The theory of electromagnetic field motion
1. Introduction to the theory

L.N. Voytsehovich

This paper describes the fact of existence of paradoxes and internal contradictions of the electromagnetic field classical theory and the way of elimination of such contradictions by more rigorous application of the relativity principle to electromagnetic phenomena and by creation of the consecutive relativistic electromagnetic theory. Here are presented general principles and requirements to any new physical theory and, in particular, to the relativistic electromagnetic theory which is a subject matter in the present cycle of works.

1.1. The classical electromagnetic theory and the relativity theory

For historical reasons, by the time of the special relativity theory emergence the main conceptual and mathematical apparatus of the electromagnetic field classical theory had already been created. It appeared that Maxwell's equations in vacuum are invariant in relation to Lorentz transformations. This fact was apparently one of the reasons why rather deep analysis of the classical electromagnetic theory statements from positions of their relevance to the relativity principle had not been carried out. In turn, it generated a large number of paradoxes and logical contradictions in the electromagnetic theory.

The modern electromagnetic field theory consists of three main parts: the electromagnetic field classical theory, the special theory of relativity in so far as it relates to electric and magnetic fields, and the quantum electromagnetic theory. All the three theories have been developing at different times almost independently from each other. The relativity theory and the quantum theory are based on the postulates having the character of mathematical axioms. Such theories will be called axiomatic ones. There are two approaches in the electromagnetic field classical theory. The first one is based on the electromagnetic field model offered by Faraday in the form of electric and magnetic lines of force. The second, axiomatic, one rests on Maxwell's equations.

On the whole all the three theories in a quantitative sense faultlessly describe all electromagnetic phenomena; in any case, in the absence of substance, namely this case will be our subject matter. At the same time, at the junction of the theories there are contradictions leading to numerous paradoxes. Especially, there are a lot of contradictions at the junction of the classical and quantum electromagnetic field theories. But such contradictions exist both in the electromagnetic field classical theory, and at its junction with the special theory of relativity. The fullest list of internal contradictions of the electromagnetic field classical theory is provided by R. Feynman in his widely known lectures on physics [1]. However, it is clear that Feynman did not name all the paradoxes of classical physics; they are also exemplified by other authors. Contradictions between the theory and practice (experiment) are often disguised to some extent by the links to other sections of physics, to temporality of contradictions in connection with their elimination in the future in the process of physical understanding development.

In general, that is right.

It is the elimination of paradoxes of the electromagnetic field theory that will be the subject matter in the present cycle of works. The purpose of this consideration is to create such physical model of the electromagnetic field that eliminates available theory contradictions without introducing the new ones and eliminating, at least partially, contradictions between the classical and quantum theories of the electromagnetic field.

1.2. The electromagnetic theory and paradoxes

In XIX century when the electromagnetic field classical theory was created, it was based on the combination of physical (Faraday's lines of force) and mathematical (first of all, Maxwell's equations) representations according to the two types of human thinking: figurative, and abstract and logical. Attempts to create a purely mathematical theory of the electromagnetic field only on the basis of Maxwell's equations were unsuccessful. Let us recollect at least the Lorentz force which is difficult to explain when refusing the lines of force concept.

The situation changed with the advent of XX century. In the first half of XX century, the relativity theory and quantum mechanics appeared. Those theories were based on the principles and postulates which, in turn, were obtained by generalizing experimental data. At such purely mathematical axiomatic approach it is possible to do without a special physical model. Sometimes, this purely axiomatic way of creating the electromagnetic field theory is declared the only correct one. In our opinion, it is the neglect of the necessity of an electromagnetic field physical model that appeared to be a source of internal logical contradictions, paradoxes of the classical electromagnetic theory and logical contradictions at the attempts of applying the relativity principle to electromagnetic phenomena. In turn, it resulted in relative stagnation in the development of this theory in the second half of XX century in comparison with XIX century and the first half of XX century.

Any complete mathematical theory alone does not lead to paradoxes, such mathematical theory has no internal contradictions. Absence of internal contradictions is the main condition of creating a mathematical theory. Paradoxes arise at the junction of physical representation, a physical model and a mathematical theory. The source of contradictions is incompleteness or inaccuracy of postulates from the point of view of physical reality, errors in physical interpretation of experiments and mathematical results, distribution of the theory conclusions having private character to the area out of the scope of theory postulates. These errors and inaccuracies have, as a rule, logical character in spite of the fact that the mathematical theory underlying physical representation has no internal contradictions. Logical errors arise at the junction of the physical model reflecting physical reality and the mathematical theory which quantitatively describes this reality.

It should be noted that at pointing to the errors made by the authors of monographs, the references to which are given in the present cycle of works, we have not pursued the aims of reviewing or assessing the value of the work itself. We were choosing the best of monographs known and available to us. The authors' mistakes and also the logical errors (paradoxes) given by the authors themselves reflect the condition of the electromagnetic theory as of the time of writing the relevant monographs.

1.3. Faraday lines of force

The line of force concept for the first time introduced by Faraday underlies everything stated below. Lines of force are not always mentioned directly but are always meant.

Representation of electric and magnetic fields in the form of lines of force is figurative, evident representation of the electromagnetic field. The usage of lines of force allows the figurative thinking to swing into action;

lines of force are graphic representation of the vector electromagnetic field. The electromagnetic field as opposed to lines of force is material. We do not know the physical essence of the electromagnetic field, and even the issue of this essence is not raised now. At the same time, we conditionally identify the material properties native to the electromagnetic field with the properties of the lines of force not forgetting about their conditional character.

In view of importance of the issue, some accepted truths shall be recalled. Let us compare electromagnetic lines of force with current lines which are widely used in describing the fluid or gas flow in hydrodynamics. "Tubes of current" is a relatively stricter concept in hydrodynamics. When there is a laminar flow (fluxes of electric or magnetic fields, which are the subject of interest for us, are always laminar), the whole fluid stream can be broken into tubes with physically infinitesimally small section so that the fluid stream will not cross tube sides anywhere. From the point of view of fluid stream modeling, such tubes are, as it is often noted, a stricter concept than the current lines. However, they are less evident and more difficult to be represented on paper. Therefore, it is possible to do the following. Let us assume that we broke the whole stream into very large, ideally into infinitely large quantity of tubes with an equal stream through each tube. On paper we will represent only one of a huge number of nearby located tubes in the form of a line so that the number of lines is enough for figurative representation of the whole flow configuration. We can deflect the stream at any direction, expand or narrow it, we can move with respect to the whole stream or move the whole pipe with a fluid stream, and in all cases the current lines will correctly show the manipulations with the fluid stream.

All said above can be repeated for electric or magnetic fluxes. In all cases imaginary conditional lines of force will behave as real-life material objects. And, eventually, there is nothing more real than the thing that behaves as if it really exists. Despite all their convention, electromagnetic lines of force act like factual material objects as well.

The electromagnetic field is a material object. Being a physical analogue of the filed, lines of force should have the same characteristics of material objects as real electric and magnetic fields do. Lines of force should not only be an aid for graphic display of the field, they can and should serve as a basis for creating a physical analogue of the electromagnetic field giving the opportunity to predict characteristics of the electromagnetic field in addition to Maxwell's axiomatic mathematical theory. A well-formed physical analogue and a mathematical theory should complement each other never coming into conflict with each other. Only combination of a physical analogue and an axiomatic mathematical theory can be considered a complete physical theory.

1.4. Causality principle and the theory of electromagnetic field motion

What should other requirements be imposed on the new complete physical theory?

One of the root principles of the special theory of relativity is the causality principle. The causality principle underlies not only the relativity theory but all modern science including mathematics and physics as well. If there is only one reason of some event, the causality principle can be applied at once, as it is done in the special theory of relativity while proving the conclusion that the velocity of physical objects cannot be more than the light velocity. If there are two or several reasons, logical laws are applied. Any event has one or more reasons, up to physically uncountable number of reasons. Interrelationship between reasons and the result should be realized in accordance with logical laws. A breach of logical laws is a breach of the causality principle.

In mathematics logical laws underlie all reasoning and evidence, all original postulates (reasons) are considered exhaustively. There can be no lack or excess of original postulates, all conditions are preliminary stipulated otherwise a contradiction occurs. At the same time, a mathematician is not overloaded with argumentation of correctness of the postulates, their accordance to some events in the real outworld. It is good if such accordance exists. If not, it will not influence the mathematical theory.

In theoretical physics while deriving the mathematical theory, logical laws play the same part as in pure mathematics. But contrary to mathematics, in physics the postulates should be proven by experiment and should be tested by the whole practical activity of a person in the future. At the same time, the history of physics shows that all postulates, principles and axioms taken as a basis for some physical theory are correct only in limiting conditions. These are the conditions in which the previous experiments *have been carried out* and which *have been taken into account* by the theory while carrying out these experiments.

Based on the above, it can be asserted that new experimental results can be obtained if an experiment runs far beyond the conditions (energy, velocity, temperature and so on) of previously carried out experiments or if the factors that have never been taken into account before are taken into account (and there are reasons for this account). Otherwise, the expected result is only one more confirmation of the existing theory.

In further works of the present cycle it is shown that the velocity of electrical and magnetic components of the electromagnetic field is such a factor previously not taken into account. This velocity can coincide with the velocity of the source of the electric or magnetic field, or it cannot coincide in case the source with which the velocity of the field can be clearly and identically connected is absent.

The theory taking into account the velocity of the electromagnetic field components and based on principle of motion relativity will be called *the theory of electromagnetic field motion*. The theory of electromagnetic field motion is, in its turn, in combination with the classical theory, constituent of *the relativistic electromagnetic theory*. Nowadays such a term is sometimes used (see, for example, [2]), but the usage of the definition “the relativistic electromagnetic theory” instead of “the classical electromagnetic theory” or “Maxwell’s electromagnetic theory” is proven mainly by the fact that Maxwell’s equations are invariant in relation to Lorentz transformations. Nevertheless, this is not enough to consider the theory to be consequently relativistic. Introduction of the Lorentz force in Maxwell’s theory does not save the situation as well. The Lorentz force allows to take into account the charge motion in relation to the magnetic field, but motion of the magnetic field itself in relation to the charge is neglected, and the main thing is that motion of magnetic fields in relation to each other is neglected as well, if there are two or more sources of the field.

1.5. General requirements to the new physical theory

Any new physical theory should eliminate at least part of contradictions of the known theory.

One should bear in mind that all acknowledged physical theories even containing inherent contradictions (paradoxes) are proven by an uncountable number (in physical understanding of infinity) of experiments. Not only direct specially set up experiments but also a large number (which is much more than the number of direct experiments) facts of using conclusions of the theory in engineering practice serve such confirmation of the theory.

The new physical theory should not contradict any of the known experimentally-confirmed fact from the old theory. If a new result different from the known one is obtained, the known old result should not be rejected but be included in the new theory as a special case. Otherwise, it can be asserted that the new theory has an error or is completely untenable. In any case, the known universally recognized theory should be included in the new one as a special case and not be disproven by the new theory.

It is the most important conclusion, the most important principle we have been guided by at analyzing physical paradoxes and eliminating the found logical falsities of the physical theory.

The velocity of electromagnetic field components cannot be measured directly. At the best case, if a source of the field as a physical object exists, the velocity of the object can be identified with the velocity of the field induced by this object. In other cases, it is necessary to speak only about a virtual source of the field inducing as a result of its motion (again, virtual motion) experimentally measured complementary, electric and magnetic components of the electromagnetic field. Such a virtual character of the generic field and its motion frequently induces difficulties at interpretation of obtained theoretical results. In all cases coincidence or non-contradiction of the obtained theoretical results with the results from the classical electromagnetic theory, the relativity theory or the quantum theory serve as a fidelity criterion of physical interpretation.

Finally, let us come up with brief conclusions that are only indicated in the introduction. We have been applying these conclusions while writing the present cycle of works, and these conclusions are proven by the whole scope of the cycle of works.

Conclusions

1. The classical electromagnetic theory and the relativity theory constitute a whole, the electromagnetic field theory insufficiently takes into account the principles laid down in the special theory of relativity, which leads to paradoxes in the electromagnetic theory.

2. Velocity is the most important and inseparable characteristic of electrical and magnetic components of the electromagnetic field. The relativistic theory of the electromagnetic field taking into account the velocity

of electromagnetic field components is the point at issue of the present cycle of works.

3. The classical electromagnetic theory is a constituent of the new electromagnetic field relativistic theory as a special case. The relativistic theory should eliminate the present contradictions (paradoxes) of the classical theory. The new contradictions should not emerge by any known experimentally verified fact, if such a fact has been consistently described by the existing theories. Different interpretation of these pieces of evidence is possible only in the classical and relativistic theory.

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