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ON RELATIONSHIP BETWEEN ELECTROMAGNETIC AND GRAVITATIONAL INTERACTIONS

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Tc establish the relationship between electromagnetic and gravitational interactions the physical content of the concepts "electromagnetic field", "particle", "charge", "mass" are revised and made more precise. By comparing and analysing particular physical phenomena the basic (primary) concept "moving matter" is introduced, by which a space carrier of energy, momentum and photon spin is meant. Then, the concepts "electromagnetic field", "particle", "charge" become secondary and lose their primary properties, i.e. electromagnetic field is the field of "moving matter" and particle is the dynamic process of moving matter localized in a limited space. The next step is to construct the system of the nonlinear equations of moving matter using the vector functions $\vec{w}(\vec{r},t)$, $\vec{\nu}(\vec{r},t)$ ($[w]={}^{m}/c^{2}$, $[\nu]={}^{1}/c$) characterizing its motion. The system is shown to satisfy the correspondence principle, i.e. it deductively leads to Maxwell's equations, Newton's law of universal gravitation, Newton's second law of dynamics. The quality of gravitational and inertial masses has been proved. Energy losses by a light beam has been estimated. The field of uniformly and slowly rotating macroscopic bodies has been found. No discrepancy has been found in this approach to the problem.

1. INTRODUCTION

As is well-known, there are certain problems in classical electrodynamics associated with the ideas of Maxwell-Lorents theory. For example, the calculation of the "field" mass of a charged particle, which should be regarded as the point mass because of the agreement between electrodynamics and the principles of the theory of relativity, leads to a result void of any physical meaning. The infinite value (divergence) of the field mass remains, though in a slightly changed form, in passing from the classical theory to the quantum one.

The attempts to change Maxwell equations (nonlinear

generalization of electrodynamics equations), but at the same time preserving the concept "charge" and eliminating contradictions, failed /1/.

The problems in classical electrodynamics are likely to be got over not by changing the latter, but by revising and making more precise the physical content of the concepts "electromagnetic field", "particle", "charge", "mass".

2. BASIC CONCEPTS

It would be proper to recall in brief the concept of matter in the classical and quantum theories.

In the classical theory physical phenomena are composed of two basic elements, i.e. particles and fields.

A classical particle (or a material point) is a small cluster of matter localized in a limited space, moving according to the laws of Newtonian mechanics. An electromagnetic field is a specific form of matter, "nonmechanical" matter, i.e. it follows other laws than those of Newtonian mechanics, Maxwell equations being their mathematical expression.

Everything that has mass at rest is meant by matter, in other words it is a field.

The electromagnetic field can be generated and absorbed, whereas the idea of particle generation and absorption is alien to classical mechanics. The electromagnetic waves when superposed may enhance or attenuate or even sometimes quench each other (wave interference), this not being the case with superposed fluxes of classical particles.

Though particles and fields are connected by a complicated system of interrelations, each of these objects acts as a carrier of quite different individual features. So, the physical phenomena in the classical theory are characterized by distinct features of duality.

Studying the problem of electromagnetic waves emitted by heated bodies Plank found, that the results conforming with the experiment were obtained only when radiation occurred by packets (quanta). This discovery was the first to demonstrate the limited nature of the classical theory. But it would not be proper to regard photon as a classical corpuscle, as it possesses wave properties as well, as in

case, for example, with the diffraction and interference of light . So, it would be proper to name photon a wave-particle.

This dual particulate-wave nature of a quantum of electromagnetic field, i.e. photon, is inherent to all forms of matter. Electrons, protons, neutrons and any other elementary particles possess both particulate and wave properties. As "micro units" resemble particles and at the same time possess wave properties they can not be regarded as classical waves or classical particles. The particulate-wave dual nature of "micro units" was experimentally confirmed and the most typical feature of elementary particles is their universal interconvertibility. Thus, the physical phenomena in the quantum theory are of a distinct dual nature.

A question arises: Shouldn't we introduce one basic (primary) concept to determine the concepts like "electromagnetic field", "particle", "charge", "mass". If it is possible, the concepts "electromagnetic field", "particle", "charge" would be approximate and lose their primary properties.

For this purpose let's analyse some specific physical phenomena.

As is known, a photon is a quantum of the electromagnetic field, i.e. the carrier of electromagnetic interaction, and quantitatively its motion in space, as the motion of a material body, is integrally characterized by energy, momentum and spin, i.e. by six parameters. Photon is electroneutral. It is not correct to raise a question about the nature of the material substance of a photon (a space carrier of energy, momentum, spin), as it is impossible to answer it experimentally, because objects influence each other only through interaction, and the latter can not offer any answer to the question.

Hereafter this substance (the carrier of energy, momentum and photon spin) is called "moving matter", which shouldn't be confused with the term "matter" as a philosophical category. Thus, by electromagnetic field we would mean not some "special form of matter, nonmechanical matter", but the "field" of moving matter.

The next step is to find out, how a photon moves and interacts.

In classical electrodynamics the electromagnetic waves are considered as non-interacting. This applies to the quantum theory, as well, in the form of the statement on the lack of interaction between

photons. However, photon scattering is observed experimentally on the outer electrostatic field (Delbruck scattering). Consequently, photons interact and the superposition principle does not work, i.e. it is true approximately for weak fields. In quantum electrodynamics this process is explained by effects caused by an electron-positron vacuum, i.e. due to virtual electron-positron pairs an incident photon of the electrostatic field starts interacting. Gamma-quantum of a sufficiently high energy, while interacting with the electrical field of the nucleus, may generate a real e-p pair, which is interpreted by quantum electrodynamics as excitement of an e-p vacuum.

As by the definition the virtual particles are not observable experimentally, it is natural to interpret the above processes as direct interaction of photons (i.e. without virtual particles). Furthermore, the photon-hadron interaction can not be determined only by an electric charge, as is evident from that a neutral pion decomposes into two γ-quanta. At very high energies (greater than several GeV) a photon starts revealing hadron properties /2/. Besides, it is worth noting that a photon interacts gravitationally, i.e. nonlinearly. Hence, the generally accepted interpretation of a photon is not sufficient and is to be generalized, i.e. the moving matter of a photon itself should be characterized by certain coordinate functions satisfying the nonlinear equations. Moreover, with the electromagnetic field present a photon of a proper energy is able to convert not only into an e-p pair but into any other pair of particles (in particular, muon-antimuon or proton-antiproton pair). And here a question arises: what is the physical mechanism of the interconversions of elementary particles, for example, of a photon into an e-p pair, and what does an electron consist of?

Examining the process of the annihilation of the e-p pair into to γ-quanta in the reverse order we arrive at the following conclusion: one form of moving matter (photon-photon system) after a direct interaction converts into another form (electron-positron system), i.e. the material substance of a photon and electron is common (moving matter), an electron being a particle-like form of its motion. One more fact is worth noting that only one type of radiation has been found out experimentally, i.e. the electromagnetic one, including the processes on the "elementary" level. Thus, by an electron we shall

understand not some nonstructural matter, but the dynamic process of moving matter localized in a limited space.

This understanding may be applied to all elementary particles. But we should take into account their universal interconvertibility, which does not enable the assumption to be made without contradictions, that the chain of the components of elementary particles results in nonstructural formations. Indeed:

1) at $r_0 \to 0$ (r_0 - the elementary particle radius) there arises a discrepancy while calculating electrostatic field energy;

2) if $r_0 \neq 0$, the forces of nonelectric nature should be introduced for a charge ("Poincare voltage"), which would confine its different parts from Coulomb repulsion;

3) the above suggestion contradicts, in particular, the process $e^- + e^+ \to \gamma + \gamma$.

The above problems are solved, if one understands the elementary particle as the dynamic process of moving matter, localized in the limited space[1]. It concerns as well the known problem in classical electrodynamics related to conduction and displacement currents. Let's recall the gist of the problem.

"From present-day point of view conduction currents on the one hand and displacement currents in the vacuum on the other hand, the terms though being similar, are as a matter of fact quite different physical concepts. The only thing they have in common is that they excite the magnetic field in the same way, i.e. they similarly enter into the right part of the equation. In other respects these currents are quite different"[2] . In this connection one should only put the question: "How do different heterogeneous material substances (conduction currents and displacement currents) excite one and the same substance, different though from the first twos, i.e. the magnetic field?", and the physical interpretation of the phenomenon becomes problematic. It is possible to avoid contradictions by

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1 Compare with the concept of an elementary particle and the way it is described in present-day calibration theories (see, for example, refs.3 and 4, where there is a vast list of quoted literature). The method to describe nonpoint elementary particles presented below is not probabilistic.

2 I.E.Tamm "Unlike the original Maxwell ideas", Principles of the theory of electricity, Gostekhizdat. M.-L., 1948, p.402.

admitting (according to the original Maxwell ideas), that conduction and displacement currents are of common physical nature, i.e. the form of moving matter is different, but the material substance is just the same.

Substantiation of the concepts "charge", "mass" for the introduced concept of the particle is reasonable only upon deriving the nonlinear equations of moving matter in terms of quantitative ratios.

3. FUNCTIONS FOR MOVING MATTER DESCRIPTION. DERIVATION OF EQUATIONS

Let's analyse a certain volume of moving matter, which has the energy density $\varepsilon(\vec{r}, t)$ and momentum density $p(\vec{r}, t)$.

The equivalent mass density ρ corresponds to the energy density ε:

$$\rho = \frac{\varepsilon}{c^2}, \tag{1}$$

where c - light velocity in vacuum. But any mass (energy) interacts gravitationally, i.e. nonlinearly.

In search of the nonlinear equations of moving matter we would proceed from Newton's law of universal gravitation:

$$F = m'\vec{w}, \tag{2}$$

$$\vec{w} = -\gamma \frac{m}{R^2} \frac{\vec{R}}{R}, \tag{3}$$

where γ - gravitational constant, and the radius vector $\vec{R}$ is directed from the point м tom'. Using Gauss theorem combined with the superposition principle, which is known to hold for a weak gravitational field (Newton's approximation) the following is obtained instead of Eq.(3):

$$\operatorname{div} \vec{w} = -4\pi\gamma\rho. \tag{4}$$

It is reasonable to transform this equation by multiplying its both parts by the electric constant ε_0:

(5) $$\operatorname{div} \varepsilon_0 \vec{w} = \tilde{\gamma}\rho,$$

where

(6) $$\tilde{\gamma} = \gamma\, 4\pi\varepsilon_0.$$

Newton's law of universal gravitation, Eqs.(2) and (3), can not be applied directly to moving matter. It is necessary to explain the use of Eq.(5) as the basis for generalization. First, it is not Newton's law of gravitation, as one equation would not unambiguously determine the vector function. Second, Eq.(5) only connects the equivalent mass density $\rho(\vec{r}, t)$ with the function $\vec{w}(\vec{r}, t)$ in the point $(\vec{r}, t)$. In addition let's take into account, that in the limit Newton's law of gravitation must hold for the inversion from more generalized ratios to nonrelativistic velocities and macroscopic masses.

As seen from Eqs.(2)-(5), w has the acceleration dimensionality $[w]=m/s^2$. Hence, Newton's gravitational field $\vec{w}$ is the vector field of accelerations. According to Eq.(2) the mass ρ' in the field is effected by the space force:

(7) $$\vec{f} = \rho'\vec{w}.$$

The aim of these transformations, Eqs.(2)-(5), is to obtain not only differential relation (5), but also to naturally introduce 3 parameters $(\vec{w})$, characterizing moving matter instead of the integral parameters (energy, momentum, spin). They have distinct physical sense and may be measured experimentally.

Still, the same moving matter, interactions not being taken into account (linear approximation, see paragraph 2), is described by the vectors $\vec{E}$, $\vec{B}$, which have an abstract sense within the scope of classical electrodynamics and satisfy Maxwell's equations. As a result we have different description methods for one and the same substance. So, the transformations:

(8) $$\vec{E} = \frac{k}{\tilde{\gamma}^{1/2}}\vec{w},\ \vec{B} = \frac{k}{\tilde{\gamma}^{1/2}}\vec{v},$$

where k is the dimensionless scale multiplier, and $\tilde{\gamma}$ is determined by ratio (6), enable $\vec{E}$, $\vec{B}$ to be reduced to the dimensionalities of

functions, suitable to describe matter in terms of the movement $[w]=M/s^2$, $[\nu]=I/s$.

Hence, the equations of moving matter in the linear approximation are of the form:

$$\text{rot}\,\vec{\nu} = \frac{1}{c^2}\,\frac{\partial \vec{w}}{\partial t} \tag{9}$$

$$\text{rot}\,\vec{w} = -\frac{\partial \vec{\nu}}{\partial t} \tag{10}$$

$$\text{div}\,\vec{w} = 0 \tag{11}$$

$$\text{div}\,\vec{\nu} = 0. \tag{12}$$

Here,

$$c^2 = \frac{1}{\varepsilon_0 \mu_0}\,, \tag{13}$$

where μ_0 is the magnetic constant.

Keeping in mind the definition of the fields $\vec{E}$ (force per unit charge) and $\vec{B}$ (force per unit length of one of two parallel linear current-carrying conductors) transformations (8) serve as a connecting link in going from force fields of one dimensionality to those of the same origin but with another dimensionality. We would have the latter at our disposal now, if proper dimensionalities of charge (current) had been introduced in due time.

To avoid misunderstandings let's point out, that it would be wrong to state on the basis of transformations (8) for an electromagnetic wave, that the gravitation field affects the charge without taking into account the physical content of the concepts "electromagnetic field", "particle", "charge", "mass". As will be seen below, Newton's and Coulomb's laws result from different ratios. It is worth noting here, that the vector $\vec{E}$ in the electromagnetic wave is transverse to its propagation direction and is longitudinal for the virtual photon of the electrostatic field. But photons with a

longitudinal polarization have not been found experimentally.

The next step is to find out, why the vector $\vec{w}$ is identified in Eqs.(5) and (9)-(12).

It is clear by intuition, that it is one and the same characteristic of moving matter, i.e. the acceleration vector function. Mathematically this statement is not proved in rigorous terms and its substantiation in the long run results from the validity and correlation of deductive corollaries, directly following from the motion equations.

To take into account the interaction Eq.(5) should be used instead of Eq.(11). Let's see, whether the new system of equations correlates well. With this aim in view let's use the continuity equation:

$$\frac{\partial \rho}{\partial t} + \operatorname{div} \vec{p} = 0 \tag{14}$$

for the values ρ and $\vec{p}$. Bearing in mind the known arguments we find out, that Eqs.(5) and (9) contradict each other. To correlate Eqs.(5),(9),(14) the term $\tilde{\gamma}\mu_0\vec{p}$ should be added. Hence, to take into account the interactions both the scalar value ρ and the vector value $\vec{p}$ are required. Eqs.(10) and (12) are readily seen to correlate.

Thus, we arrive at a conclusion, that moving matter taking into account the interactions may be described by the vector functions of acceleration, $\vec{w}$, and frequencies, $\vec{\nu}$, satisfying the equations:

$$\operatorname{rot} \vec{\nu} = -\tilde{\gamma}\mu_0\vec{p}(\vec{w},\vec{\nu}) + \frac{1}{c^2}\frac{\partial \vec{w}}{\partial t} \tag{15}$$

$$\operatorname{rot} \vec{w} = -\frac{\partial \vec{\nu}}{\partial t} \tag{16}$$

$$\operatorname{div} \vec{w} = -\frac{\tilde{\gamma}}{\varepsilon_0}\rho(w, \nu) \tag{17}$$

$$\operatorname{div} \vec{\nu} = 0, \tag{18}$$

ρ and p being connected by Eq.(14).

Let's obtain expressions for $\vec{p}$ and ρ using the functions $\vec{w}$, $\vec{\nu}$ from system (15)-(18). Multiplying Eq.(15) in a scalar way by $\vec{w}$ and Eq.(16) by $\vec{\nu}$ and subtracting them termwise we obtain:

$$(19) \qquad \frac{\partial}{\partial t}\left(\frac{\frac{w^2}{c^2}+\nu^2}{2\,\tilde{\gamma}\mu_0}\right) = \vec{p}.\vec{w} - \mathrm{div}\left(\frac{\vec{w}\times\vec{\nu}}{\tilde{\gamma}\mu_0}\right)$$

Using the notations:

$$(20) \qquad \varepsilon = \frac{\frac{w^2}{c^2}+\nu^2}{2\,\tilde{\gamma}\mu_0}$$

$$(21) \qquad \vec{S} = \frac{\vec{w}\times\vec{\nu}}{\tilde{\gamma}\mu_0}$$

we are convinced, that ε has a meaning of the energy density of moving matter, and $\vec{S}$ is the energy flow density, as while integrating Eq(19) for a certain volume the integral $\int\vec{p}\vec{w}dv$ determines the work of Newton's forces (7) per unit time. But a decrease in the moving matter energy in some closed volume happens only due to its escape through the surface. That is why, the expression for the momentum $\vec{p}(\vec{w},\vec{\nu})$ should satisfy the following condition:

$$(22) \qquad \vec{p}(\vec{w},\ \vec{\nu}).\ \vec{w}=0,$$

in this case Eq.(19) may be written as:

$$(23) \qquad \frac{\partial \mathcal{E}}{\partial t} = -\mathrm{div}\ \vec{S}$$

Multiplying Eq.(23) by $^{I}/c^2$ and taking into account Eq.(1) we obtain the following instead of Eq.(23):

$$(24) \qquad \frac{\partial \rho}{\partial t} = -\mathrm{div}\ \vec{p},$$

i.e. continuity equation (14). Hence:

$$(25) \qquad \rho(w,\nu) = \frac{\frac{w^2}{c^2}+\nu^2}{2\tilde{\gamma}\mu_0 c^2} = \frac{\varepsilon}{c^2}$$

$$\vec{p}(\vec{w}, \vec{\nu}) = \frac{\vec{w} \times \vec{\nu}}{\eta\mu_0 c^2} = \frac{\vec{S}}{c^2} \tag{26}$$

and Eq.(26) satisfies Eq.(22). By substituting Eqs.(25), (26) into (15), (17) the self-consistent system of nonlinear equations will be obtained:

$$\mathrm{rot}\ \vec{\nu} = -\frac{\vec{w} \times \vec{\nu}}{c^2} + \frac{1}{c^2}\frac{\partial \vec{w}}{\partial t} \tag{27}$$

$$\mathrm{rot}\ \vec{w} = -\frac{\partial \vec{\nu}}{\partial t} \tag{28}$$

$$\mathrm{div}\ \vec{w} = -\frac{\frac{w^2}{c^2} + \nu^2}{2} \tag{29}$$

$$\mathrm{div}\ \vec{\nu} = 0, \tag{30}$$

where c is the electrodynamic constant in Eq.(13).

4. FORCE DENSITY

The expression for the force density $\vec{f}$ of moving matter results directly from equations (27)-(30). Indeed, multiplying Eq.(27) vectorially by $\vec{\nu}$ and Eq.(28) by $\vec{w}/c^2$ and adding them the following is obtained:

$$\vec{p} \times \vec{\nu} = \frac{\partial}{\partial t}\left(\frac{\vec{w} \times \vec{\nu}}{\tilde{\gamma}\mu_0 c^2}\right) + \operatorname{grad}\left(\frac{\frac{w^2}{c^2} + \nu^2}{2\tilde{\gamma}\mu_0}\right) - \tag{31}$$

$$- \frac{I}{\tilde{\gamma}\mu_0}\left[\left(\frac{\vec{w}}{c} \cdot \nabla\right)\frac{\vec{w}}{c} + (\vec{\nu} \cdot \nabla)\vec{\nu}\right]$$

Here the Eq.(26) is used. Taking into account Eq.(25) we can transform Eq.(29) to:

$$\rho\vec{w} = -\frac{1}{\tilde{\gamma}\mu_0}\frac{\vec{w}}{c}\operatorname{div}\left(\frac{\vec{w}}{c}\right). \tag{32}$$

Adding Eqs.(31) and (32) we finally obtain:

$$\vec{f} = \rho\vec{w} + (\vec{p} \times \vec{\nu}) \tag{33}$$

$$\vec{f} = \frac{\partial}{\partial t}\left(\frac{\vec{w} \times \vec{\nu}}{\tilde{\gamma}\mu_0 c^2}\right) + \operatorname{grad}\left(\frac{\frac{w^2}{c^2} + \nu^2}{2\tilde{\gamma}\mu_0}\right) - \tag{34}$$

$$- \frac{1}{\tilde{\gamma}\mu_0}\left[\left(\frac{\vec{w}}{c} \cdot \nabla\right)\frac{\vec{w}}{c} + (\vec{\nu}\cdot\nabla)\vec{\nu} + \frac{\vec{w}}{c}\operatorname{div}\left(\frac{\vec{w}}{c}\right)\right].$$

The first summand in Eq.(33) coincides with Newtons force, which is only a part of the total force.

5. CONDITION OF STATIONARITY. THE MECHANISM OF INTERACTION OF MOVING MATTER

Before estimating the order of values dealt with here let's point out one common property of moving matter. Suppose, at some moment there is a "field"[3] of motion $(\vec{w},\vec{\nu})$ in the limited space. Then, as follows from the integral form of Eqs.(27)-(30)

$$\oint_{(l)} \vec{\nu} \cdot d\vec{l} = -\int_{(\sigma)} \frac{\vec{w} \times \vec{\nu}}{c^2} \cdot d\vec{\sigma} + \int_{(\sigma)} \frac{1}{c^2} \frac{\partial \vec{w}}{\partial t} \cdot d\vec{\sigma}$$

$$\oint_{(l)} \vec{w} \cdot d\vec{l} = -\int_{(\sigma)} \frac{\partial \vec{\nu}}{\partial t} \cdot d\vec{\sigma}$$

$$\oint_{(S)} \vec{w} \cdot d\vec{S} = -\int_{(V)} \frac{\frac{w^2}{c^2} + \nu^2}{2} dV$$

$$\oint_{(S)} \vec{\nu} \cdot d\vec{S} = 0,$$

the motion field is generated in the space surrounding V. The very fact of generation does not depend on the character of motion of the initial field. According to the energy conservation law the excitation field appears only due to energy losses of the initial field, which will loose its energy until the dynamic equilibrium with the field of motion of surrounding space is reached. Consequently, the stationary field motion $(\vec{w}, \vec{\nu})$ in the limited space is possible only with the dynamic equilibrium reached: the losses of moving matter are compensated by its inflow from the surrounding space. Hence, taking

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3 Hereinafter by the term "field" the mathematical vector fields $(\vec{w}, \vec{\nu})$ are meant. Only moving matter, the motion characteristics of which are these very vector functions $(\vec{w}, \vec{\nu})$, has the physical meaning. They are non-zero, where there is moving matter.

Eq.(34) into account without additional assumptions the interaction of moving matter results from the exchange by portions of moving matter.

6. STATIONARY EQUATIONS

Understanding the stationary motion as stated above let's average Eqs.(27)-(30) over time. Average values of the derivatives $\frac{\partial \vec{w}}{\partial t}$, $\frac{\partial \vec{\nu}}{\partial t}$ of limited functions equal zero. The limitation of the functions $(\vec{w},\vec{\nu})$ follow from physical considerations. Then, instead of Eqs.(28), (29) and (27), (30), taking into account Eqs.(25), (26), we get the following:

$$\text{(35)} \qquad \operatorname{div} \bar{\vec{w}} = -\frac{\tilde{\gamma}}{\varepsilon_0}\bar{\rho}, \quad \operatorname{rot} \bar{\vec{w}} = 0,$$

$$\text{(36)} \qquad \operatorname{rot} \bar{\vec{\nu}} = -\tilde{\eta}\mu_0\bar{\vec{P}}, \quad \operatorname{div} \bar{\vec{\nu}} = 0.$$

The solution of system (36) with zero conditions at infinity is of the form:

$$\text{(37)} \qquad \bar{\vec{\nu}}_2 = -\frac{\tilde{\eta}\mu_0}{4\pi}\int_{V_1}\frac{\bar{\vec{p}}_1 \times \vec{R}_{12}}{R_{12}^3}\,dV_1,$$

where the radius-vector $\vec{R}_{12}$ is directed from the field source point $\bar{\vec{p}}dV$ (index 1) towards the observation point (index 2). It allows the following physical interpretation of the vector field $\vec{\nu}$ to be obtained. Rewriting Eq.(37) as follows:

$$d\bar{\vec{\nu}}_2 = -\frac{\tilde{\eta}\mu_0}{4\pi}\frac{\bar{\vec{p}}_1 dV_1 \times \vec{R}_{12}}{R_{12}^3} = -\frac{\tilde{\eta}\mu_0}{4\pi}\frac{d\vec{M}}{R_{12}^3}$$

we note, that $d\vec{M} = \vec{R}_{21} \times \bar{\vec{p}}_1 dv_1$ is the moment of the field momentum relative to the observation point ($\vec{R}_{21} = -\vec{R}_{12}$).

7. ESTIMATION OF MOVING MATTER LOSSES BY A LIGHT BEAM. TRANSVERSALITY OF THE VECTORS ($\vec{w}$, $\vec{v}$) AND MAXIMUM VELOCITY. ROTATIONAL MOTION RELATIVE TO THE MOMENTUM DIRECTION

Let's consider now a continuous light beam of an infinite length with a constant energy density ε and constant momentum density

$$\vec{p} = \frac{\varepsilon}{c}\vec{n},$$

where $\vec{n}$ is the propagation direction. The assumption ε=const is approximate. The accepted energy-momentum ratio is true for a plane electromagnetic wave. Then, in the space surrounding the beam there are excited the stationary fields ($\vec{w}$, $\vec{v}$), which are found from the integral form of Eqs.(35), (36) and determined by the expressions:

$$\bar{w}_r = \frac{\tilde{\gamma}}{\varepsilon_0}\frac{\varepsilon}{c^2}\frac{1}{2\pi r}, \quad \bar{v}_\varphi = \tilde{\gamma}\mu_0\frac{\varepsilon}{c}\frac{1}{2\pi r} = \frac{\bar{w}_r}{c},$$

where r is the distance from the beam axis. The vector $\bar{\vec{w}}$ is directed along the radius towards the beam axis, a v-in the clockwise direction (if one looks from the end of the vector $\vec{n}$) tangentially to the circumference with the radius r. The vectors $\bar{\vec{w}}$, $\bar{\vec{v}}$, $\vec{n}$ are mutually perpendicular and correspond to the orientation of the unit vectors in the right coordinate system. The flux of excited field energy

$$\vec{S}^* = \frac{\vec{w}\times\vec{v}}{\tilde{\gamma}\mu_0} = \frac{\bar{w}_r\,\bar{v}_\varphi}{\tilde{\gamma}\mu_0}\vec{n} = c\,\frac{\bar{v}_\varphi^2}{\tilde{\gamma}\mu_0}\vec{n}$$

is stationary. The energy density equals:

$$\varepsilon^* = \frac{\frac{w^2}{c^2} + v^2}{2\tilde{\gamma}\mu_0} = \frac{\bar{v}_\varphi^2}{\tilde{\gamma}\mu_0} = \frac{\gamma}{c^4}\frac{\varepsilon^2}{\pi r^2} = \frac{6{,}67.10^{-44}}{8{,}1}\cdot\frac{\varepsilon^2}{\pi r^2}.$$

Hence, it may be concluded, that energy losses of a light beam are negligible, if it moves for a short period of time. As the energy of photons in the visible part of spectrum ranges between (3÷1.6) eV (1 eV = 1.6×10^{-19} J), the estimation reveals, that the conclusion of classical optics on the noninteraction between light beams and natural energy densities proves to hold true with a high accuracy. It is worth noting, that the value and sign of the force, as seen from Eq.(34), is determined by the value and direction of interacting forces. That is why, it would not be enough to characterize the beam only by $\varepsilon=\rho c^2$ and $\vec{p}$ and their connection with the field vectors in Eqs.(25), (26) should be used.

It follows from Eqs.(25), (26), that if the vectors $\vec{w}$, $\vec{\nu}$ are transverse to the motion direction and they are themselves mutually perpendicular, the momentum value is maximum. Hence, maximum velocity is obtained, which is numerically equal to the electrodynamic constant. As the force of Eq.(33) $\vec{(p \times \nu)}$ is perpendicular to the vectors $\vec{p}$ and $\vec{\nu}$, the rotational motion is a property of moving matter. The moment of momentum of the rotational motion coincides with the direction of the total motion or is directed opposite.

8. CONDITION OF ELECTRIC INTERACTION BETWEEN ELEMENTARY PARTICLES. TRANSFER TO MAXWELL'S EQUATIONS WITH CHARGES AND CURRENTS. EVIDENT PHYSICAL CONNECTION BETWEEN ELECTRIC AND MAGNETIC INTERACTIONS

If elementary particles are particle-like forms of matter motion, then will they interact electrically?

Suppose, there are stationary states of the motion fields in certain volumes V_1 and V_2 (see paragraph 5).The distance $\vec{R}_{12}$ between the centres of the volumes is considerably larger than their transverse dimensions. Then, ignoring the first summand (i.e. gravitation with the Newton's force $\vec{\rho}w$), in Eq.(33), the following force acts between elements of the volumes of the motion fields according to Eqs.(33), (37):

$$(38) \quad d\vec{f} = \bar{\vec{p}}_2 dV_2 \times d\bar{\vec{\nu}}_2 = -\frac{\tilde{\gamma}\mu_0}{4\pi} \frac{\bar{\vec{p}}_2 \times (\bar{\vec{p}}_1 \times \vec{n}_{12})}{R_{12}^2} dV_2 dV_1,$$

where: $\vec{n}_{12} = \vec{R}_{12} / R_{12}$;

$$\bar{\vec{p}}_1 = \frac{\overline{\vec{w}_1 \times \vec{\nu}_1}}{\tilde{\gamma}\mu_0 c^2} ; \quad \bar{\vec{p}}_2 = \frac{\overline{\vec{w}_2 \times \vec{\nu}_2}}{\tilde{\gamma}\mu_0 c^2} .$$

Let's analyse two particular cases. Let the fields in V_1 and V_2 at a certain moment of time be characterized by the same vectors ($\vec{w}$, $\vec{\nu}$). Hence, possible orientations of $\bar{\vec{p}}_1$ and $\bar{\vec{p}}_2$ momenta projections relative to the direction $\vec{n}_{12}$ are reduced to two cases:

1) they have similar directions and are perpendicular to $\vec{n}_{12}$;
2) momenta projections are parallel (antiparallel) to $\vec{n}_{12}$.

In case 2) the interaction force in Eq.(38) equals zero, and in case 1) $\bar{\vec{p}} \bullet \vec{n}_{12} = 0$ and

$$(39) \quad d\vec{f} = \frac{\tilde{\gamma}\mu_0}{4\pi} \frac{\bar{p}_1 \cdot \bar{p}_2}{R_{12}^2} \vec{n}_{12} dV_2 dV_1 = \frac{1}{4\pi\varepsilon_0} \frac{\tilde{\gamma}^{1/2} \frac{\bar{p}_1}{c} \cdot \tilde{\gamma}^{1/2} \frac{\bar{p}_2}{c}}{R_{12}^2} \vec{n}_{12} dV_2 dV_1,$$

i.e. the repulsive force acts between the elements of the volumes of the motion fields with parallel momenta. If the initial vectors ($\vec{w}$,$\vec{\nu}$) differ from the above case only in momenta directions, then the attractive force acts between the elements of the volumes of the motion fields with antiparallel momenta. As the multipliers $\tilde{\gamma}^{1/2} \frac{\bar{p}}{c}$ have a dimension of charge density, ρ_q may be expressed as $\rho_q = \tilde{\gamma}^{1/2} \frac{\bar{p}}{c}$. As the force ($\vec{p} \times \vec{\nu}$) is always perpendicular to the

vectors $\vec{p}$ and $\vec{\nu}$, the rotational motion is a property of moving matter. That is why, $\bar{p} = k_1 p$ is the effective momentum, and k_1 is the non-dimensional factor. Correlating signs in Eqs.(24) and (27) we obtain:

$$(40) \qquad \rho_q = -k_1 \tilde{\gamma}^{1/2} \frac{p}{c} = -\frac{k_1 \tilde{\gamma}^{1/2}}{c} \left| \frac{\vec{w} \times \vec{\nu}}{\tilde{\gamma} \mu_0 c^2} \right|,$$

where $p = \pm|p|$. Hence, Eq.(39) is equivalent to Coulomb law. The corresponding $\tilde{\gamma}^{1/2} \frac{p}{c}$ in Eq.(39) has a sense of electric field strength, and there is no divergence.

If $\vec{p}_1 = 0$ or $\vec{p}_2 = 0$ the elements of the volumes of the motion fields do not electrically interact.

Now, let's multiply Eqs.(27),(28) by $k/\tilde{\gamma}^{1/2}$, where k is the non-dimensional coefficient. By introducing the notation

$$(41) \qquad \vec{E} = \frac{k}{\tilde{\gamma}^{1/2}} \vec{w}, \quad \vec{D} = \varepsilon_0 \vec{E}$$

$$(42) \qquad \vec{B} = \frac{k}{\tilde{\gamma}^{1/2}} \vec{\nu}, \quad \vec{H} = \frac{1}{\mu_0} \vec{B}$$

$$(43) \qquad \vec{j} = -k\tilde{\gamma}^{1/2} \vec{P} = -k\tilde{\gamma}^{1/2} \frac{\vec{w} \times \vec{\nu}}{\tilde{\gamma} \mu_0 c^2}$$

and understanding by "current" the "charge" motion Eq.(40), we'll obtain:

$$\text{rot}\ \vec{H} = \vec{j} + \frac{\partial \vec{D}}{\partial t}$$

(44)

$$\text{rot}\ \vec{E} = -\frac{\partial \vec{B}}{\partial t}\ .$$

The values in Eqs.(41)-(43) coincide in dimensions with the above electromagnetic field vectors. Taking into account Eqs.(24),(40), (43) an additional pair of Maxwell's equations is found from Eq.(44):

$$\text{div}\ \vec{D} = \rho_q,\ \text{div}\ \vec{B} = 0.$$

Thus, the transform from system (27)-(30) to Maxwell's equations with charges and currents is realized, charge, current and electromagnetic field having a generally accepted meaning. With a "field" approach it means the lack of moving matter losses by "charges" or rather these losses may be ignored.

Note, that transformations (41), (42) are true only for a wave process but not for the Coulomb field in Eq.(39), as $\vec{E}_{coul}$ is longitudinal and $\vec{E}_{wave}$ is transverse to the propagation direction. That is why, the multiplication of Eq.(29) by $k/\tilde{\gamma}^{1/2}$ results in correct electromagnetic dimensions, but contradicts experimental facts, as $(w^2/c^2+\nu^2)\geqslant 0$.

Substituting relations (42), (43) into the second summand the following expression is obtained:

$$\vec{f} = \vec{p} \times \vec{\nu} = -\frac{1}{k^2}\,(\vec{j} \times \vec{B})$$

Which is equivalent to Ampere law. It follows, that Coulomb and Ampere laws result from the second summand of Eq.(33). Here, the connection between electric and magnetic interactions is clearly seen.

9. WHY IS THE METHOD FOR ELEMENTARY PARTICLE DESCRIPTION NOT PROBABILISTIC?

The functions $(\vec{w}, \vec{\nu})$, which have a direct physical meaning, are used to describe mathematically non-point microobjects and may be measured experimentally. Such an approach (non-probabilistic) to microobject description is possible but only if classical characteristics of particles are discarded, i.e. it is necessary to eliminate discrepancy in describing microobjects, which consists in that a particle possesses on the one hand permanent classical features (mass at rest, charge) and on the other hand wave features. The experimental parameters of elementary particles (mass at rest, charge, spin), may be, in principle, determined by functions found from the solution of the problem with initial conditions for nonlinear motion equations. As the bound states are likely to appear at all organizational levels of matter motion, the concepts "discreteness" and "continuity" are the complement of one another. General motion equations should admit solutions both with a continuous and discrete emission spectrum. For example, an electron moving along a circular orbit in an accelerator emits continuously (synchrotron emission), but in a hydrogen atom it emits in a discrete way in going from one stationary state to another. Eqs.(27)-(30), generally speaking, admit the above solutions.

10. STATIONARY GRAVITATIONAL FIELD AND ITS PHYSICAL CARRIER. EQUALITY BETWEEN GRAVITATING AND INERT MASSES. THE SECOND NEWTON'S LAW OF DYNAMICS

The dynamical interpretation of the observed particle parameters does not contradict Newton's definition of the concept "mass". The initial property, inertness (it is measured by the equivalent mass density ρ (25)) manifests itself in that the value and direction of the available momentum density in Eq.(26) of moving matter are to be changed, the equivalent mass density being determined by the same values $(\vec{w}, \vec{\nu})$ in Eq.(25). Hence, Eqs.(35) describe the constant (stationary) gravitational (Newtonian) field $\vec{w}$, the physical carrier of which is moving matter. Poisson's equation for Newtonian potential

directly follows from Eq.(35). As one and the same value ρ appears in the equations for the field (Eq.(35)) and force (Eq.(33)), the conclusion is that gravitating and inert masses are rigorously equal. This quite an important fact in the gravitation theory results rigorously from the system of Eqs.(27)-(30) and has not been used while deriving these equations.

Besides, it becomes possible to correlate different display of properties of one and the same value, i.e. mass, which in non-relativistic mechanics behaves as a measure of body inertness or gravitational action, and in the relativistic one as a measure of body energy.

Eqs.(27)-(30) include the laws of energy conservation, momentum, moment of momentum of field ($\vec{w}$, $\vec{\nu}$) for closed systems. As Eq.(34) may be written in the form of the second Newton's law of dynamics (by separating the total derivative of momentum of Eq.(26) with respect to time) the universal applicability of the law of conservation for any closed system in classical mechanics, without depending on the character of acting forces, proves to be the result of their unity.

11. FIELD OF MACROSCOPIC BODIES ROTATING SLOWLY AND REGULARLY

The system of Eqs.(36) is the new one in its sense.

Let's analyze the field of regularly and slowly rotating macroscopic objects. For non-rotating bodies the field $\vec{\nu}$ is balanced in detail due to interaction between elementary particles (electrical interaction) and the outer average field $\bar{\vec{\nu}} = 0$. With the movement, which is rotational relative to the observation point, the microfields $\vec{\nu}$ of particles become disbalanced and $\bar{\vec{\nu}}$ is non-zero. For example, let's estimate the steady geomagnetic field of the Earth taking a uniformly dense ball with mass M as a model. For this purpose let's use equations (37) and (42)

$$\vec{B} = k\,\frac{\vec{\nu}}{\tilde{\gamma}^{1/2}} = -\frac{k}{\tilde{\gamma}^{1/2}}\cdot\frac{\tilde{\gamma}\mu_0}{4\pi}\int\frac{\bar{\vec{p}}_1 \times \vec{R}_{12}}{R_{12}^3}\,dV_1 =$$

$$= -kk_p \frac{\tilde{\gamma}^{1/2}\mu_o}{4\pi} \int \frac{\rho_1 \vec{V}^* \times \vec{R}_{12}}{R_{12}^3} dV_1 ,$$

where k_p is the averaged coefficient, taking into account the microfields disbalance. The magnetic field on the rotation axis z equals:

$$B_z = -kk_p \frac{\tilde{\gamma}^{1/2}\mu_o}{4\pi} \frac{8\pi\omega}{3r^3} \int_0^{r_o} \rho_1(r) r^4 dr =$$

$$= -kk_p \frac{\tilde{\gamma}^{1/2}\mu_o}{4\pi} \frac{8\pi\omega}{15} \bar{\rho} \frac{r_o^5}{r^3} = -kk_p \cdot 2{,}35 \cdot 10^{-4} \text{ (T)}$$

for parameters: $\omega=2\pi/T$, T=23 h 56'=8,816x10^4 s, r_o=6,378x10^6 m, $\bar{\rho}$=5,5x10^3 kg/м^3, $r=r_o$, r is the distance from the ball centre. According to the linear law the matter density increases towards the ball centre and B_z= $-kk_p$x1,57 Gauss, where $\rho_1|_{r=r_o}$= 1x10^3 kg/м^3. The magnetic field at the pole is known to equal 0,7 Gauss with a positive direction from the South to the North geographic poles. So, in this case we get the following estimation

$$kk_p \sim (\frac{1}{3} \div \frac{1}{2}).$$

The idea of the steady geomagnetic field resulting from the Earth rotation appeared long ago (see, for example, Refs.5,6).

The negative result of Blackett's experiment /Ref.6/ is accounted for by the magnetometer (scale spacing 1x10^{-9} Oersted/div) and observed body (a gold cylinder 10 см in diameter and 10 см long) having been motionless relative to each other. As mentioned above the motion of the observed body, which is rotational relative to the observation point, results in the disbalance of the microfields $\vec{\nu}$.

12. ON THE LAW OF INERTIA AND REFERENCE SYSTEMS

In Maxwell's equations with charges and currents, which rigorously follow from system (27)-(30), the charge is known to be of a primary meaning. In this approach Eqs.(27)-(30) correlate with all conclusions of the special theory of relativity, since Lorents transformations were contained in Maxwell's equations with their initial concepts of particle, mass, charge, electromagnetic field.

In the approach presented the basic concepts have changed drastically. For moving matter it is impossible to rigorously introduce the concept "inertial motion" and, hence, the inertial reference systems. Nonlinear equations (27)-(30) include as a special case not only the gravitational (Newtonian) field, which itself breaks the inertial motion, but also the mechanism of moving mater interaction. The latter results in a moving (or at a relative rest) body's loosing spontaneously its energy, this breaking, as well, the rigour of the concept "inertial motion".

The introduction of random reference systems[4] is equivalent to specifying the vector functions $(\vec{w}, \vec{v})$, i.e. as a matter off act, specifying moving matter, and is unacceptable because of the behaviour of an equivalent field at infinity. The nonlinear equations of moving matter are formulated in the simplest and physically clear way for the reference system rigidly connected with three "motionless" stars. It may be considered as "stationary" with a good approximation.

As all our experiments point to only the mutual relations between bodies (but not those between different parts of space), we seem to have no means to solve the problem of an absolute motion. In this sense the relativity principle is true, but it is understood by the

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[4]The way of description of the gravitational field by means of the geometrization was realized in the relativistic theory and restricted relativistic theory /7/.

way A.Poincare formulated it, i.e. the relativity principle is true, but may be realized in different forms. Its particular mathematical form for moving matter may be chosen only experimentally.

13. IRREVERSIBILITY OF THE PROCESS OF MATTER MOTION. STATEMENT OF THE PROBLEM

In general the process of matter motion is irreversible because of inevitable energy losses (time "arrow"). Equations (27)-(30) retain their form by formally substituting $t \to -t$, $\vec{v} \to -\vec{v}$, $\vec{w} \to \vec{w}$. The process is reversible for special cases of a stationary movement.

To rigorously calculate the particle parameters observed it is necessary to solve a problem with initial conditions for the nonlinear system of equations (27)-(30) and with an additional condition of a stationary state on the surface, enveloping the particle. The latter acts as a boundary condition. In so doing the problem may be formulated relative to the scalar $\varphi(\vec{r}, t)$ and vector $\vec{a}(\vec{r}, t)$ functions according to Eqs.(28), (30). The initial conditions should satisfy Eqs.(27)-(30). This statement results from a random selection of time origin.

The functions $(\vec{w}, \vec{v})$ for particles, found by solving the problem, allow the forces in Eq.(34), acting between them, to be calculated as well, including nuclear forces (weak and strong). Since Maxwell's equations with charges and currents, the law of gravitation, the second Newton's law of dynamics rigorously deductively follow from Eqs.(27)-(30), the latter satisfy the correspondence principles. With nuclear forces it may be examined only as mentioned above. It stands to reason, that the correctness criterion is its agreement with an experiment.

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1. MECHANISM OF THE INTERACTION TRANSFER BY THE ELECTROMAGNETIC FIELD

In classical electrodynamics the electromagnetic field, which is described mathematically by the vectors $\vec{E}$, $\vec{B}$, has an abstract sense. By definition the electromagnetic field is a special form of matter, "nonmechanical" matter. By the term "nonmechanical" we understand the functions $\vec{E}$, $\vec{B}$ changing according to Maxwell's equations and not with Newton's laws for dynamics. There is no physical understanding of the mechanism of the interaction transfer by the field, as the carrier of the electromagnetic interaction hasn't been determined. By saying "the field affects the charge" the mathematical expression of the force is understood. The latter is the generalization of the experimental data.

In quantum electrodynamics a photon is the carrier of the electromagnetic interaction. "We'd like to interpret $\vec{E}$ and $\vec{H}$ as quantities, describing photon's states in the "quantum-mechanical" meaning of the word" (Ahiezer A.I., Berestetsky V.B. "Quantum electrodynamics", Nauka. M., 1969, p.28). A photon is electroneutral and as an entity possesses energy,momentum and spin, i.e. the integral features of motion. However, quantum electrodynamics in its turn doesn't provide the full understanding of the mechanism of the interaction transfer by a photon. Photon is said to be absorbed by the charge, while transferring the interaction. Mathematically it can be written in the form of the consequence of the classical expression for force:

$$\frac{e}{c} A_i dx^i.$$

By definition $\vec{E}$ and $\vec{B}$ are forces, i.e. $\vec{E}$ - force per unit charge, $\vec{B}$ - force per unit length of one of two unit current linear conductors. But force must be transferred somehow, i.e. it must be connected with the carrier of the electromagnetic interaction, i.e. by a photon. But a photon possesses only motion. Hence, $\vec{E}$ and $\vec{B}$ are the features of motion of the substance, which is the volume carrier of energy, momentum and photon spin. This substance is called "moving matter".

The dimensionalities of the fields $\vec{E}$ and $\vec{B}$ had been developed historically. If proper dimensionalities for charge (current) had been chosen in due time, the vectors $\vec{E}$ and $\vec{B}$ would have had the dimensionalities, accepted by Newton to describe matter motion.

Such an understanding of $\vec{E}$ and $\vec{B}$ excludes both classical and quantum concept of charge(positively or negatively charged matter, quantum number). In this case both classical and quantum definition of an elementary particle is unacceptable.

By the elementary particle we'll understand the dynamic process of moving matter, localized in the limited space. Under certain circumstances (they've been formulated in this paper) they interact electrodynamically, that is the concept of charge is the conventional one. It's noteworthy that the dynamic interpretation of the particle parameters (mass, charge, spin) does not contradict the Newton's definition of the concept "mass".

The formulated concept of the particle is the direct generalization of the experimental data, namely the processes of annihilation of an electron-positron pair into two gamma-quanta and universal interconvertibility of elementary particles, where a photon is an equivalent particle.

Actually, by studying the process $e^+ - e^- \rightarrow \gamma + \gamma$ in a reverse order, we'll come to the conclusion that one form of moving matter (photon-photon system) after direct interaction is transferred into another form (electron-positron system), an electron (positron) being a particlelike form of its motion. The universal interconvertibility of elementary particles doesn't make it possible to think that the chain of the components of elementary particles ends in structureless formations.

2. ON PROPORTIONALITY OF $\vec{E}$ AND $\vec{w}$

It would be a mistake to conclude from transformations (8) that the fields $\vec{E}$ and $\vec{w}$ are physically identical, though formally they differ from each other only in one constant dimensional quantity. We must take into account the concept of charge for the moving matter, which is known to be a conventional name of the resultant (effective)

momentum of the rotational movement of an elementary particle. And, accordingly, the resultant force acting on this "charge" is understood as the electric field. Let's make the scheme of the calculation of the latter clear. Suppose, moving matter as a carrier of interaction is characterized by the values ($\vec{w}_1$, $\vec{\nu}_1$) and "charge" -by ($\vec{w}_2$, $\vec{\nu}_2$). Then, after direct interaction (a photon has been absorbed by the charge), we'll get the following:

$$\vec{w} = \vec{w}_1 + \vec{w}_2,\ \vec{\nu} = \vec{\nu}_1 + \vec{\nu}_2,\ \vec{p} = (\vec{w}x\vec{\nu})/\tilde{\gamma}\mu_0 c^2,\ \vec{f} = \vec{p}x\vec{\nu}$$

and the force f either coincides with w in direction or is opposite to it (two signs of charge). A part of the total force in the direction $\vec{w}_1$ (correct to a constant dimensional multiplier) is the electric field. It follows that equations (8) favour only the proportionality of $\vec{E}$ and $\vec{W}$. They also result from a formal analogy between Newton's law of gravitation and Coulomb's law.

The longitudinal part of momentum of internal motion of elementary particles while interacting with a photon gives the force, which is the magnetic field.

3. PASSING FROM THE NONLINEAR EQUATIONS OF MOVING MATTER TO THE EQUATIONS OF CLASSICAL PHYSICS

This procedure lies in the following. The second (approximate) concepts: "charge", "particle", "electromagnetic field" are formulated on the basis of the basic (primary) notion "moving matter". In so doing, Newton's definition of the concept "mass" holds true. In classical physics, these concepts are the basic (primary) ones.

Mass of a particle generates the gravitational field and its charge, accordingly, excites the electromagnetic field. Though the electromagnetic field possesses energy (and hence, the equivalent mass), momentum and a moment of momentum, none the less the particle parameters (mass, charge, spin) are considered to remain constant. We don't treat the mechanism of field generation, but the remaining aspects are presented in detail in the paper.

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