The theory of electromagnetic field motion.
6. Electron

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The article shows that in a rotating frame of reference the magnetic dipole has an electric charge with the value depending on the dipole magnetic moment and rotational velocity. A hypothesis was stated that the electric charge of elementary particles, and in particular the electron charge, is caused by rotation of their magnetic field. It was shown that the electron is the system composed of bound negative and positive charges whose net charge is equal to the charge of a classical single point electron, and that in external uniform electric fields the electron behaves like a single point charge.

It is noticed that all charged leptons – electrons, muons and tau-leptons – are described by similar equations. Difference of leptons from each other is caused by distinction in magnitudes of their magnetic moments and the magnetic field angular velocity, being inversely proportional to the magnetic moment of a corresponding particle.

There was stated an assumption that particles differ from their antiparticles only by direction of the magnetic field rotation. The electron - positron annihilation process is explained by the fact that all fields become fully zero provided particles with opposite magnetic moments are superposed.

6.1. Introduction

It was noticed in preceding work [1] that rotation of a rod-like permanent magnet about longitudinal axis does not lead to magnetic field rotation. So long as we have not any possibility to force magnetic field rotation, we try to consider magnetic field properties of the magnet or the solenoid from the point of view of the observer who is located in a rotating frame of reference. To abstract away from the effects related to the reference frame rotation, the rotation is considered to be rather slow. The results obtained can be also easily used in case of magnetic field rotation in motionless frame of reference.

6.2. Rotation of a magnetic dipole

At distances much longer than magnet radius it is possible to believe with sufficient accuracy that all electrons are concentrated at a magnet axis, so it is possible to neglect their translation motion about the magnet axis. It would be noted once again that such an assumption is not valid when a unipolar generator is considered, however we consider the fields at large distances, when a permanent magnet is appeared to be the point magnetic moment. In these conditions, magnetic fields of a solenoid and a permanent magnet are equivalent to each other.

Let's return to the solenoid. To rotate the solenoid is unreasonable, therefore a unique possibility to consider the solenoid rotating magnetic field is to consider it from a rotating frame of reference. The rotating frame of reference is a noninertial frame of reference. However, as it is known, Lorentz transformations for electric and magnetic fields in case of the accelerated frame of reference remain valid for an instantly concomitant inertial frame of reference at a given point. Along with the angular velocity and distance from a rotation axis are considered to be so small that the linear velocity is lower than the velocity of light.

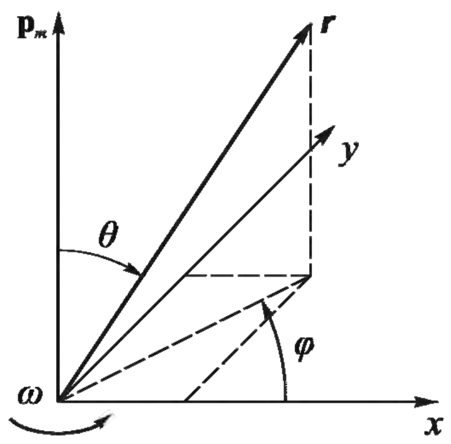

Fig. 6.1. Magnetic dipole $\mathbf{p}_m$ in a rotating reference frame.

As it is known (see, for example, [2]), the vector equation for magnetic field induction $\mathbf{B}$ of a point dipole with the magnetic moment $\mathbf{p}_m$ is as follows:

$$\mathbf{B} = \frac{\mu_0}{4\pi} \frac{3\mathbf{n}(\mathbf{p}_m \mathbf{n}) - \mathbf{p}_m}{r^3}, \tag{6.1}$$

where $\mathbf{n}$ is a unit vector in the direction of position vector $\mathbf{r}$, and μ_0 is a magnetic constant.

In a spherical coordinate system (fig. 6.1) with the polar axis directed along $\mathbf{p}_m$, the equation (6.1) becomes:

$$B_r = \frac{\mu_0 p_m \cos\vartheta}{2\pi r^3}, \tag{6.2}$$

$$B_\vartheta = \frac{\mu_0 p_m \sin\vartheta}{4\pi r^3}, \tag{6.3}$$

$$B_\varphi = 0. \tag{6.4}$$

Let's observe the magnetic field from a rotating frame of reference whose axis of rotation coincides with the polar axis of our spherical coordinate system. Then magnetic flux lines relative to this frame of reference rotate in a direction shown in fig. 6.1, with angular velocity ω, and their linear velocity V is equal to:

$$V_\varphi = \omega r \sin\vartheta, \qquad V_r = 0, \qquad V_\vartheta = 0. \tag{6.5}$$

Since an electric component of the electromagnetic field in a motionless frame of reference is absent, electric field $\mathbf{E}$ in a rotating frame of reference, according to (2.5) is equal to[3]:

$$\mathbf{E} = [\mathbf{B}\mathbf{V}_m], \tag{6.6}$$

where $\mathbf{V}_m$ is the velocity of the magnetic field in a rotating frame of reference.

From (6.2) - (6.6) it follows in a spherical coordinate system

$$E_r = B_\vartheta V_\phi = \frac{\omega \mu_0 p_m \sin^2\vartheta}{4\pi r^2}, \tag{6.7}$$

$$E_\vartheta = -B_r V_\phi = -\frac{\omega \mu_0 p_m \sin\vartheta \cos\vartheta}{2\pi r^2}, \tag{6.8}$$

$$E_\varphi = 0. \tag{6.9}$$

Fig. 6.2 shows the view of electric and magnetic flux lines of the electromagnetic field from a magnetic dipole in a rotating frame of reference. Direction of the magnetic dipole rotation (clockwise, the top view) is opposite to its magnetic moment. Dark blue lines indicate magnetic flux lines, and red ones are referred to the electric field.

It comes under notice that electric flux lines, unlike magnetic ones, are not closed and, as appears from (6.7) and is seen from the drawing, the radial component of electric field E_r is directed inside everywhere, except for the rotation axis. At the rotation axis $E_r = 0$. Hence, the flux of the electric strength vector through a spherical surface in whose centre the magnetic dipole is located is always negative. In other words, it means that in a rotating frame of reference at whose axis of rotation the magnetic dipole is placed, a negative electric charge will be found. Let`s find the value of this charge.

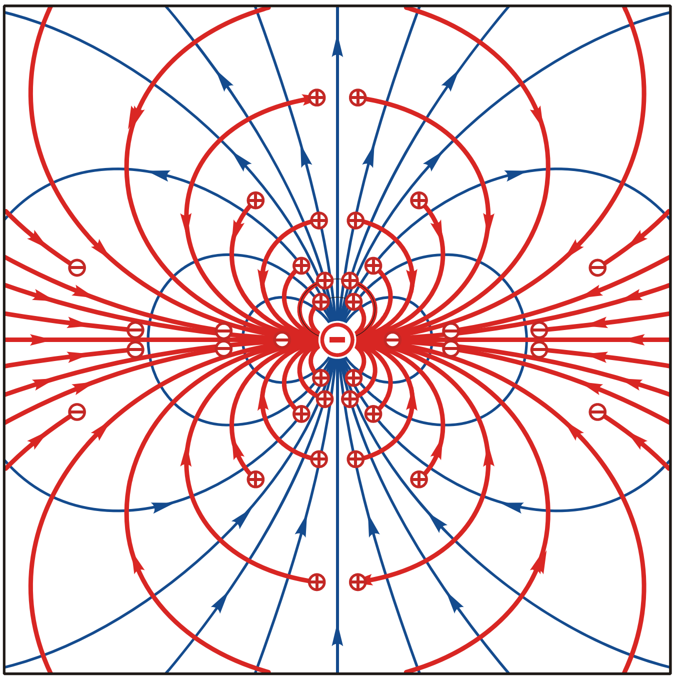

Fig. 6.2. The electromagnetic field of a magnetic dipole in a rotating frame of reference. The direction of the rotation vector is opposite to the direction of magnetic moment.
→ - magnetic flux lines;
→ - electric flux lines;
⊕ and ⊖ - accordingly the positive and negative bound charges;
⊖ - a negative charge e of the electron core.

Flux of electric strength vector $\mathbf{\Phi}_e$ through closed surface $\mathbf{S}$ is equal by definition:

$$\mathbf{\Phi}_e = \int_S \mathbf{E}\, d\mathbf{s}, \qquad (6.10)$$

where $\mathbf{E}$ is the electric strength vector.

For a spherical coordinate system let`s make use of replacement $d\mathbf{s} = r^2 \sin\vartheta \, d\vartheta \, d\varphi$. As surface $\mathbf{S}$ we choose sphere of radius r and with the centre at the origin of the coordinates. In this case it is only possible to consider a component of electric field E_r, and equation (6.10) becomes:

$$\Phi_e = \int_0^{2\pi}\int_0^{\pi} E_r r^2 \sin\vartheta d\vartheta d\varphi. \tag{6.11}$$

Let's compare usual charge q with spherical symmetry and the required charge which is located inside a sphere with the centre coinciding with dipole position $\mathbf{p}_m$.

For usual single point charge q with spherical symmetry

$$E_r = \frac{q}{4\pi\varepsilon_0 r^2}, \tag{6.12}$$

where ε_0 is an electric constant.

By substituting (6.12) in (6.11), we obtain the known relation for the charge and the flux of electric strength vector Φ_e through the closed surface covering charge q:

$$\Phi_e = \frac{q}{\varepsilon_0}. \tag{6.13}$$

Similarly, substituting (6.7) in (6.11), after simple transformations we obtain:

$$\Phi_e = \frac{2}{3}\mu_0 p_m \omega. \tag{6.14}$$

By equating (6.13) and (6.14), we obtain:

$$\omega = \frac{3qc^2}{2p_m}, \tag{6.15}$$

where c is the velocity of light.

In expression (6.15) it is taken into account that

$$c^2 = \frac{1}{\mu_0 \varepsilon_0}. \quad (6.16)$$

At the angular velocity of reference frame ω defined by expression (6.15), total vector fluxes of the electric field strength (6.14) and (6.15) are equal. In other words, the sphere of any radius with the centre at the origin of the coordinates of our rotating frame of reference contains electric charge q.

We considered the electric field arising in a rotating frame of reference with a motionless dipole placed at the rotation axis. But it means that if in a motionless frame of reference the solenoidal magnetic field is forced by some way to rotate about the longitudinal axis, an electric charge will emerge. Certainly, it is impossible. We noticed earlier that rotation of a solenoid or a permanent magnet does not lead to the magnetic field rotation. Now, we can say that such a rotation would lead to infringement of the charge conservation law. There are no forces in macrouniverse which could force the magnetic field to rotate. On the other hand, if such a rotation, nevertheless, occurs, there are no forces which could stop it, it should occur eternally as should also exist an electric charge related to the magnetic field rotation.

6.3. Electron

In this connection let`s state a hypothesis that an electric charge of elementary particles, in particular, an electron charge, is caused by rotation of their magnetic fields. Such a hypothesis, in case of its validity, should not contradict any known experimental fact, which is explained within the concepts of the electromagnetic field classical theory, and at the same time must explain at least some of the phenomena conflicting with these concepts.

In this case, the electromagnetic field configuration shown in fig. 6.2 is valid not only for a magnetic dipole in a rotating frame of reference, but also for a rotating magnetic dipole, i.e. electron, in an inertial laboratory frame of reference. Below we consider properties of such an electron.

Let's rewrite expressions (6.2) – (6.4) by substituting in them value of electron magnetic moment μ_e and value μ_0 from (6.16):

$$B_r = \frac{\mu_e \cos\vartheta}{2\pi\varepsilon_0 c^2 r^3}, \tag{6.17}$$

$$B_\vartheta = \frac{\mu_e \sin\vartheta}{4\pi\varepsilon_0 c^2 r^3}, \tag{6.18}$$

$$B_\varphi = 0. \tag{6.19}$$

Let's assume expressions (6.7) - (6.9) and (6.15) to be valid for the electron. Then by taking into account (6.16) we obtain:

$$E_r = -\frac{3e\sin^2\vartheta}{8\pi\varepsilon_0 r^2}, \tag{6.20}$$

$$E_\vartheta = \frac{3e\sin\vartheta\cos\vartheta}{4\pi\varepsilon_0 r^2}, \tag{6.21}$$

$$E_\varphi = 0, \tag{6.22}$$

where e is the magnitude of an electron charge (elementary charge).

The angular velocity of electron magnetic field ω_e, as follows from (6.15), is directed to the direction opposite to the direction of electron magnetic moment μ_e, and is equal to:

$$\omega_e = -\frac{3ec^2}{2\mu_e}. \tag{6.23}$$

Accordingly, the angular momentum of electron related to the magnetic field rotation is also directed to the direction opposite to the direction of the electron magnetic moment, which completely satisfies the concepts of quantum mechanics. If the electron magnetic moment value is accepted to be equal to Bohr magneton, $\mu_B = e\hbar / 2m_e$, we obtain from (6.23) another interesting expression for the angular velocity:

$$\omega_B = -\frac{3m_e c^2}{\hbar}, \tag{6.24}$$

where m_e is an electron mass, and $\hbar$ is Planck's constant.

If the direction of the magnetic field rotation is to be changed to the opposite and accordingly signs in the equations (6.20) - (6.22) are to be changed to the opposite, the equations will describe the positron. Thus, it is possible to draw a conclusion that the antimatter (positron) differs from matter (electron) only by the direction of the magnetic field rotation.

Let's name the charge described by equations (6.20) - (6.22) an elementary electromagnetic field source, since these equations pretend to describe the electron charge, and we shall name a charge of the same value but described by equation (6.12) a point charge. Single point and elementary sources of the electromagnetic field are equal by their magnitudes, but between them there is a principal difference: electric flux lines of a single point charge are of spherical symmetry and are directed from infinity to the charge centre (for a negative charge); flux lines of an elementary electromagnetic field source has axial symmetry, they originate (or come to the end for positron) at the final distance from the charge centre, except for the equatorial plane (plane xy in fig. 6.1). This difference manifests itself, in particular, in that the expression for flux of electric field strength (6.14) is valid only for the case if the closed surface is spherical and the sphere centre coincides with the centre of an elementary electromagnetic field source. If the surface differs from a spherical one or it is positioned in another way, relation (6.14) will be invalid, as a rule. These requirements are not effective for a single point charge: expression (6.13) is valid in all cases if the charge is located inside the closed surface.

There is the only one explanation for the features specified above: in the space surrounding the centre of an elementary electromagnetic field source, electric charges are dispersed, as is shown in fig. 6.2. Neither in the centre of an elementary electromagnetic field source nor in the space surrounding a charge, there is either "electric liquid" or "solid charged balls" which, according to classical representations, could be an electric field source. Therefore, we come to a conclusion that the *electric charge is only a property of the electromagnetic field, but not its source*.

Let's find an electric charge distribution. For this purpose, we use Gauss' theorem, or one of Maxwell's equations for the electric field strength divergence:

$$\rho = \varepsilon_0 \operatorname{div} \mathbf{E}, \tag{6.25}$$

where ρ is an electric charge density. We have exchanged left and right parts of the equation by their places in comparison with the standard view of the equation because a usual view underlines that the charge is an electric field source, but we use equation (6.25) as a definition of the electric charge.

In a spherical coordinate system, equation (6.25) will become [4]:

$$\rho = \frac{\varepsilon_0}{r^2}\frac{\partial}{\partial r}\left(r^2 E_r\right) + \frac{\varepsilon_0}{r\sin\vartheta}\frac{\partial}{\partial\vartheta}\left(E_\vartheta \sin\vartheta\right) + \frac{\varepsilon_0}{r\sin\vartheta}\frac{\partial E_\varphi}{\partial\varphi}. \tag{6.26}$$

When expressions (6.20) - (6.22) are substituted in (6.26), the first and third members in (6.26) become zero and (6.26) becomes:

$$\rho = \frac{\varepsilon_0}{r\sin\vartheta}\frac{\partial}{\partial\vartheta}\left(\frac{3e\sin^2\vartheta\cos\vartheta}{4\pi\varepsilon_0 r^2}\right). \tag{6.27}$$

After simple transformations and differentiation of expression (6.27), we finitely obtain:

$$\rho = \frac{3e}{4\pi r^3}\left(3\cos^2\vartheta - 1\right). \tag{6.28}$$

Let's summarize the preliminary results of electron properties study and arrest our attention to some of these properties.

The total electron charge (of an elementary electromagnetic field source), as well as of a classical single point electron, is equal to $-e$. Negative charges are concentrated in the equatorial area of the electron. This follows from comparison of expression (6.20), (6.21) for the elementary electromagnetic field source with expression (6.12) for a single point charge because the field of an elementary electromagnetic field source exceeds the field of a single point charge in that area. The same conclusion follows directly from expression (6.28). For the same reasons it is possible to assert that positive charges are concentrated in polar areas. The total charge of any spherical layer with the centre coinciding with the centre of an elementary electromagnetic field source is equal to zero since the full flux through the closed sphere does not depend on the sphere radius as follows from (6.14). The same result can be obtained from (6.28) by integrating it by the volume of the spherical layer.

Charges of the electron, located outside the central zone, electrona core, about which it is necessary to speak separately, are bound charges, they cannot be broken off or separated from the central charge. Forces acting on bound charges, are actually applied to the elementary electromagnetic field source as a whole. The total charge of an elementary electromagnetic field source acts as a free charge and can take part in all interactions with other charges.

It follows from the said above that in a uniform electric field the elementary electromagnetic field source (electron) will behave like a single point charge: the force acting on a spherical layer in a uniform field is equal to zero, and the central charge is equal to the single point charge. This is valid at large distances from other elementary sources of the electromagnetic field (electrons) or single point charges since, firstly, at large distances the electric field from external charges in which electron is located becomes almost uniform, and, secondly, the density of bound charges, as seen from (6.28), quickly decreases as inversely proportional to the distance cubed. And, finally, the field from external charges at their considerable quantity is averaged and becomes even more uniform.

That's quite another story considering small distances when the field, in which the electron is located, is non - uniform. In a non - uniform field the moment of force acts on the electron and it will begin precess, which is unusual in comparison with the classical single point electron, but naturally enough from the quantum mechanics point of view.

When the direction of the magnetic field rotation is changed to opposite, the general configuration of the fields will not change, but the electric field direction and also signs of every charge will exchange to the opposite. Thus, we have to do with a positron but not with an electron, as in fig. 6.2.

We have every reason to assume that equations (6.17) - (6.23) also describe, except for an electron and a positron, other leptons having an electric charge – a muon and a tau lepton as well as their antiparticles. As for an electron - positron pair, the direction of rotation of antiparticles is opposite to the direction of rotation of relevant particles, and the angular velocity of rotation, as it is clear from (6.23), is inversely proportional to the magnetic moment of a relevant particle.

The difference of leptons from each other by mass is apparently caused by distinction in magnitudes of their magnetic moments and, as consequence, in the various dimensions of their cores, the central areas of particles.

Let's note one more feature of leptons that have a charge: particles have an anti-parallel magnetic moment and a rotation direction (spin), whereas for their antiparticles they are parallel, which quite corresponds to the concepts of quantum mechanics.

6.4. Electron and the relativity theory

Above, we obtained relations for the electric and magnetic field of the electron, and also the electric charge distribution. The obtained relations concern the electron external area. We would like to note the fact which attracts attention first of all: at some distance from the rotation axis the linear rotation velocity of the magnetic field reaches the velocity of light, and then exceeds it. To complete consideration of electron external area, we consider, whether it conflict with conclusions of the special theory of relativity. With that end in view we consider rotating magnetic field of an electron from the several various points of view.

1. Let's consider the electron field relative to a motionless laboratory frame of reference.

In spherical coordinate system r, ϑ, φ linear velocity of a magnetic field V is defined by expressions (6.5) and the electron angular velocity is defined by expression (6.23).

Let's introduce the designation

$$R = r\sin\vartheta. \tag{6.29}$$

Here R is a distance of any point from the electron rotation axis.

Let's find R from (6.5), taking into account designation (6.29), by substituting (6.23) in (6.5) and omitting sign "–" in (6.23), since we are interested in the angular velocity magnitude:

$$R = \frac{2\mu_e V_\varphi}{3ec^2}. \tag{6.30}$$

By substituting in (6.30) value $V_\varphi = c$, we find distance R_c at which magnetic field velocity is equal to velocity of light:

$$R_c = \frac{2\mu_e}{3ec}. \tag{6.31}$$

Equation (6.31) represents the equation of the cylinder with the radius equal to R_c.

Thus, at value $R = R_c$ defined by (6.31), the magnetic field velocity is equal to the velocity of light, and if R increases, the velocity of light will be exceeded. By itself it is not in contrast with the conclusions of the special theory of relativity because the velocity of light cannot be exceeded only by the processes which are used to transfer information. It is obvious that the rotating field cannot transfer information, hence, there are no restrictions imposed on the magnetic field linear velocity.

Let's also notice that the formulas of Lorentz transformations calculating the intrinsic magnetic field moving with the superlight velocity contain value $\sqrt{1-V^2/c^2}$. Thus, if the velocity of light is exceeded, when value $R > R_c$, we obtain an imaginary value of the intrinsic rotating magnetic field. In turn, the rotation of this imaginary field with superlight velocity at $R > R_c$ leads to occurrence of the real value of electron magnetic field observable in a laboratory reference frame.

2. Let`s consider the electron field relative to a frame of reference rotating together with the magnetic field.

For this purpose, we find the intrinsic field of a rotating electron. For this purpose, we use the known formula for the first invariant I_1 of the electromagnetic field (equation (2.6) [3]):

$$I_1 = c^2B^2 - E^2. \tag{6.32}$$

Let's remind that the intrinsic field of a source is magnetic if the electromagnetic field invariant in brackets of expression (6.32) is positive. Otherwise, the intrinsic field of a source is electric. The equality of invariant to zero (i.e. if $c^2B^2 = E^2$) means that the intrinsic velocity of both the magnetic and electric fields (see expressions (2.8) and (2.9) [3]) is equal to the velocity of light.

To define the sign of rotating electron invariant $I_{1,}$ let find preliminary the values of c^2B^2 and E^2 entering into it.

Magnetic induction B for the electron as it has been shown earlier is described by relations (6.17) - (6.19).

Then, taking into account these relations,

$$c^2B^2 = c^2\left(B_r^2 + B_\vartheta^2\right). \tag{6.33}$$

By substituting in (6.33) values B_r and B_ϑ from (6.17) and (6.18), after elementary transformations we obtain:

$$cB = \frac{\mu_e}{4\pi\varepsilon_0 cr^3}\sqrt{1+3\cos^2\vartheta}. \tag{6.34}$$

Similarly, the value of E^2 is found. The electric field strength for the electron is described by relations (6.20) - (6.22). Proceeding from them, it is possible to write down:

$$E^2 = E_r^2 + E_\vartheta^2. \qquad (6.35)$$

By substituting expressions (6.20) and (6.21) in (6.35), after transformations we obtain:

$$E = \frac{3e\sin\vartheta}{8\pi\varepsilon_0 r^2}\sqrt{1+3\cos^2\vartheta}. \qquad (6.36)$$

After substitution in (6.32) values cB and E from (6.34) and (6.36) we find invariant I_1:

$$I_1 = \frac{1+3\cos^2\vartheta}{64\pi^2\varepsilon_0^2 r^4}\left(\frac{4\mu_e^2}{c^2r^2} - 9e^2\sin^2\vartheta\right). \qquad (6.37)$$

Invariant I_1 is equal to zero when the expression inside the brackets of equation (6.37) is equal to zero:

$$\frac{4\mu_e^2}{c^2r^2} - 9e^2\sin^2\vartheta = 0. \qquad (6.38)$$

Using substitution (6.29) let's rewrite equality (6.38) in a more convenient form:

$$\frac{4\mu_e^2}{c^2R^2} - 9e^2 = 0. \qquad (6.39)$$

Solving (6.39) for R, we obtain value R coinciding with equation (6.31). In other words, at radius value $R = R_c$ the velocity of the intrinsic electron field, as appears from (6.31), reaches the velocity of light, and invariant I_1 becomes equal to zero.

Let's consider the behavior of the intrinsic field and the intrinsic velocity of the electron when R increases from zero indefinitely.

Case $0 < R < R_c$.

The left part of equation (6.39) corresponding to the expression in the brackets of equation (6.37) is more than zero. Hence, invariant I_1 (6.37) is also more than zero and the electron intrinsic field in this case is magnetic. Its velocity magnitude V_m, as appears from equations (6.5), (6.29) and (6.30) is equal to:

$$V_m = \omega_e R = \frac{3e^2c^2}{2\mu_e} R. \tag{6.40}$$

Case $R = R_c$ has already been considered above: in this case $V = c$.

Case $R_c < R < \infty$.

Similarly, as we did it for the first case, we will come to a conclusion that invariant I_1 (6.37) is less than zero, and the intrinsic electron field in this case is electric. In other words, the observer in a rotating intrinsic frame of reference of the electron will come to a conclusion that at $R_c < R < \infty$ the intrinsic electron field is electric, and it is this field that moves relative to the centre of electron. Let`s find linear velocity V_e of this movement proceeding from expression (2.8 [3]. Due to the fact that all the vectors entering into this expression are orthogonal, expression (2.8) may be simplified:

$$V_e = c\frac{cB}{E}. \tag{6.41}$$

Values cB and E for electron are defined accordingly by expressions (6.34) and (6.36). Then after transformations, expression (6.41) becomes:

$$V_e = \frac{c^2}{\omega_e R}. \tag{6.42}$$

It is clear from here that in case $R_c < R < \infty$ the electron intrinsic field is the electric field. From expression (2.2 [3] it is seen that at point

$V_e = c$ the denominator of expression (2.2) goes to zero, and hence, numerator (2.2) must also aspire to zero because **B** at this point has a quite certain final value. Since $V_e \neq 0$ ($V_e = c$), intrinsic electric field $\mathbf{E}_0$ at this point goes to zero. It would be noted that it is possible to show in similar way using expression (2.4) that the electron intrinsic magnetic field at the same point is also equal to zero.

Thus, generalizing all the three cases of R value, we see that as R increases from zero to R_c the intrinsic magnetic field reduces to zero, and the intrinsic velocity of a magnetic field increases to the velocity of light. In further indefinite increase of R, the intrinsic field becomes electric and the intrinsic velocity of the electric field lowers from the velocity of light to zero depending on R by inversely proportional law.

3. It is also important to notice that there is a circulation of electromagnetic energy around the electron. Let`s consider the electron electromagnetic field from this point of view.

Indeed, Poynting vector **S** is equal to:

$$\mathbf{S} = \varepsilon_0 c^2 \left[\mathbf{EB}\right]. \tag{6.43}$$

In spherical coordinate system r, ϑ, φ vector **S** has only one component coinciding with the direction of φ- component of the velocity. A magnitude of Poynting vector can be found, by substitution of values cB and E from (6.34) and (6.36) in (6.43):

$$S = \frac{3\mu_e e \sin\vartheta\left(1 + 3\cos^2\vartheta\right)}{32\pi^2\varepsilon_0^2 c}\frac{1}{r^5}. \tag{6.44}$$

It is evident from (6.44) that the energy flux density circulating about the centre of the electron quickly decreases with distance from the centre of the electron as inversely proportional to the fifth degree of the distance. At $R = R_c$ Poynting vector has no specific features and is described by the general equation (6.44).

Expression (6.44) is important in understanding the electron electromagnetic field processes. It shows that, irrespective of distance R, there is a single process of the electromagnetic energy circulation about the centre of the electron.

Let`s summarize the obtained results.

The description of the intrinsic electron field shows that it is essentially impossible to measure this field and, hence, it is impossible to check up experimentally the conclusions concerning the intrinsic electron field.

The first approach to the intrinsic field estimation is based on the fact that the electron is represented as a magnetic dipole rotating as a rigid body. This approach results in the fact that the intrinsic magnetic field becomes imaginary at large distances, and the rotation linear velocity exceeds the velocity of light. It is hard to say what physical meaning may be enclosed in the concept of an imaginary magnetic field; it is more likely a mathematical abstraction only. At the same time, it cannot be excluded that in the future it will, nevertheless, be explained. Meanwhile, such a representation does not lead to contradictions within the scope of the special theory of relativity.

In the second approach the intrinsic field becomes electric at large distances, and its velocity reduces to zero with the distance from the centre of the electron. This approach is well based within the scope of the developed electromagnetic field theory and does not contradict the general physical concepts and the basic postulates of the special theory of relativity. Nevertheless, though it is also essentially impossible to measure this circulating electric field and it is only a result of theoretical reasoning, its physical meaning as well as in the first case may be clarified in the future.

The third approach fully ignores the intrinsic electromagnetic field in a rotating frame of reference, but considers the electromagnetic energy circulation only and does not find out any critical points.

In every of the approaches the magnetic and electric fields in a motionless laboratory frame of reference are described by equations (6.17) - (6.19) and (6.20) - (6.22) respectively.

6.5. On electromagnetic field reality

The whole collection of the facts, both of mathematical and physical character, indicates that the *electron is a whirl of the electromagnetic field* *velocity*. Any material carrier is not necessary for charges, except for the electromagnetic field itself; charges as it was mentioned above are a property of the electromagnetic field, but not its source.

The electromagnetic field substantiality is understood as the statement that all substances are formed by the electromagnetic field and entirely consist of it. One convincing argument or even several arguments are not enough to prove the substantiality. The whole complex of studies and arguments are necessary.

Two physical essences are known in science: the substance and the field. The field cannot be turned into the substance, but the substance can be turned into the electromagnetic field, as shown in the present work.

The following arguments indicate in favor of the substantiality of the electromagnetic field:

- The elementary and fundamental particle of the substance, electron, represents an electromagnetic whirl;
- The electric charge has no special material carrier; the charge is a property of the electromagnetic field;
- The equations obtained for the electron also provide the possibility to describe other charged leptons, muons and tau leptons;
- The fact of existence of antimatter, antiparticles of the electron and of the leptons specified above finds its natural explanation;
- The physical and mathematical description of the electron and the positron clarify the mechanism of matter and antimatter annihilation. The annihilation process is in general transparent enough. When the electron and the positron approached one another, precession gives rise to a single photon emission and the state with oppositely directed magnetic moments is reached. Then, the electron and the positron approach one another up to their absolute coincidence. Thus, all the fields are completely became zero and the field energy is released in the form of electromagnetic radiation.

These results and arguments are certainly not enough to prove the identity of the matter and the electromagnetic field. To obtain such proof a considerable work is necessary to be done on additional substantiation of arguments. It is obvious that in general this problem is difficult to solve within the scope of one or several articles, however, the solution to specific problems can significantly enhance the argumentation.

Among such problems we outline the following ones which are planned to be solved in the nearest subsequent works:

- To obtain general expressions and following from them specific expressions for charges in electromagnetism;
- To study the mechanism of interaction of electrons between themselves and other elementary particles;
- To consider the relation between electromagnetic field properties and laws of mechanics, otherwise it is difficult to speak about the field substantiality.

The latter problem forces to return again to the electromagnetic and inertial electron mass problem. This problem was widely discussed at the turn of XX century, in particular, the great attention to this question was given by Lorentz, but it has remained unsolved till now. The problem is in the fact that the inertial and electromagnetic electron masses calculated with the use of experimental data were found to be different. It contradicts not only to the hypothesis of the electromagnetic field substantiality, but also to the conclusions of the special theory of relativity.

Conclusions

1. The magnetic dipole is considered in a rotating frame of reference. It was shown that the magnetic dipole possess an electric charge in a rotating frame of reference, the value of which depends on the dipole magnetic moment and the rotation velocity.

2. The hypothesis is stated that the electric charge of elementary particles, the electron in particular, is caused by rotation of their magnetic fields, with the angular velocity and a configuration of the electron electric field were calculated.

3. It was shown that electric charges are not the electromagnetic field source. The charge is a property of the electromagnetic field and the electron represents a system of bound negative and positive charges totally equal to the classical single point electron charge.

Distribution of bound electric charges in the external electron shell was calculated. It was noticed that in external uniform electric fields the electron behaves like a single point charge.

4. It was suggested that all charged leptons – electrons, muons and tau leptons – are described by the same equations (6.17) - (6.23). Leptons are differed from each other by mass due to distinction in their magnetic moments and, thereof, in sizes of their cores. The magnetic field angular

velocity is inversely proportional to the magnetic moment of a corresponding particle.

5. It was suggested on example of the electron that particles only differ from antiparticles by the magnetic field rotation direction. The electron - positron annihilation process is explained by the fact that the fields fully come to zero provided there is a superimposition of particles with opposite magnetic moments. As a result of this superimposition, the energy of particles is released as electromagnetic radiation.

6. The magnetic moment and the rotation direction (spin) of the electron and other charged leptons are antiparallel, whereas those of their antiparticles are parallel, which completely corresponds to the concepts of quantum mechanics.

7. The hypothesis was stated that the electromagnetic field structured in the form of stationary vortex processes underlies all kinds of matter.

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The article is published on the site of the REM journal on May, 21st, 2013

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