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Electron as a Structure Made of Basic Elementary Particles: Spinning Speed and Radius

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Abstract

We have calculated the orbital speed, the radius of an orbit of the revolving basic particles, and the angular speed of an electron in three models of an electron as a spinning composite particle. The three models suggested in our previous work [1] are the centered square structure, the rhombus structure, and the tetrahedral structure. The calculated speed of revolving basic particles, for all three models of an electron, does not exceed c, the maximum possible speed in nature: $v = \frac{3}{5}c$ for the centered square model, $v = \frac{\sqrt{5}}{3}c$ in the rhombus model, and $v = \frac{\sqrt{7}}{4}c$ in the tetrahedral model. The results show that the spin of an electron can be reasonably explained assuming that an electron is not an elementary particle, but a composite structure made of five basic elementary particles of mass $m_e/6$ and of charge +e/3 (one particle) and -e/3 (four particles). The calculated angular frequencies of spinning electron structures have characteristic values for the considered models and are in the range of $(2.5 - 2.7) \cdot 10^{20} \frac{1}{s}$. The angular frequency of electrons might be determined in experiments on the interaction of X-rays with electrons.

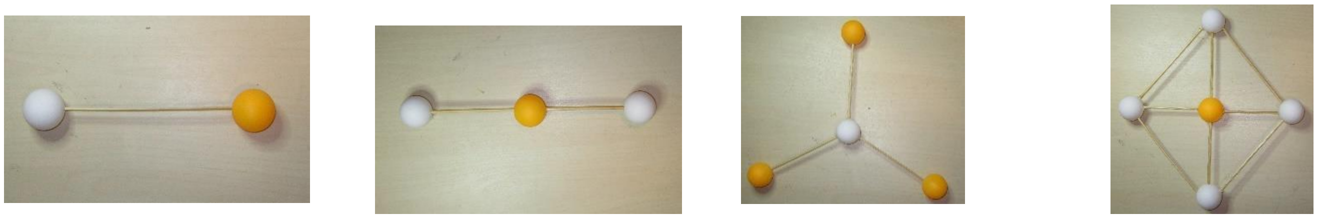
In our paper [1], we suggested that the 1st generation quarks and an electron are not elementary particles but are made of basic elementary particles of mass m_{basic} of about 1/6 of the electron mass, with the fractional charges of (+e/3) and (-e/3). The structures (quarks) are in rotation about an axis of symmetry. In our models, an electron is a quark composed of one basic particle of charge (+e/3) and four basic particles of charge (-e/3). The suggested in [1] quark structures are shown in Fig. 1 and are listed below:

1. Structure 1- a neutral structure (neutrino?) made of two basic particles (labeled (a) in Fig. 1): one of charge $(+e/3)$ and one of charge (-e/3), revolving about the axis through the middle point between the charges, perpendicular to the line connecting the charges (the structure is shown as a ball and stick model). This neutral structure has a non-zero spin but its magnetic moment is zero.
2. Structure 2 (d-quark) (labeled (b) in Fig. 1): one (+e/3) charge in the center and two (-e/3) charges at both sides from the central positive charge (ball and stick model). The structure is in spinning motion about the axis through the central charge, perpendicular to the line connecting the charges.
3. Structure 3 (u-quark) (a trigonal plane structure labeled (c) in Fig. 1.): one(-e/3) charge in the center and three (+e/3) charges positioned symmetrically around the central negative charge. The structure is in spinning motion about the axis through the central charge, normal to the plane where the charges are located.
4. Structure 4 (electron): one (+e/3) charge in the center and four (-e/3) charges positioned around the central positive basic charge. There are three possible variants of a stable structure: one – as a centered square with the axis of rotation normal to the plane with the charges and passing through the central positive charge; second – a tetrahedral structure (like a methane molecule), with the axis of rotation passing through two basic charges - the central positive charge and one negative basic charge; third – a rhombus structure, with its long diagonal being 1.04 times longer than the short diagonal, rotating about its long diagonal, as shown in Fig 1, d, with the axis of rotation passing through three basic charges.

For all the structures, the net force on each charge on the axis of rotation is zero, and the net force on any revolving charge is a central force, toward the axis of rotation. The spin of each quark structure is in fact the angular momentum of the rotating structure made of basic elementary particles of mass m_{basic}. The magnetic moment of each structure is the sum of the magnetic moments of the revolving charges in the composite structure.

As suggested in [1], an electron is a structure made of one basic elementary particle of charge (+ e/3) and four basic elementary particles of charge (-e/3), each of the mass about 1/6 of the electron rest mass. In our models, an electron is the only quark that has been observed as an isolated particle, not being bonded to other quarks. With many of the electron properties being determined experimentally, the study of electron composite structures might lead to better understanding of properties of other particles (quarks, neutrinos) currently considered as being “elementary”.

Before our work [1], the spin of an electron had no explanation and was considered as just an intrinsic property of an electron as an elementary particle. In [1], we gave the first explanation of electron spin as being an angular momentum of an electron as a rotating structure made of five basic elementary particles



(b) (c) (d)

Fig. 1. Quark models as the rotating structures made of the basic charges (+e/3) and (-e/3). (a) – a neutral quark (neutrino?) made of one (-e/3) basic charge and one (+e/3) basic charge; (b) – d-quark of charge (-e/3), made of a (+e/3) basic charge and two (-e/3) basic charges; (c) - u-quark of charge (+2e/3), made of one (-e/3) and 3 (+e/3) basic charges; (d) – electron as a quark of charge (-e), made of one (+-e/3) and 4 (-e/3) basic charges. Positive basic charges are shown as orange balls, and negative basic charges are represented by white balls.

As an extension of that work, we determined the speed of motion of the revolving basic particles in the suggested structures of an electron and the radius of the rotating structures. The calculated speed of moving basic particles in the electron structure, for all three models of an electron, does not exceed c, the maximum possible speed in nature. That demonstrates the feasibility of our models of an electron.

There are three possible arrangements of these five elementary basic particles in an electron structure, with some basic particles being at rest and some being in a revolving motion. In our models of an electron, it is assumed that there is a rotation (spinning) of the entire structure about some axis. The angular momentum of the rotational motion is the electron spin.

(a) (b)

Fig. 2. two models of an electron as a particle with the total charge of -e composed as a with a q = +e/3 basic charge (red) in the center and four basic charges -q = -e/3 (green) around the central charge. (a) – the centered square structure, where the four negative basic charges are in the corners of the square. The centered square structure is assumed to be in rotation about the axis of rotation normal to the plane of the structure and passing through the central positive charge. (b) - a rhombus structure where the four negative charges are in the corners of a rhombus. This rhombus structure is assumed to be in rotation about its longer diagonal (vertical diagonal of length 2d).

Below, for each of three suggested structures of an electron, we will calculate the speed of the revolving basic particles as well as the radius of the spinning structure and the angular frequency of the spinning structure of an electron. The equations used in the calculations are given in undergraduate University Physics textbooks (see, for example, [2]).

1. The speed of revolving particles in the composite models of an electron

We will determine the speed of the revolving basic elementary particles of mass m_{basic} for three models of an electron, each consisting of one basic particle of charge (+e/3) and four basic particles with the charge of (-e/3). The total relativistic energy of the structure is the sum of the relativistic total energies of all five basic particles. Using the equation for the total relativistic energy [2, p.1241] of a particle moving with a speed v as applied to the basic elementary particle of mass m_{basic}, we can write for the total energy of a basic particle in the suggested electron structures as

$$E_{basic} = \frac{m_{basic}c^2}{\sqrt{1-\frac{v^2}{c^2}}} \quad (1)$$

The total rest energy of an electron is $m_e c^2$, which, with $m_{basic}=m_e/6$ in our models of an electron, is $6m_{basic}c^2$.

The sum of the energies of those basic particles which are (at rest) on the axis of rotation and those which revolve about the axis is the total energy of the composite electron structure – which is the known rest energy of an electron $m_e c^2$. In all our models, the basic elementary particle mass is $m_{basic}=m_e/6$. Therefore, the total rest energy of an electron can be expressed as $m_e c^2 = 6m_{basic}c^2$.

2. Radius of an orbit of basic particles revolving about the axis of rotation in the composite models of an electron

To calculate the radius of the rotating structure of an electron, we can use the known magnitude of the angular momentum of an electron (its spin) and the speed of the revolving basic particles in the electron model structure.

The relativistic momentum of a particle moving with a velocity $\vec{v}$ is [2, p.1238]

$$\vec{p} = \frac{m\vec{v}}{\sqrt{1-\frac{v^2}{c^2}}} \quad (2)$$

so, the angular momentum of a particle at the position $\vec{r}$ moving with the momentum $\vec{p}$ is

$$\vec{L} = \vec{r} \times \vec{p} = \frac{m\vec{r}\times\vec{v}}{\sqrt{1-\frac{v^2}{c^2}}} \quad (3)$$

Because for the circular motion of a particle its velocity and radius vectors are perpendicular to each other, the radius of an orbit can be determined from equation (3) as

$$r = \frac{L\sqrt{1-\frac{v^2}{c^2}}}{mv} \quad (4)$$

3. Angular frequency of a spinning electron structure

With the known speed *v* of the revolving basic particles and the radius *r* of their orbit, the angular frequency of the spinning electron structure can be calculated as

$$\omega = \frac{v}{r} \quad (5)$$

4. Calculations for the centered square model of an electron

The centered square model of an electron consists of one basic particle of charge (+e/3) at rest in the center and four basic particles of charge (-e/3) located in plane symmetrically around the central positive charge, as shown in Fig. 2,a. The structure rotates about the axis that is normal to the plane and passes through the center of the structure. Equating the total energy of five basic particles to the known energy of an electron at rest, we get:

$$m_{basic}c^2 + 4\frac{m_{basic}c^2}{\sqrt{1-\frac{v^2}{c^2}}} = 6m_{basic}c^2 \quad (6)$$

Hence, for the centered square model of an electron,

$$\sqrt{1-\frac{v^2}{c^2}}=\frac{4}{5}\text{, so }\frac{v}{c}=\frac{3}{5} \quad (7)$$

The angular momentum of the entire rotating structure is its spin S, and the angular momentum L of each of four revolving particles in this model is L = S/4. Plugging this value and the speed v = (3/5)c into equation (4), we can calculate the radius of the rotating structure (the electron radius) as:

$$r=\frac{L\sqrt{1-\frac{v^2}{c^2}}}{mv}=\frac{\frac{S}{4}\cdot\frac{4}{5}}{m_{basic}\frac{3}{5}c}=\frac{S}{3m_{basic}c} \quad (8)$$

The electron spin $S=\frac{\sqrt{3}}{2}\hbar$. With this,

$$r=\frac{1}{2\sqrt{3}}\frac{\hbar}{m_{basic}c} \quad (9)$$

The angular frequency of the rotating centered square structure of an electron is

$$\omega=\frac{v}{r}=\frac{6\sqrt{3}}{5}\frac{m_{basic}c^2}{\hbar} \quad (10)$$

Hence, for the centered square model of an electron, v = 0.60c, r = $6.7\cdot10^{-13}$m, and $\omega=2.7\cdot10^{20}\,\frac{1}{s}$

5. Calculations for the rhombus model of an electron

The rhombus model of an electron consists of one (+e/3) charge in the center and four (-e/3) charges located in plane in the corners of the rhombus (see Fig. 2,b), the long diagonal of which 2d is about 1.04 times longer than its short diagonal 2r. The rhombus is assumed to be in rotation about the long diagonal passing through the central particle of charge (+e/3) and two basic particles of charge (-e/3). Hence, three of five basic particles are at rest and two basic particles are revolving about the long diagonal, moving with a speed v. The geometry of the rhombus structure of an electron is determined from the condition that the net electrostatic force on each basic particle that is at rest (being on the axis of rotation) is zero.

Equating the total energy of five basic particles to the energy of an electron at rest, we get

$$3m_{basic}c^2+2\frac{m_{basic}c^2}{\sqrt{1-\frac{v^2}{c^2}}}=6m_{basic}c^2 \quad (11)$$

From this, $\sqrt{1-\frac{v^2}{c^2}}=\frac{2}{3}$, and $\frac{v}{c}=\frac{\sqrt{5}}{3}$ (12)

The angular momentum of the entire rotating structure is its spin S, and the angular momentum L of each of two revolving particles in this model is L = S/2. Plugging this value and the speed $v=\frac{\sqrt{5}}{3}$c into equation (4), we can calculate the radius of the rotating rhombus structure (the electron radius) as:

$$r=\frac{L\sqrt{1-\frac{v^2}{c^2}}}{mv}=\frac{\frac{S}{2}\cdot\frac{2}{3}}{m_{basic}\frac{\sqrt{5}}{3}c}=\frac{S}{\sqrt{5}m_{basic}c} \quad (13)$$

With the electron spin $S=\frac{\sqrt{3}}{2}\hbar$, we get

$$r=\frac{\sqrt{3}}{2\sqrt{5}}\frac{\hbar}{m_{basic}c} \quad (14)$$

The angular speed of the rotating rhombus structure of an electron is

$$\omega=\frac{v}{r}=\frac{10}{3\sqrt{3}}\frac{m_{basic}c^2}{\hbar} \quad (15)$$

Hence, for the rhombus model of an electron, v = 0.75c, r = 9·10^{-13}m, and $\omega = 2.5 \cdot 10^{20}\frac{1}{s}$.

6. Calculations for the tetrahedral model of an electron

A tetrahedral structure (like a methane molecule) consists of two basic particles on the axis of rotation and three basic particles positioned symmetrically around the axis at some distance r. The axis of rotation passes through two basic charges - the central positive charge and one negative basic charge, so these two basic particles are at rest; the other three basic particles are revolving with a speed v about the axis. Equating the total energy of five basic particles to the energy of an electron at rest, we get

$$2m_{basic}c^2 + 3\frac{m_{basic}c^2}{\sqrt{1-\frac{v^2}{c^2}}} = 6m_{basic}c^2 \qquad (16)$$

From this, $\sqrt{1-\frac{v^2}{c^2}} = \frac{3}{4}$, and $\frac{v}{c} = \frac{\sqrt{7}}{4}$ (17)

With 3 basic particles revolving, the angular momentum L of each revolving particle in this model is 1/3 of the spin S of the spinning structure, so L = S/3. Plugging this value and the speed $v = \frac{\sqrt{7}}{4}$c into equation (4), we can calculate the radius of the rotating tetrahedral structure (the electron radius) as:

$$r = \frac{L\sqrt{1-\frac{v^2}{c^2}}}{mv} = \frac{\frac{S}{3}\frac{3}{4}}{m_{basic}\frac{\sqrt{7}}{4}c} = \frac{S}{\sqrt{7}m_{basic}c} \qquad (18)$$

With the electron spin $S = \frac{\sqrt{3}}{2}\hbar$, we get

$$r = \frac{\frac{\sqrt{3}}{2}\hbar}{\sqrt{7}m_{basic}c} = \frac{\sqrt{3}}{2\sqrt{7}}\frac{\hbar}{m_{basic}c} \qquad (19)$$

The angular speed of the rotating tetrahedral structure of electron is

$$\omega = \frac{v}{r} = \frac{7}{2\sqrt{3}}\frac{m_{basic}c^2}{\hbar} \qquad (20)$$

Hence, for the tetrahedral model of an electron, v = 0.66c, r = 7.6·10^{-13}m, and $\omega = 2.6 \cdot 10^{20}\frac{1}{s}$

7. Conclusion

We have calculated the orbital speed, the radius of an orbit of the revolving basic particles, and the angular speed of a spinning electron in three models of an electron as a spinning composite particle. The three models suggested in our previous work [1] are the centered square structure, the rhombus structure, and the tetrahedral structure. The calculated speed of revolving basic particles, for all three models of an electron, does not exceed c, the maximum possible speed in nature: $v = \frac{3}{5}c$ for the centered square model, $v = \frac{\sqrt{5}}{3}c$ in the rhombus model, and $v = \frac{\sqrt{7}}{4}c$ in the tetrahedral model. The results show that the spin of an electron can be reasonably explained assuming that an electron is not an elementary particle, but a composite structure made of five basic elementary particles of mass m_e/6 and of charge +e/3 (one particle) and -e/3 (four particles). The calculated angular frequencies of spinning electron structures have characteristic values for the considered models and are in the range of $(2.5 - 2.7) \cdot 10^{20}\frac{1}{s}$. The angular frequency of electrons might be determined in experiments on the interaction of X-rays with electrons.

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