Model of the Electron

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The interpretation of some of theoretical foundations of physics will be changed. Planck's constant is known to be one of such foundations, which serves as a basis of quantum mechanics [1], [3], [6], [7], [8], [13]. Let us consider how a refinement of interpretation of the physical essence of this constant allows to make a theoretical penetration into the depth of electromagnetic structure of the electron and to connect this structure with the results of the experiment [9], [10].

Difficulties encountered in explaining the radiation of the theoretical "black body" were overcome in December 1900 when Max Planck supposed that energy, E_p, in EM form is not emitted continuously, but discrete amounts Planck named *quanta*; that is [4]:

$$E_p = hn, \tag{1}$$

where n - frequency of EM radiation; h - a universal constant later called Planck's constant.

As it is assumed, another formula for the determination of energy of a single photon has been suggested by Albert Einstein.

$$E_p = mC^2, \tag{2}$$

where m - the mass of a photon; C - the velocity of a photon.

The frequency of a photon's oscillations is n, its velocity C, and its wavelength l are related by:

$$C = l \cdot n \tag{3}$$

Solving (1), (2) and (3) we fined:

$$h = m\,l^2 n \ldots\left(\frac{Kg \cdot M^2}{S}\right) \tag{4}$$

It is difficult to understand why Planck has ascribed physical sense of *action* to his constant, h, which does not necessarily correspond to its dimensionality. "If Planck had determined his constant as a quantum of angular momentum modern physics would have been quite different" [11].

Actually Planck's constant has dimensionality of angular momentum, which has vector properties. But as some Physicists think, it does not mean that Planck's constant is a vector value. We shall not contradict their stereotype mentality, let us use the suitable possibility of hypothetical approach to this problem and consider its fruitfulness. As it is clear, dimensionality of Planck's constant is that of angular momentum, how can we coordinate this dimensionality with the square of the wavelength, l^2?

The matter is that in the mathematical expression of Planck's constant $h = m\,l^2 n$ mass m is multiplied by square value of wave length l^2 and by frequency n. But wave length characterizes wave process, and dimensionality of Planck's constant demonstrates that an electromagnetic formation, which is described by it, rotates relative to the own axis, and we are faced with the task to coordinate the wave process with the rotation one. Detailed investigations carried out by us [4], [9], [10], [20], [22] have shown that the photon and the

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electron have such electromagnetic structures during rotation and movement which radii r are equal to lengths of their waves l, *i.e.*

$$l = r \tag{5}$$

Now Planck's constant has the following appearance:

$$h = mr^2 n \ . \tag{6}$$

It becomes clear that mr^2 is moment of inertia of the ring, and $mr^2 n$ is angular momentum of the rotating ring. It points out to the fact that the photons and the electrons have a form which is similar to the form of the rotating ring.

It is known that if angular moment is constant, the law of conservation of angular momentum, one of the main laws of nature, is accomplished. As Planck's constant is constant ($\bar{h} = const$) and has dimensionality of angular momentum, it characterizes the law of conservation of angular momentum. Thus, the law of conservation of angular momentum, one of the main laws of Nature, governs constancy of Planck's constant [10], [14].

It is known that the electron has its own energy which is usually determined according to the formula $E_e = m_e C^2$. But the meaning of such an assumption is deciphered not always. And the meaning is that if the whole energy of the electron is transformed into energy of the photon, its energy becomes equal to $E_e = m_e C^2$. This fact has a strong experimental confirmation. It is known the masses of electron and positron are equal. When they interact they form two γ - photons. That's why the energy being equal to the energy of the photon which has the corresponding mass can be attributed to the electron. Electron rest mass m_e =9.1 10^{-31} kg is determined with great accuracy. Let us call electron energy E_e being equal to photon energy a photon energy of the electron.

First of all, let us investigate the possibilities of the ring model of free electron. It is known that the electron has kinetic energy and potential energy which are equal to each other.

$$E_e = m_e C^2 = m_e r_e^2 w_e^2 = h \cdot w_e \ , \tag{7}$$

where: r_e - is the radii of the electron; w_e -frequency of electron; $h = mr^2 w_e$ - is Planck's constant.

The calculation according to this formula gives the following value of photon energy of the electron:

$$E_e = m_e C^2 = \frac{9.109 \cdot 10^{-31} \cdot (2.998 \cdot 10^8)^2}{1.602 \cdot 10^{-19}} = 5.110 \cdot 10^5 \, eV \tag{8}$$

If free electron rotates only relatively to its axis, angular frequency w_e of rotation of ring model of free electron determined according to the formula (7) is equal to

$$w_e = \frac{E_e}{h} = \frac{5.111 \cdot 10^5 \cdot 1.602 \cdot 10^{-19}}{6.626 \cdot 10^{-34}} = 1.236 \cdot 10^{20} \, s^{-1}, \tag{9}$$

and radius of the ring is equal to

$$r_e = \sqrt{\frac{E_e}{m_e w_e^2}} = \sqrt{\frac{5.111 \cdot 10^5 \cdot 1.602 \cdot 10^{-19}}{9.109 \cdot 10^{-31} \cdot (1.236 \cdot 10^{20})^2}} = 2.426 \cdot 10^{-12} \, m. \tag{10}$$

Velocity of V_e points of the rotating ring is equal to velocity of light:

$$V_e = w_e \cdot r_e = 1.236 \cdot 10^{20} \cdot 2.426 \cdot 10^{-12} = 2.998 \cdot 10^8 \, m/s. \tag{11}$$

Let us try to find such mathematical models which describe behaviour of the ring model of the electron, which contain its charge e, magnetic moment M_e and electron electromagnetic field strength B_e (magnetic induction of electron).

If we assume that the electron charge is distributed uniformly along the length of its ring model, each element of the ring Δl will have mass Δm and charge Δe (Fig. 1). In this case the rotating ring model of the electron will resemble ring current, and two forces which have equal values and opposite directions: inertial force $F_i = \Delta m \cdot V_e^2 / r_e$ and Lorentz force $F_e = \Delta e \cdot B_e \cdot V_e$ (Fig. 1).

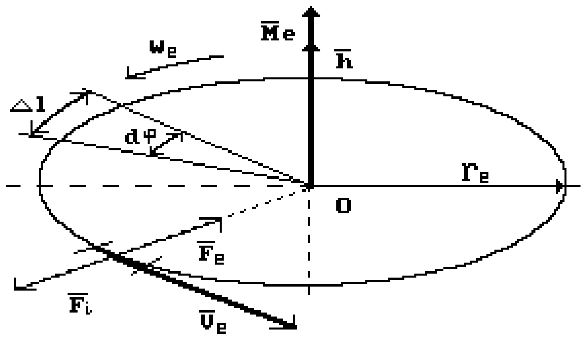

Fig. 1. Diagram of ring model of the electron

$$\Delta e \cdot B_e \cdot V_e = \frac{\Delta m \cdot V_e^2}{r_e}. \tag{12}$$

Let us pay attention to the fact that there are two notions for the magnetic field characteristic which are similar as far as physical sense is concerned: magnetic field induction B_e and magnetic field strength H which are connected by the dependence:

$$H = \frac{B_e}{m_0},$$

where m_0 is magnetic constant.

The analysis experience shows that it creates a certain confusion during the formation of the ideas concerning magnetic field, that's why some authors refuse to use a clumsy term "magnetic induction" and preserve only one, more felicitous term "magnetic field strength" using symbol B_e for it. Cl. E. Suortz, the author of the book "Unusual physics of usual phenomena" [12], acted in this way, and we follow his example. Magnetic field will be characterized by vector B_e, it will be called magnetic field strength measured in SI system in T (tesla).

If we write d_m for mass density of the ring and d_e for charge density, we shall have:

$$\Delta m = d_m \cdot \Delta l = d_m \cdot r_e \Delta j, \tag{13}$$

$$\Delta e = d_e \Delta l = d_e \cdot r_e \Delta j. \tag{14}$$

As:

$$d_m = \frac{m_e}{2p\, r_e}, \tag{15}$$

$$d_e = \frac{e}{2p\, r_e} \tag{16}$$

and $V_e = C$, the equation (12) assumes the form:

$$\frac{eB_e}{2p\, r_e} \cdot dj = \frac{m_e C}{2p\, r_e \cdot r_e} \cdot dj \qquad (17)$$

or

$$eB_e = \frac{m_e C}{r_e} = \frac{m_e w_e r_e}{r_e} = m_e \cdot w_e, \qquad (18)$$

where $w_e r_e = C.$

Thus, we have got the mathematical relation which includes: mass m_e of free electron, its charge e, magnetic field strength B_e inside the electron ring which is generated by rotating ring charge, angular frequency w_e and radius r_e of the electron ring. Magnetic moment of electron or, as it is called, Bohr magneton is missing in this relation which mathematical presentation is as follows [19]:

$$M_e = \frac{eh}{4p \cdot m_e} = 9.274 \cdot 10^{-24} J/T. \qquad (19)$$

Let us pay attention to the fact that in the above-mentioned relation h is vector value; it gives vector properties to Bohr magneton M_e as well. It follows from the formula (19) that the directions of vectors $\overline{h}$ and $\overline{M}_e$ coincide. Let us convert the relation (18) in the following way:

$$B_e = \frac{m_e w_e}{e} = \frac{4p \cdot m_e h w_e}{4p \cdot eh} = \frac{h w_e}{4p \cdot M_e} = \frac{E_e}{4p \cdot M_e}. \qquad (20)$$

The result from it is as follows:

$$4p \cdot B_e \cdot M_e = E_e.$$

Now from the relations (20) we can determine magnetic field strength B_e inside the ring mode of the electron, angular velocity w_e, rotations of the ring and its radius r_e:

$$B_e = \frac{E_e}{4p \cdot M_e} = \frac{.5111 \cdot 10^5 \cdot 1.602 \cdot 10^{-19}}{4 \cdot 3.142 \cdot 9.274 \cdot 10^{-24}} = 7.017 \cdot 10^8 T. \qquad (21)$$

Let us pay attention to rather large magnetic field strength in the centre of symmetry of the electron and let us remind that it diminishes along the electron rotation axis directly proportional to the cube of a distance from this centre [12]. We find from the relations (20):

$$w_e = \frac{4p \cdot M_e \cdot B_e}{h} == \frac{4 \cdot 3.142 \cdot 9.274 \cdot 10^{-24} \cdot 7.025 \cdot 10^8}{6.626 \cdot 10^{-34}} = 1.236 \cdot 10^{20} s^{-1}. \qquad (22)$$

As peripheral velocity of the ring points is equal to velocity of light, we have:

$$r_e = \frac{C}{w_e} = \frac{2.998 \cdot 10^8}{1.236 \cdot 10^{20}} = 2.426 \cdot 10^{-12} m. \qquad (23)$$

The main parameters of the ring model of free electron: ring radius r_e (10), (23) and angular frequency of its rotation (9), (22) determined from the different relations (8) and (21) have turned out to be equal. A drawback of the ring model is in the fact that it does not open a cause of positron birth, that's why the intuition prompts that the ring should have some internal structure. Our next task is to find out this structure.

We'd like to draw the attention of the reader to the fact that in all cases of our electron behaviour analysis Planck's constant in the integer form plays the role of its spin. In modern physics it is accepted to think that the photon spin is equal to h , and the electron spin is equal to $0.5h$. But the electron spin value ($0.5h$) is used only for the analysis of qualitative characteristics of electron behaviour. Value h is used for quantitative calculations. In our investigations the integer of angular momentum h is the spin of the photon and the electron. It is used for quantitative calculations and qualitative characteristics of behaviour of both photon and electron [2], [4], [9], [10], [13], [21].

Torus is the nearest "relative" of the ring. For the beginning let us assume that torus is hollow. Let us write r_e for torus section circle radius (Fig. 2). The area of its surface is determined according to the formula:

$$S_e = 2p r_e \cdot 2p r_e = 4p^2 r_e r_e . \tag{24}$$

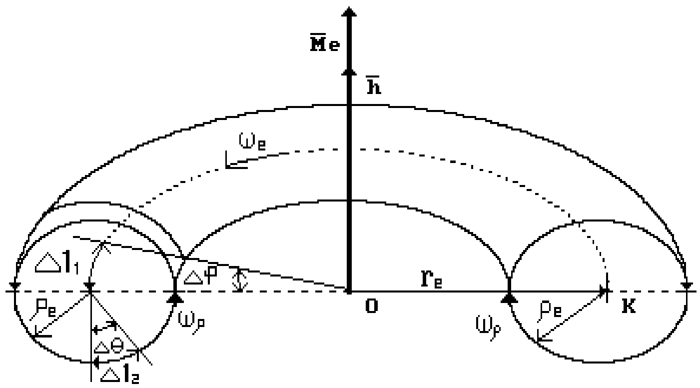

Fig. 2. Diagram of toroidal model of the electron

Let us write d_m for surface density of electromagnetic substance of the electron. Then

$$d_m = \frac{m_e}{S_e} = \frac{m_e}{4p^2 r_e r_e} . \tag{25}$$

Let us determine moment of inertia of hollow torus. We shall have the following equation from Fig. 2:

$$I_Z = \sum \Delta m \cdot r_e^2 . \tag{26}$$

$$\Delta m = 2p r_e \cdot \Delta l_1 \cdot d_m = 2p r_e \cdot d_m \cdot r_e \Delta j . \tag{27}$$

$$I_Z = \int_0^{2p} \frac{m_e r_e^2}{2p} \cdot dj = m_e \cdot r_e^2 . \tag{28}$$

As the electron demonstrates the electrical properties and the magnetic ones at the same time and has angular momentum, we have every reason to suppose that it has two rotations. Let us call the usual rotation relative to the axis of symmetry with angular frequency w_e kinetic rotation which forms its angular momentum and kinetic energy. And secondly, let us call vortical rotation relative to the ring axis with angular frequency w_r (Fig. 2) potential rotation which forms its potential energy and potential properties. It is natural to assume that the sum of kinetic energy E_k and potential energy E_o of free electron is equal to its photon energy E_e . Let us consider the possibility of realization of our suppositions. Kinetic energy of hollow torus rotation is determined according to the formula (Fig. 2):

$$E_K = \frac{E_e}{2} = \frac{1}{2} \cdot I_Z \cdot w_e^{\ 2} = \frac{1}{2} \cdot m_e \cdot r_e^{\ 2} \cdot w_e^{\ 2} = \frac{1}{2} h w_e. \tag{29}$$

Frequency w_e of kinetic rotation of torus is equal to

$$w_e = \frac{E_e}{h} = \frac{5.111 \cdot 10^5 \cdot 1.602 \cdot 10^{-19}}{6.626 \cdot 10^{-34}} = 1.236 \cdot 10^{20} s^{-1}. \tag{30}$$

We shall determine radius r_e of torus from the formula

$$r_e = \sqrt{\frac{E_e}{m_e \cdot w^2{}_e}} = \sqrt{\frac{5.111 \cdot 10^5 \cdot 1.602 \cdot 10^{-19}}{9.109 \cdot 10^{-31} \cdot (1.236 \cdot 10^{20})^2}} = 2.426 \cdot 10^{-12} m. \tag{31}$$

As it is clear, r_e and w_e (30), (31) coincide with the values of r_e and w_e in formulas (9), (10), (22) and (23) in this case as well. It is interesting to find out if there is an experimental confirmation of value r_e obtained by us. It turns out that there is such confirmation. In 1922 A. Compton, the American physicist - experimenter, found that dissipated X-rays had larger wave-length that incidental ones. He calculated the shift of wave Δl according to the formula [10], [18], [21]:

$$\Delta l = l_e (1 - \cos b). \tag{32}$$

The experimental value of magnitude l_e turned out to be equal to $2.42631058 \cdot 10^{-12} m$ [17], [19]. Later on a theoretical value of this magnitude was obtained by means of complex mathematical conversions based on the ideas of relativity $l_e = h / m_e \cdot C =$ $2.42631060 \cdot 10^{-12} m$ [18].

When we have studied Compton effect and have carried out its theoretical analysis, we have shown that the formula for the calculation of theoretical value of Compton wave-length l_e is obtained quite simple if we attach sense of the electron radius to the electron wave-length and consider the diagram of interaction of the ring model of electron with the ring model of roentgen photon [21].

The diagram of interaction of the ring model of roentgen photon with the ring model of the atomic electron is shown in Fig. 3. The pulse hw_0 / C of the photon falling on the electron and the pulse $(hw)/C$ of the photon reflected from the electron are connected by simple dependence:

$$\frac{hw}{C} = \frac{hw_o}{C} \cdot \cos b. \tag{33}$$

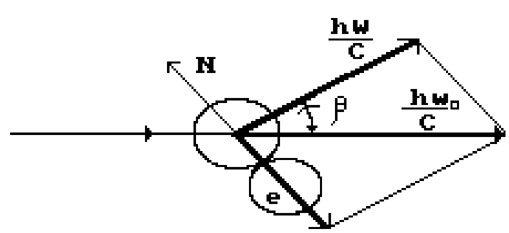

Fig. 3. Diagram of interaction of the photon with the electron in Compton effect

After the interaction of the photon with the electron its pulse will be changed by the value:

$$\frac{hw_o}{C} - \frac{hw}{C} = \frac{hw_o}{C} - \frac{hw_o}{C} \cdot \cos b \tag{34}$$

or

$$w_o - w = w_o \cdot (1 - \cos b). \tag{35}$$

As

$$w_o = C / l_o \text{ è } w = C / l \ ,$$

so

$$\frac{C}{l_o} - \frac{C}{l} = \frac{C}{l_o} \cdot (1 - \cos b) \tag{36}$$

or

$$l - l_o = l \cdot (1 - \cos b). \tag{37}$$

The relation can be converted in the following way:

As $m_e l^2 w = h$ and $l w = C,$ the equation is as follows:

$$l - l_o = \Delta l = \frac{h}{m_e C} \cdot (1 - \cos b) = l_e (1 - \cos b). \tag{38}$$

This is Compton formula of the calculation of the change of wave-length Δl of reflected roentgen photon. Value l_e being a constant is called Compton wave-length. In the formula (38) it is a coefficient determined experimentally and having the value [17]:

$$l_e(\exp er) = 2.42630158 \cdot 10^{-12} m, \tag{39}$$

which coincides completely with the value of radius r_e of the electron which has been calculated by us theoretically according to the formula (10), (23) and (31):

$$r_e(theor) = 2.42630157 \cdot 10^{-12} m. \tag{40}$$

It should be noted that we have obtained the formula (38) without any relativity idea using only the classical notions concerning the interaction of the ring models of the photon and the electron.

As the analysis of the results of experimental spectroscopy has shown that electron wave-length is equal to radius of its ring model and as the results of various methods of the calculation of radius of electron coincide completely with Compton experimental result, the toroidal model of the electron is now the fact that is enough for the resolute advancement in our search.

It is desirable to know the value of radius r_e of torus cross section circumference. Let us try to find this value from the analysis of potential rotation of electron with frequency w_r (Fig. 2).

We should pay attention to the fact that the pulse of both the photon and the electron is determined according to one and the same relation:

$$P = \frac{h}{l} = \frac{h}{r}. \tag{41}$$

It means that both the photon and the electron display their pulse in the interval of one wave-length. This fact has been reflected in the models of the photon as an equality between wave-length l of the photon and its radius r. As the photon is absorbed and radiated by the electron, the electron should have the same connection between the wave-length and radius. Besides, the models of the photon has six electromagnetic fields; the same quantity should be in the model of the electron when it radiates or absorbs the photon [2], [4], [13]. The described conditions prove to be fulfilled if one assumes that angular frequency w_e of kinetic rotation is one-sixth of angular frequency w_r of potential rotation of free electron, *i.e.*:

$$w_r = 6 w_e. \tag{42}$$

If we assume that velocity of the points of the axis ring of torus in kinetic rotation is equal to velocity of the points of the surface of torus in potential rotation, we shall have:

$$C = w_e \cdot r_e = w_r \cdot r_e = C. \tag{43}$$

From these relations we shall find out:

$$w_r = 6 \cdot 1.236 \cdot 10^{20} = 7.414 \cdot 10^{20} s^{-1} \tag{44}$$

and

$$r_e = \frac{C}{w_r} = \frac{2.998 \cdot 10^{8}}{7.416 \cdot 10^{20}} = 4.043 \cdot 10^{-13} m. \tag{45}$$

If we substitute the data being obtained into the formula (29), we shall find out the value of potential energy E_o of the electron

$$E_o = \frac{1}{2} m_e \cdot r_e^{2} \cdot w_r^{2} = \frac{9.091 \cdot 10^{-31} \cdot (4.043 \cdot 10^{-13})^2 \cdot (7.416 \cdot 10^{20})^2}{2 \cdot 1.602 \cdot 10^{-19}} = 2.555 \cdot 10^{5} eV. \tag{46}$$

If we double this result, we shall obtain complete photon energy of free electron (8). Complete coincidence of photon energy of the electron obtained in different ways gives us the reason to suppose that the electron is a closed ring vortex which forms a toroidal structure which rotates relatively its axis of symmetry generating potential and kinetic energy.

It results from sixfold difference between angular velocities w_e and w_r that radius r_e is greater by sixfold than radius r_e. We postulate this fact supposing that, as we have shown, the most economical model of the photon movement is possible only at six electromagnetic fields [2], [4], [9], [13]. This principle is realized when the vortex moves in a closed helix of the torus. It results from the difference of radii and angular velocity that the vortex which moves along the surface of torus makes six rotations relative to the ring axis in a helix during one rotation of torus relatively its axis of rotation. A lead of a helix is equal to radius r_e of the axis ring and wave-length l_e of the electron (Fig. 4) [2], [4], [9], [10], [20], [22].

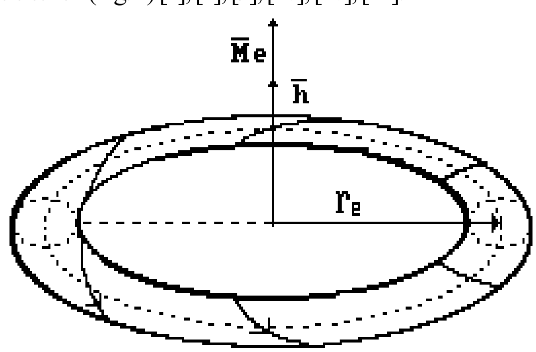

Fig. 4. Electron model diagram

Besides rotary motion, in this case the electron has potential (vortical) rotation. We have noted that a sharp change of the relations between kinetic and potential rotations of the electron leads either to absorption or radiation of the photon depending on the direction of the change of this relation. If this change slows down kinetic rotation, the photon radiation process takes place; if this change accelerates it, the absorption process takes place.

When we have substantiated the model of the electron, we have used the existing Coulomb's law and Newton's law, spectrum formation law formulated by us, Lorentz electromagnetic force and the following constants: velocity of light C, Planck's constant h, electron rest mass m_e, its charge e, electron rest energy, Bohr magneton M_e, electrical constant e, Compton wave-length of the electron which should be called Compton radius of the electron.

Thus, the electron has the form of the rotating hollow torus (Fig. 5). Its structure proves to be stable due to availability of two rotations. The first rotation takes place about an axis which goes through the geometrical centre of torus perpendicular to the plane of rotation. The second rotation is a vortical about the ring axis which goes through the torus cross section circumference centre.

Only a part of magnetic lines of force and the lines which characterize electric field of the electron is shown in Fig. 5. If the whole set of these lines is shown, the model of the electron will assume the form which resembles of the form of an apple. As the lines of force of the electric field are perpendicular to the lines of force of the magnetic field, the electric field in this model will become almost spherical, and the form of the magnetic field will resemble the magnetic field of a bar magnet.

Several methods of torus radius calculation which include its various energy and electromagnetic properties give the same result which completely coincides with the experimental value of Compton wave-length of the electron, *i.e.* $l_e = r_e = 2.42630157 \cdot 10^{-12}$ m [17], [19].

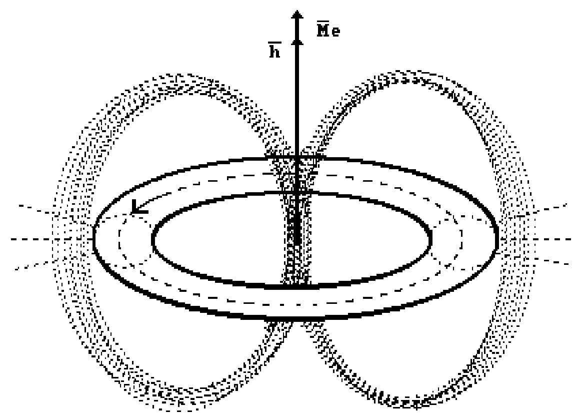

Fig. 5. Diagram of electromagnetic model of the electron (only a part of electric and magnetic lines of force is given in the figure)

Conclusion

Max Planck lived in the time when many physics denied the possibility of the implementation of the classical laws for its further development. The people who tried to do it were called mechanists. Probably, he feared these accusations and used an uncertain notion "*quantum of the least activity*" or "*quanta*," or "*action*" for the determination of his constant. We return a true physical sense to his constant. The Nature has put the *law of conservation of angular momentum* into it. The recognition of this fact opens wide prospects for physics and chemistry of the 21st century. The way for the exposure of the electromagnetic structures of the elementary particles, atoms, ions and molecules is opened. The beginning for this way has already been marked [2], [4], [9]. [10], [13].

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