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Structural factors of an electron as the spinning tetrahedral structure composed of fractional charges

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Abstract
As suggested in our papers [1,2], the elementary particles of the 1\textsuperscript{st} generation such as an electron, quarks, and neutral particles, are all spinning composite structures made of basic elementary particles of fractional charges \pm e/3. The tetrahedral structure of an electron was suggested as one of the possible composite structures of that particle. The structure consists of one positive and four negative charges of magnitude e/3, with one positive and one negative charge located on the axis of rotation and three negative charges revolving about the axis. In this paper, the form factors such as the angles and the relative distances between the fractional e/3 charges of the tetrahedral-like structure of an electron are calculated from the condition of the zero net forces on each charge located on the axis of rotation. The results might be of special interest in view of the recently published experimental observations [3, 4] of electrons as spinning structures made of quasiparticles of a fractional e/3 charge that agree with our model of an electron suggested in [1].

It was suggested in [1, 2] that the elementary particles of the 1\textsuperscript{st} generation – up and down quarks, an electron, and neutrinos - are all not elementary, but spinning composite structures composed of basic \pm e/3 charges. As for the electron composite structure, a particle with the total charge of -e, it was suggested that it can be a composition made of one positive and 4 negative charges of magnitude of e/3. For such a composition, three different spatial structures were suggested: 1) a planar centered square, where four -e/3 basic charges revolve about the axis normal to the plane of the structure and passing through a single +e/3 charge in the center; 2) a rhombus, where two -e/3 charges revolve about the axis passing through a +e/3 charge and two -e/3 charges located symmetrically on both sides from the +e/3 charge; 3) a tetrahedral structure Similar to a methane molecule structure) where 3 basic -e/3 charges revolve about the axis passing through one +e/3 charge and one -e/3 charge. Recently, the fractional charge composite structure of an electron was experimentally observed in the angle-resolved photoemission experiments on the FeNi magnetic material [2]. In that paper, it was shown that an electron was a spinning structure with 3 lobes, each of charge of magnitude e/3. Those important experimental results of the paper [2] were also described in a paper on the phys.org site [3]. That data can be the first experimental evidence of an electron being a spinning structure composed of the fractional charges of magnitude e/3. The experimental results on the structure of an electron as composed of fractional charges agree with the tetrahedral structure of an electron as one of three possible spinning structures of an electron suggested in our working paper [1]. Our suggestion [1] that an electron and other elementary particles of the 1\textsuperscript{st} generation are all composite spinning structures made of fractional charges of magnitude e/3 can be successfully used to explain many other experimental observations, such as beta-decay reactions and the proton-neutron transmutation processes [5].

In this paper, we will analyze the structural parameters of the stable spinning composite structures of an electron. If we assume that an electron, of the total charge of -e, is a composite structure made of several fractional positive and negative charges of magnitude e/3, the total charge of -e is the sum of all the charges in the structure, with the number of -e/3 charges being larger by 3 than the number of +e/3 charges. There are two main requirements to be fulfilled for any (not only the electron) stable spinning structure made of several charges: the net force acting on any charge located on the axis of rotation must be zero, and the net force on any revolving charge must be non-zero and directed toward the axis. In [4], the form factors (the ratios of the radius
of an orbit of a revolving charges to the distance between the basic charges located on the axis of rotation) of different spinning structures were calculated.

In a symmetrical centered square structure of an electron suggested in [1], with just one charge (+e/3) on the axis of rotation passing through it and four (-e/3) charges located in the corners of the square, the net force on that positive charge is obviously zero. In the rhombus composite structure of an electron suggested in [1] (with one positive and 2 negative fractional charges located on the axis of rotation, and 2 negative charges revolving about the axis), the form-factor (the ratio of the radius of an orbit of the revolving charges to the distance between the charges located on the axis) was calculated in [4] as 0.96. The structural parameters of the third suggested in [1] spinning composite structure of an electron, the tetrahedral structure, were not calculated so far. In view of experimental data [3, 4], the form factors of the tetrahedral-like structure of an electron, with three e/3 basic charges revolving about the axis, might be of special interest.

In this paper, we present the calculated structural parameters of the tetrahedral composite structure of an electron that is similar to the tetrahedral structure of a methane molecule. In such a structure of an electron, suggested in [1], there is a +e/3 charge in the middle and four -e/3 charges arranged in a tetrahedral-like pattern around the central charge. The structure is assumed to be in a rotational motion, with three -e/3 charges revolving about the axis passing through one positive and one negative fractional charge. The structure has a rotational symmetry about the axis, with equal distances (d2, see Fig 1) between the central +e/3 charge and each of the revolving charges. The distance d1 between the central +e/3 charge and the -e/3 charge located on the axis of rotation can however be different from d2. The relative distances can be calculated from the condition of zero net force on each charge located on the axis of rotation.

Fig 1 shows the two charges (one +e/3 and the other -e/3) on the axis of rotation, and one of three revolving -e/3 charges. We will use the requirement of zero net force on each of the charges on the axis of rotation to determine the relative distances between the charges and the angles shown in the figure. Z-axis is drawn along the axis of rotation. For each charge, the z-component of the net force on it must be zero. For the charges on the axis, the r-component (perpendicular to the axis) of the net force is zero due to symmetrical considerations.

Fig. 1. Sketch of a composite tetrahedral structure of an electron. The +q= +e/3 and one of four -q = -e/3 charges are on the axis of rotation, at a distance d1 from each other. Three remaining -q = -e/3 charges are located symmetrically about the axis and revolve about it (only one of them is shown), at the distance d2 from the +q charge in an orbit of radius r.
Let us select the z-axis to be along the axis of rotation. The net force on the +q charge, due to the rotational symmetry of the structure, can have only z-component. The +q charge is at rest on the axis of rotation, so all the forces between this charge and each of the other charges in the structure are the electrostatic forces, described by Coulomb’s Law. The z-component of the net force can be written as a sum of z-components of all the forces acting on the +q charge, and the sum must be zero.

\[ F_{+q \text{ net } z} = -\frac{q^2}{4\pi \varepsilon_0} \left( \frac{1}{d_1^2} - \frac{3}{d_2^2} \cos \varphi \right) = 0 \]  

(1)

From this equation,

\[ \cos \varphi = \frac{1}{3} \left( \frac{d_2}{d_1} \right)^2 \]  

(2)

The z-component of the net force applied to the -q charge that is on the axis of rotation should also be zero, so

\[ F_{-q \text{ net } z} = \frac{q^2}{4\pi \varepsilon_0} \left( \frac{1}{d_1^2} - \frac{3}{d_3^2} \cos \beta \right) = \frac{q^2}{4\pi \varepsilon_0} \left( 1 - \frac{3 \cos \beta}{d_3/d_1} \right) = 0 \]  

(3)

Hence, the net force on the -q charge that is on the axis will be zero if

\[ \cos \beta = \frac{1}{3} \left( \frac{d_3}{d_1} \right)^2 \]  

(4)

Noticing that \( \gamma = \pi - \varphi \) and using (2) and the equation \( d_3^2 = d_1^2 + d_2^2 - 2d_1d_2 \cos \gamma \) valid for any triangle, we get

\[ d_3^2 = d_1^2 + d_2^2 - 2d_1d_2 \cos \gamma = d_1^2 + d_2^2 + 2d_1d_2 \cos \varphi \]  

(5)

Using (2), we get

\[ \left( \frac{d_3}{d_1} \right)^2 = \left[ 1 + \left( \frac{d_2}{d_1} \right)^2 + \left( \frac{2}{3} \right) \left( \frac{d_2}{d_1} \right)^3 \right] \]  

(6)

According to the theorem of sines for the triangle with the sides of \( d_1, d_2, \) and \( d_3, \)

\[ \frac{d_1}{\sin \alpha} = \frac{d_2}{\sin \beta} = \frac{d_3}{\sin \gamma} \]  

(7)

From (7), \( d_2 \sin \gamma = d_3 \sin \beta , \) and noticing that \( \sin \gamma = \sin \varphi , \) we get \( \sin \beta = \frac{d_2}{d_3} \sin \varphi = \frac{d_2/d_1}{d_3/d_1} \sin \varphi. \) With these, the equation (3) is a function of the \( d_2/d_1 \) ratio only. Using (6) and the equations (1) and (3) and doing the calculations in Excel, it can be shown that both the condition of \( F_{-q \text{ net } z} = 0 \) and \( F_{+q \text{ net } z} = 0 \) are fulfilled at \( \frac{d_2}{d_1} = 0.9443. \)

Hence, the structural parameters of the tetrahedral-like spinning structure of an electron as calculated in Excel are
\[
\frac{d_2}{d_1} = 0.9443, \quad \frac{d_3}{d_1} = 1.5662, \quad \frac{r}{d_1} = 0.9016, \quad \varphi = 72.71^\circ, \quad \beta = 35.15^\circ, \quad \alpha = 37.56^\circ \quad (8)
\]

The net force on each charge revolving in a circular orbit about the axis must be non-zero and directed toward the axis, so its z-component must be zero. The magnetic and the electrostatic forces applied to each revolving charge by the other two revolving charges are normal to the axis, so their z-components are zero. Hence, the z-component of the sum of the electrostatic forces applied to the revolving charge by the two charges that are on the axis must be zero. The z-component of that sum is given by the equation

\[
F_{-q \text{ rev net } z} = -\frac{q^2 \cos \varphi}{4\pi \varepsilon_0 d_2^2} + \frac{q^2 \cos \beta}{4\pi \varepsilon_0 d_3^2} \quad (9)
\]

Due to (3) and (4), this expression is zero.

Hence, the net force applied to each revolving charge has a radial component only which magnitude and direction are defined by the sum of the r-components of the electrostatic forces from the -q and +q charges located on the axis of rotation and the magnetic forces from the other two revolving charges. For the closed orbit motion of the revolving charges, that radial component of the net force must be negative (for the net force on the revolving charge to be directed toward the axis of rotation). Our calculations of the radial component of the net force will be presented in another paper.

**Conclusion**

The tetrahedral spinning composite structure of an electron composed of fractional charges was suggested in [1] but without calculations of the geometrical parameters of the structure. In this paper, the calculations of the structural parameters of the tetrahedral-like structure of an electron are presented. The structure consists of one positive and four negative charges of magnitude e/3, with one positive and one negative charge located stationary on the axis of rotation and three negative charges revolving in a circular orbit about the axis. The form factors such as the angles and the relative distances between the fractional e/3 charges of the tetrahedral-like structure of an electron are calculated from the condition of zero net forces on each charge located on the axis of rotation. The results might be of special interest in view of the recently published experimental observations [3, 4] of electrons as spinning structures made of quasiparticles of a fractional e/3 charge.

**Appendix:**

The Excel worksheet with calculations of the relative distances in the composite tetrahedral-like structure of an eketon made of fractional charges of magnitude q = e/3.

**References**

1. Perov, Polievkt, "Electron And Other Quarks As Particles Made Of Elementary Particles Of Charge e/3 And Mass me/6" (2023). *College of Arts & Sciences Faculty Works*. 7. [https://dc.suffolk.edu/cas-faculty/7](https://dc.suffolk.edu/cas-faculty/7)