one obtains for the gradient part

APPENDIX 3. GRAVIDYNAMIC FORCES

$$\mathbf{F}_{21}^{1}=-\frac{\gamma\, m_1 m_2}{4\pi r^3}\mathbf{r}_{21}+\frac{\gamma\, m_1 m_2}{4\pi r^3 a^2}\times$$
$$\times\left[\mathbf{w}_1\times(\mathbf{r}_{21}\times\mathbf{w}_2)+\mathbf{w}_2\times(\mathbf{r}_{21}\times\mathbf{w}_1)+\frac{1}{r^2}3(\mathbf{r}_{21}\times\mathbf{w}_1)\bullet(\mathbf{r}_{21}\times\mathbf{w}_2)\mathbf{r}_{21}\right]=$$
$$=-\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21}+\frac{\gamma m_1 m_2}{4\pi r^3 a^2}\times \qquad \text{(A3.15)}$$
$$\times\left[\mathbf{w}_1(\mathbf{r}_{21}\bullet\mathbf{w}_2)+\mathbf{w}_2(\mathbf{r}_{21}\bullet\mathbf{w}_1)+\mathbf{r}_{21}(\mathbf{w}_1\bullet\mathbf{w}_2)-\frac{3(\mathbf{r}_{21}\bullet\mathbf{w}_1)(\mathbf{r}_{21}\bullet\mathbf{w}_2)}{r^2}\mathbf{r}_{21}\right]$$

The expression after the second equality sign is obtained by revealing the triple vector products in the previous one.

The first item here determines Newtonian static force of gravity. We have obtained it not as a generalization of experimental information, but rather as an implication of fundamental correlation between energy and force. We obtained the Coulomb force in [1] just in the same way, but in contrast to Coulomb force Newtonian force in (A3.15) has opposite sign; *i.e.*, two masses are attracted, and not repulsed. Items in square brackets describe forces that appear because of movement of masses. The first two summands predict forces directed along accelerations of masses; the second two summands predict the appearance of forces additional to Newtonian force. They are directed along the radius vector.

All of these forces are zero if at least one of the masses is at rest, or moves with constant velocity. Actually, this is another formulation of the Newton's first law. One can name $\mathbf{F}_{21}^{1}$ the 'Huygens force'. We have obtained it following his concept of force as energy gradient. The difference is that he applied it to analysis of movement of a separate massive body. Formula (A3.14) uses this idea to describe the interaction of massive bodies with the help of interaction of the fields induced by these bodies.

One can say the same words about the second, Newtonian, part of the force (A3.14). The first time derivative of the second square brackets in (A3.14) supplies us with the fields' interaction impulse, and the second time derivative furnishes us the force formula. After corresponding calculations, one obtains: the first part of Newtonian gravidynamic force

$$\mathbf{F}_{21}^{2}=\frac{\gamma m_1 m_2}{4\pi a^2 r^3}\big[(\mathbf{w}_1-\mathbf{w}_2)\times[\mathbf{r}_{21}\times(\mathbf{w}_1-\mathbf{w}_2)]+2(\mathbf{v}_1-\mathbf{v}_2)\times$$
$$\times(\mathbf{v}_1-\mathbf{v}_2)\times(\mathbf{w}_1-\mathbf{w}_2)+2(\mathbf{v}_1-\mathbf{v}_2)\times[\mathbf{r}_{21}\times(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)]+ \qquad \text{(A3.16)}$$
$$+2\mathbf{r}_{21}\times[(\mathbf{v}_1-\mathbf{v}_2)\times(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)]+\mathbf{r}_{21}[\mathbf{r}_{21}\times(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)]\big]$$

This part of the Newton's dynamic force is inverse in a^2. The second part of it is a^3 inverse, and appears as follows:

$$\mathbf{F}_{21}^{3}=\frac{\gamma m_1 m_2}{4\pi a^3 r^3}\big[(\mathbf{r}_{21}\times\ddot{\mathbf{w}}_2)\times(\mathbf{r}_{21}\times\mathbf{w}_1)+(\mathbf{r}_{21}\times\mathbf{w}_2)\times(\mathbf{r}_{21}\times\ddot{\mathbf{w}}_1)+$$
$$+(\mathbf{w}_1\times\mathbf{w}_2)\times[(\mathbf{r}_{21}\times\mathbf{w}_1)-(\mathbf{r}_{21}\times\mathbf{w}_2)]+$$
$$+2[(\mathbf{v}_1-\mathbf{v}_2)\times\dot{\mathbf{w}}_2]\times(\mathbf{r}_{21}\times\mathbf{w}_1)++2[(\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2]\times[(\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_1]+ \qquad \text{(A3.17)}$$
$$+2[(\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2]\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_1)+2[(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)\times[(\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_1]+$$
$$+2[(\mathbf{r}_{21}\times\mathbf{w}_1)\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)]++2(\mathbf{r}_{21}\times\mathbf{w}_2)\times[(\mathbf{v}_1-\mathbf{v}_2)\times\dot{\mathbf{w}}_1)]$$

As was said above, permanent acceleration a plays the same part in gravidynamics that constant light velocity c plays in electrodynamics. There are certain reasons to believe that a is not less than c numerically, and perhaps is equal to it with 2π accuracy.

One obtains revealing triple vector products in (1.16)

$$\mathbf{F}_{21}^{2}=\frac{\gamma m_1 m_2}{4\pi a^2 r^3}\Big\{\mathbf{r}_{21}\Big[|\mathbf{w}_1-\mathbf{w}_2|^2+2(\mathbf{v}_1-\mathbf{v}_2)\bullet(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)+\mathbf{r}_{21}\cdot(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)\Big]+$$
$$+2(\mathbf{v}_1-\mathbf{v}_2)[(\mathbf{v}_1-\mathbf{v}_2)\bullet(\mathbf{w}_1-\mathbf{w}_2)+\mathbf{r}_{21}\bullet(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)]-(\mathbf{w}_1-\mathbf{w}_2)+ \qquad \text{(A3.18)}$$
$$+\Big[\mathbf{r}_{21}\bullet(\mathbf{w}_1-\mathbf{w}_2)+2|\mathbf{v}_1-\mathbf{v}_2|^2\Big]-4(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)\big[\mathbf{r}_{21}\bullet(\mathbf{v}_1-\mathbf{v}_2)]\big]-(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)\mathbf{r}^2\Big\}$$

The coefficient before the curly braces is equal to the corresponding coefficient before the dynamic gradient force; *i.e.*, they both have the same multiplicity. But this force depends on the differences of first, second, third and fourth time derivatives. The square brackets contain scalar products of such derivatives. The vectors pointing direction of the corresponding forces stay before the square brackets. They are radius vector derivatives of the zero, first, second, third and fourth order. All the summands, except one containing the fourth derivative, decrease as r^2. The term containing fourth derivative decreases as r. Just like the gradient part, this part contains terms directed along the radius and the 'deforming' static force of gravity.

By revealing the triple vector products in (A3.17) one obtains:

$$\mathbf{F}_{21}^{3} = \frac{\gamma m_1 m_2}{4\pi a^3 r^3}\Big\{\mathbf{r}_{21}\big[\mathbf{r}_{21}\bullet[(\ddot{\mathbf{w}}_1 \times \mathbf{w}_2) - 2(\dot{\mathbf{w}}_2 \times \dot{\mathbf{w}}_1) + (\mathbf{w}_2 \times \ddot{\mathbf{w}}_1)] + \\ +2(\mathbf{v}_1 - \mathbf{v}_2)\bullet[(\dot{\mathbf{w}}_2 \times \mathbf{w}_1) + (\mathbf{w}_2 \times \dot{\mathbf{w}}_1)]\big] + \\ +2(\mathbf{v}_1 - \mathbf{v}_2)\big[\mathbf{r}_{21}\bullet(\dot{\mathbf{w}}_2 \times \mathbf{w}_1) + (\mathbf{v}_1 - \mathbf{v}_2)\bullet(\mathbf{w}_2 \times \mathbf{w}_1) + \mathbf{r}_{21}\bullet(\mathbf{w}_2 \times \dot{\mathbf{w}}_1)\big] + \\ +(\mathbf{w}_2 - \mathbf{w}_1)[\mathbf{r}_{21}\bullet(\mathbf{w}_1 \times \mathbf{w}_2)]\Big\} \qquad \text{(A3.19)}$$

This force is a^3 inverse, in contrast to the (A3.18) force. If permanent acceleration a with which gravity moves is big enough, this means that this force is modulo less as (A3.18) (the first part of Newtonian gravidynamic force) as dynamic part of the gradient force (A3.15) (Huygens force). Just as in (1.18) vectors pointing force direction stay before square brackets in (A3.19). They are radius vector and velocities and accelerations differences Scalar values constructed from different radius-vector time derivatives from zero up to the fourth order stay in square brackets. They determine values of the corresponding force. (A3.19) contains items directed along radius and predicting force deforming static force just as in the case of forces (A3.15) and (A3.18).

In contrast to Huygens force (A3.15) forces (A3.18) and (A3.19) are not zero if one of the masses is in rest or moves with constant velocity. This means that the first Newton law is not universal and a certain although small additional force appears between masses moving with constant velocities. Forces (A3.18) and (A3.19) does not contain static item in contrast to Huygens force (1.15), *i.e*. they are zero if both masses are in rest. If masses m_1 and m_2 move with equal velocities, accelerations, the third and the fourth time derivatives force (A3.18) is zero but in general force directed along radius is not zero in (1.19) expression. One obtains finally : gravidynamic force acting on mass m_1 from moving mass m_2 is

$$\mathbf{F}_{21} = \mathbf{F}_{21}{}^{1} + \mathbf{F}_{21}{}^{2} + \mathbf{F}_{21}{}^{3} = -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} +$$
$$+\frac{\gamma m_1 m_2}{4\pi r^3 a^2}\left[\mathbf{w}_1\times(\mathbf{r}_{21}\times\mathbf{w}_2)+\mathbf{w}_2\times(\mathbf{r}_{21}\times\mathbf{w}_1)+\frac{3}{r^2}(\mathbf{r}_{21}\times\mathbf{w}_1)\bullet(\mathbf{r}_{21}\times\mathbf{w}_2)\mathbf{r}_{21}\right]+$$
$$+\frac{\gamma m_1 m_2}{4\pi r^3 a^2}\cdot$$
$$\cdot\left[(\mathbf{w}_1-\mathbf{w}_2)\times[\mathbf{r}_{21}\times(\mathbf{w}_1-\mathbf{w}_2)]+2(\mathbf{v}_1-\mathbf{v}_2)\times[(\mathbf{v}_1-\mathbf{v}_2)\times(\mathbf{w}_1\times\mathbf{w}_2)]+\right.$$
$$+2(\mathbf{v}_1-\mathbf{v}_2)\times \qquad (A3.20)$$
$$\left.\times[\mathbf{r}_{21}\times(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)]+2\mathbf{r}_{21}\times[(\mathbf{v}_1-\mathbf{v}_2)\times(\dot{\mathbf{w}}_1-\dot{\mathbf{w}}_2)]+\mathbf{r}_{21}\times[\mathbf{r}_{21}\times(\ddot{\mathbf{w}}_1-\ddot{\mathbf{w}}_2)]\right]+$$
$$+\frac{\gamma m_1 m_2}{4\pi r^3 a^3}\left[(\mathbf{r}_{21}\times\ddot{\mathbf{w}}_2)\times(\mathbf{r}_{21}\times\mathbf{w}_1)+(\mathbf{r}_{21}\times\mathbf{w}_2)\times(\mathbf{r}_{21}\times\ddot{\mathbf{w}}_1)+\right.$$
$$+(\mathbf{w}_1\times\mathbf{w}_2)\times[(\mathbf{r}_{21}\times\mathbf{w}_1)-(\mathbf{r}_{21}\times\mathbf{w}_2)]+2[(\mathbf{v}_1-\mathbf{v}_2)\times\dot{\mathbf{w}}_2]\times(\mathbf{r}_{21}\times\mathbf{w}_1)+$$
$$+2((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2)\times((\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_1)+2[(\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2]\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_1)+$$
$$+2(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)\times[(\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_2]\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_1)\times[(\mathbf{v}_1-\mathbf{v}_2)\times\mathbf{w}_1]+$$
$$\left.+2(\mathbf{r}_{21}\times\dot{\mathbf{w}}_1)\times(\mathbf{r}_{21}\times\dot{\mathbf{w}}_2)+2(\mathbf{r}_{21}\times\mathbf{w}_2)\times[(\mathbf{v}_1-\mathbf{v}_2)\times\dot{\mathbf{w}}_1]\right]$$

We obtain the following formula revealing triple vector products here

APPENDIX 3. GRAVIDYNAMIC FORCES

$$\mathbf{F}_{21} = -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \frac{\gamma m_1 m_2}{4\pi r^3 a^2}\cdot$$
$$\cdot\left[\mathbf{w}_1(\mathbf{r}_{21}\bullet\mathbf{w}_2) + \mathbf{w}_2(\mathbf{r}_{21}\bullet\mathbf{w}_1) + \mathbf{r}_{21}(\mathbf{w}_1\bullet\mathbf{w}_2) - \frac{3}{r^2}(\mathbf{r}_{21}\bullet\mathbf{w}_1)(\mathbf{r}_{21}\bullet\mathbf{w}_2)\mathbf{r}_{21}\right] +$$
$$+\frac{\gamma m_1 m_2}{4\pi r^3 a^2}\left\{\mathbf{r}_{21}\left[|\mathbf{w}_1 - \mathbf{w}_2|^2 + 2(\mathbf{v}_1 - \mathbf{v}_2)\bullet(\dot{\mathbf{w}}_1 - \dot{\mathbf{w}}_2) + \mathbf{r}_{21}\bullet(\ddot{\mathbf{w}}_1 - \ddot{\mathbf{w}}_2)\right] + \right.$$
$$+2(\mathbf{v}_1 - \mathbf{v}_2)[(\mathbf{v}_1 - \mathbf{v}_2)\bullet(\mathbf{w}_1 - \mathbf{w}_2) + \mathbf{r}_{21}\bullet(\dot{\mathbf{w}}_1 - \dot{\mathbf{w}}_2)] - (\mathbf{w}_1 - \mathbf{w}_2)\cdot \qquad \text{(A3.21)}$$
$$\left.\cdot\left[\mathbf{r}_{21}\bullet(\mathbf{w}_1 - \mathbf{w}_2) + 2|\mathbf{v}_1 - \mathbf{v}_2|^2\right] - 4(\dot{\mathbf{w}}_1 - \dot{\mathbf{w}}_2)[\mathbf{r}_{21}\bullet(\mathbf{v}_1 - \mathbf{v}_{22})\left.\right] - (\ddot{\mathbf{w}}_1 - \ddot{\mathbf{w}}_2)r^2\right\} +$$
$$+\frac{\gamma m_1 m_2}{4\pi r^3 a^3}\left\{\mathbf{r}_{21}\left[\mathbf{r}_{21}\bullet[(\ddot{\mathbf{w}}_2 \times \mathbf{w}_1) - 2(\dot{\mathbf{w}}_2 \times \dot{\mathbf{w}}_1) + (\mathbf{w}_2 \times \ddot{\mathbf{w}}_1)] + \right.\right.$$
$$\left.+2(\mathbf{v}_1 - \mathbf{v}_2)\bullet[(\dot{\mathbf{w}}_2 \times \mathbf{w}_1) + (\mathbf{w}_2 \times \dot{\mathbf{w}}_1)]\right] +$$
$$+2(\mathbf{v}_1 - \mathbf{v}_2)\left[\mathbf{r}_{21}\bullet(\dot{\mathbf{w}}_2 \times \mathbf{w}_1) + (\mathbf{v}_1 - \mathbf{v}_2)\bullet(\mathbf{w}_2 \times \mathbf{w}_1) + \mathbf{r}_{21}\bullet(\mathbf{w}_2 \times \dot{\mathbf{w}}_1)\right] +$$
$$\left. + (\mathbf{w}_2 - \mathbf{w}_1)[\mathbf{r}_{21}\bullet(\mathbf{w}_2 \times \mathbf{w}_1)]\right\}$$

EXAMPLES

EXAMPLE 1

Let two masses m_1 and m_2 move with equal accelerations $\mathbf{w}_1 = \mathbf{w}_2 = \mathbf{w}$ along parallel straight lines, i.e.

$$\mathbf{w}_1\bullet\mathbf{w}_2 = w^2 \qquad \text{(A3E.1)}$$

Let angle between $\mathbf{r}_{21}$ and $\mathbf{w}_1$ be θ.It is equal to angle between $\mathbf{r}_{21}$ and $\mathbf{w}_2$. Dynamic part of Newton force is zero for such masses and gradiental part looks as follows

$$\mathbf{F}_{21} = -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \frac{\gamma m_1 m_2}{4\pi r^3 a^2}[2\mathbf{w}rw\cos\theta + \mathbf{r}_{21}w^2(1 - 3\cos^2\theta)] \qquad \text{(A3E.2)}$$

Dynamic force directed along radius and deforming static one (second item in square brackets) depends on θ, *i.e.* depends on the masses location with respect to each other.

When $(1-3\cos^2\theta)=0$ (*i.e.* at about 55° and 125°), the dynamic radial force is zero. When θ is in the interval $[0°,55°]$, or θ is in the interval $[125°,180°]$, the force is negative, and reinforces the static part. When θ is in the interval $[55°,125°]$, the force is positive, and it weakens the static force. The force directed along acceleration (the first item in square brackets) is zero when $\theta = 90^0$, *i.e.* if masses fly 'side by side'. When θ is in the interval $[180°,90°]$ (the first mass is behind), this force is directed along acceleration, and increases acceleration of the first mass (the second mass 'helps' the first one). When θ is in the interval $[90°,0°]$ (the first mass is ahead), this force is directed against the first mass acceleration (the second mass 'brakes' the first mass movement). Force of equal magnitude and opposite direction is applied to the second mass. This means that masses strive for moving 'side by side'. We observe such an effect in the movement of planets. The effect is just the strict analogue for the corresponding effect in generalized electrodynamics [1], where it manifests in the cluster effect in particular: when chargers velocities are high, they gather together in clusters instead of scattering because of Coulomb force.

EXAMPLE 2

Let under conditions of the previous example accelerations are not constant but masses oscillate along parallel straight lines with amplitude A and angular speed ω, *i.e.*

$$\mathbf{w}_1 = \mathbf{w}_2 = -A^2 w^2 \cos\omega t\, \mathbf{d} \,, \qquad \text{(A3E.3)}$$

here $\mathbf{d}$ is unit vector determining direction of the straight lines along which oscillations take place. Newtonian dynamic force here is again zero and gradiental one looks as follows

$$\mathbf{F}_{21} = -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \frac{\gamma m_1 m_2 A^2 w^4 \cos^2 \omega t}{4\pi r^3 a^2}\left[-2r\cos\theta\cdot\mathbf{d} + (1-3\cos^2\theta)\mathbf{r}_{21}\right] \text{(A3E.4)}$$

Here θ is again the angle between $\mathbf{r}_{21}$, and $\mathbf{d}$ is just as in the previous example.

We have obtained a formula very similar to (2.2). It is interesting because it shows a constructive way to ‘anti-gravitation’. The masses should oscillate ‘side by side’. The static gravitational force will be overcome when

$$A^2 w^4 \cos^2 \omega t \geq a^2 \quad \text{(A3E.5)}$$

EXAMPLE 3

Let mass m_1 rotate around static mass m_2 with constant tangential speed v_i, *i.e.* with constant centripetal acceleration w_i. For this case the gradient force is zero because one of the masses is static. The greater part of the terms in Newtonian dynamic force, which contain third and fourth derivatives, are also zero. We obtain

$$\mathbf{F}_{21} = -\frac{\gamma m_1 m_2}{4\pi r^3}\mathbf{r}_{21} + \frac{\gamma m_1 m_2}{4\pi r^3 a^2}[w_1{}^2 \mathbf{r}_{21} + (2v_1{}^2 - r w_1)\mathbf{w}_1] \quad \text{(A3E.6)}$$

Taking into account that

$$\mathbf{w}_1 = -(v_1{}^2 / r^2)\mathbf{r}_{21} \quad \text{(A3E.7)}$$

i.e. that centripetal force is anti-parallel to the radius vector, we obtain that items in square bracket in (2.6) are mutually annihilated and only static part remains (the first item in 2.6). We could predict this result if we gazed more attentively at formula (1.13) which determines gravimagnetic field. The first item in it for mass m_2 is zero because it is static ($\mathbf{w}_2 = 0$), and it is also zero for m_1 because $\mathbf{w}_1$ is anti parallel to radius vector. Vector product of radius-vector to radius-vector is zero in contrast to scalar product which participate in gradiental part of the formula where it determines static part (static Newton force).

Let us repeat the idea already mentioned above: the formula for magnetic fields interaction does not contain a static part, in contrast to the interaction formula for electric and gravitational fields.

Astronomical observations show that additional forces appear between moving planets and Sun. This means that the planets and the Sun are ‘gravitational ferromagnetics', *i.e* they are stable gravimagnets. Special investigation will be devoted to this case.

REFERENCES FOR APPENDIX 3

[1] J.G. Klyushin, "A Field Generalization for the Lorentz Force Formula", Galilean Electrodynamics, vol. 11, No. 5, p. 85 (2000).
[2] A.A. Ampere. Memoires de L'Academie de Paris 6, 175 (1823).
[3] E.T. Whittaker, A history of the theories of Aether & Electricity, p. 91 (London, green and Co. London 1910).
[4] H.G. Grassman, "Eine Theorie der Elektrodynamik", Annalen der Physik und Chemic 64, 1-18, (1845).

APPENDIX 4

The Second Continuity Eqiation

In this Appendix, an equation generalizing the classical continuity equation for the case of accelerated motion is proposed. *It turns out to be useful in the description of gravity.*

Let $\mathbf{v}$ be fluid velocity, and ρ be its density, and Q be the total fluid inside a surface S. The time rate of change of Q, or, this is the same, the rate of the fluid leaking through a surface S, is

$$dQ/dt = \iint_S \rho \mathrm{v}_n ds \tag{A4.1}$$

where v_n is the projection of $\mathbf{v}$ on the external normal to S, indicated by $\mathbf{n}$, On the other hand, the rate of change fluid in the volume υ is

$$dQ/dt = -\iiint_\upsilon \rho_t \, d\upsilon \tag{A4.2}$$

Here and below the lower index t means partial derivative with respect to time t. With the help of Gauss' theorem, one finds for any volume υ

$$\iiint_\upsilon \left[\rho_t + \mathrm{div}(\rho\mathbf{v})\right] d\upsilon = 0$$

This is satisfied if

$$\rho_t + \mathrm{div}(\rho\mathbf{v}) = 0 \tag{A4.3}$$

which is the classical continuity equation. If the flow is accelerated, then the second total derivative with respect to t in (1) will also be non-zero. One obtains:

$$\begin{aligned} d^2Q/dt^2 &= \iint_S \left[(\rho v_n)_t + v_n \mathrm{div}(\rho\mathbf{v})\right] dS = \\ &= \iiint_\upsilon \mathrm{div}\left[(\rho\mathbf{v})_t + \mathbf{v}\,\mathrm{div}(\rho\mathbf{v})\right] d\upsilon \end{aligned} \tag{A4.4}$$

On the other hand, the acceleration with which density ρ changes in volume υ is

$$d^2Q/dt^2 = -\iiint_{\upsilon} \rho_{tt} d\upsilon \quad \text{(A4.5)}$$

i.e.

$$d^2Q/dt^2 = \iiint_{\upsilon} \left\{\rho_{tt} + \mathrm{div}\left[(\rho\mathbf{v})_t + v\,\mathrm{div}(\rho\mathbf{v})\right]\right\} d\upsilon = 0 \quad \text{(A4.6)}$$

for any υ.

$$\rho_{tt} + \mathrm{div}\left[(\rho\mathbf{v})_t + v\mathrm{div}(\rho\mathbf{v})\right] = 0 \quad \text{(A4.7)}$$

If the flow is steady, *i.e* if $\rho_{tt} = 0$ and $v_t = 0$, then one can easily verify that (A4.7) comes to (A4.3). On the whole, both equations should be valid simultaneously, and (A4.3) can be used to simplify (A4.7).

One gets finally

$$\rho_{tt} + \mathrm{div}(\rho v_t) = 0 \quad \text{(A4.8)}$$

Eqs. (A4.3) and (A4.8) must be valid simultaneously for accelerated processes. ! (A4.8) becomes an identity for non-accelerated processes. Both (A4.3) and (A4.8) are kinematic facts, and are not dependent on any assumptions except the assumption that there are no sources of fluid inside the volume under consideration. If necessary, exactly analogous conclusions could be drawn for higher rank derivatives.

The continuity equation, Eq. (A4.3), is widely used in physics, and is understood as the mathematical expression of conservation laws. The above said means that this assumption is correct only for steady processes. In particular, it is acceptable when the electric charge conservation law is obtained from Maxwell equations.

But Eq. (A4.3) becomes only a necessary condition when an accelerated process, or a processes depending on the third and forth time derivatives, is investigated. In particular, we need Eq. (A4.8) when a mass conservation law is obtained from gravidynamic equations.