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Beyond Standard Model: Axial Electric Potentials Of Quarks And Neutrinos

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Abstract

The equations of axial electric potentials are presented for our models of quarks and neutrinos as spinning composite structures where up to 3 basic elementary charges are on the axis or rotation and the other N charges are revolving about the axis. The axial potential functions at given point on the axis of rotation were calculated as the sum of electric potentials at that point from all the charges in the structure. We applied these general equations specifically to the models of two types of neutral particles (neutrinos), one with 2 like charges on the axis and the other with 3 like charges on the axis. It is shown that the axial electric potential of the composite particles of zero total charge (neutrinos) is not zero at the small distances from the particles. As a result, a neutrino can experience an attractive or a repulsive force if it comes close to a charged or neutral particle.

Introduction: Interaction between elementary particles, basic elementary charges, models of quarks, electron and electron-like particles and neutral particles (neutrinos) as structures composed of basic elementary charges.

In our paper [1], we suggested that the 1st generation elementary particles considered in the Standard Model - an up quark, a down quark, an electron, and a neutral particle - are all spinning composite structures made of just two truly basic elementary particles with electric charges +e/3 and -e/3. In the suggested models, the basic elementary particles have charges of +-e/3 and mass $m_e/6$, but they do not have other intrinsic properties such as spin and magnetic moment. In fact, all suggested structures are composed in a similar way, having some basic elementary charges on the axis of symmetry of the structure and the other charges in the structure revolving about that axis. The models can be thought of as the particle structures belonging to the same family (quarks). Each particle modeled as a spinning composite structure has spin due to revolving masses and might have a non-zero magnetic moment due to revolving charges.

In this paper, we present our calculations of electric potentials of quarks, electron-like structures and neutrinos as spinning composite structures made of several basic elementary charges. The electric potentials of such structures are not spherically symmetric, but the electric potential values on the axis of rotation (axial potentials) can be easily calculated because they depend on parameters of the structures and the distance from the composite particle but do not depend on motion of basic charges the composite structure is made of.

In our paper [2], we presented calculations of the axial potentials for the models of a d-quark and a u-quark. It was shown that the axial electric potential, while changing with the distance from the quark, can change not only its magnitude but also its sign at some distance specific for the structure of the quark. It was shown that in some range of distances between the down and up quarks, the electrostatic interaction alone between composite quark structures of opposite sign of their total charges can result in not only attraction but also in repulsion between the quarks, depending on the distance between the quarks. This can be essential in the models of a proton a neutron based on the electromagnetic interaction, without invoking a concept of strong nuclear force [3].

In this paper, we consider the possible line of “elementary” particles as composite spinning structures made of just two types of basic elementary particles of charges + e/3 and -e/3. In all the variants of the spinning structures, some charges can be on the axis of rotation and other charges can be in a revolving motion about the axis. If we consider only electromagnetic forces, the net force on any charge that is on the axis of rotation is the sum of electrostatic forces from all other charges in the structure, and it must be zero. The net force on any revolving charge is the sum of all electromagnetic forces applied to that charge by the other charges in the structure. The net force on the revolving charge must be non-zero and directed toward the axis of rotation.

The simplest variants of the structures with fractional basic charges are the planar spinning structures considered in [1]:

- a neutral particle (composed of one +e/3 and one -e/3 charges revolving in a circular orbit about the axis normal to the plane of the orbit.
- a planar linear structure with two -e/3 charges revolving about one +e/3 charge (a down quark).
- a planar trigonal structure with three +e/3 charges revolving about one -e/3 charge (an up quark).
- a planar centered square structure with four -e/3 charges revolving about one +e/3 charge (an electron).

In all these structures, the net force on the charge that is on the axis of rotation (if any) is automatically zero due to a symmetry of the structures. The net electromagnetic force on any revolving charge must be non-zero, directed toward the center of the circle.

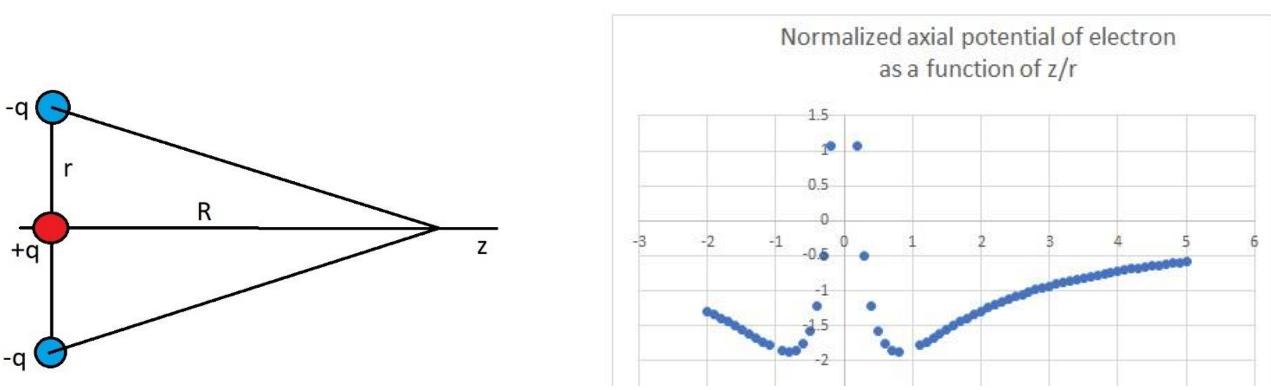
In [2], axial potentials of the d-quark, u-quark, and electron models as the spinning planar structures were calculated as functions of distance from the particle. The interesting result of the axial potential calculations was the change of sign of the potential at the distances less than some critical distance specific for the structure. t was shown that the axial electrostatic potential in our model of a d-quark, a particle of a negative total charge, can be not negative but positive at small distances from the quark. Correspondingly, the axial electrostatic potential in our model of a u-quark, a particle of a positive total charge, was shown to be negative at small distances from the quark. It was shown that in some ranges of distances between d-quark and a u-quark (for example, in protons and neutrons) the interaction between these particles of unlike total charges can be not attractive but repulsive, leading to some static equilibrium distance between the quarks. Such type of behavior assigned in the Standard Model to the strong interaction between quarks. We suggested that the EM interaction can be the origin of the strong interaction.

As for the weak interactions between particles, let us consider the axial potentials of several more spinning composite structures with special attention to neutrinos. Let us consider first the axial electric potential of a model of an electron, described briefly in [2].

For the electron planar model (Fig 1, a), with four negative basic -e/3 charges revolving in an orbit of radius r about one positive basic charge of q = +e/3,

$$V_z(R)_e = \frac{q}{4\pi\varepsilon r}\left(\frac{r}{z}\right)\left(1 - \frac{4}{\left(\sqrt{1+\frac{r^2}{z^2}}\right)}\right) \tag{1}$$

This equation shows that at large distances from the composite structure, z>>r, the axial potential of an electron is just a negative Coulomb's potential of a negative charge -e, $V_z(R)_e = -\frac{e}{4\pi\varepsilon_0 z}$. But at short distances, according to equation (1), the axial potential can be zero at $z = \frac{r}{\sqrt{15}}$ and even positive at $z < \frac{r}{\sqrt{15}}$. Fig 1 shows the calculated axial potential of the planar model of an electron with one positive +e/3 charge on the axis of rotation and 4 negative -e/3 charges revolving in a circular orbit of radius r about the central basic +e/3 charge.



(a) (b)

Fig. 1. (a) – a diagram of a composite structure of an electron, with one positive basic charge q = +e/3 on the axis of rotation and four negative basic charges revolving about the axis. (b) - normalized axial potential of an electron as a function of a relative distance from the structure (in units of z/r).

Let us consider now some other possible variants of spinning structures made of basic elementary charges, with more than one basic charge on the axis of rotation.

1. **Spinning structures with two charges on the axis of rotation.**

A schematic diagram of such structures is shown in Fig. 2.

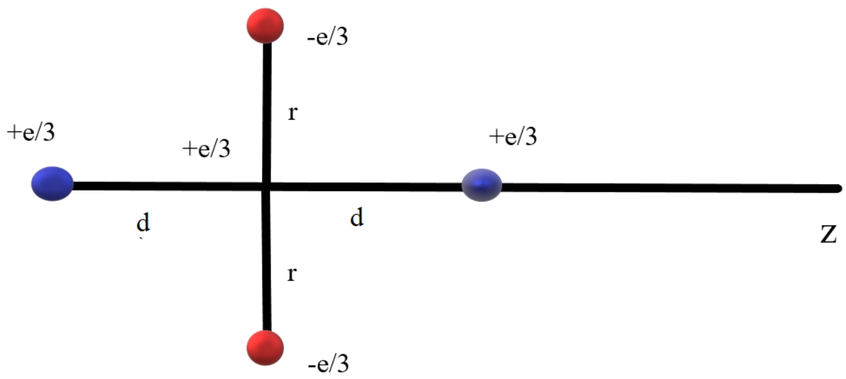


Fig.2. A schematic diagram of a spinning composite structure with two basic elementary charges q = +e/3 on the axis of rotation and N basic charges of the opposite sign revolving about the axis.

In the structures, there are two basic charges of the same sign (the charges can be either both positive or both negative) are on the axis of rotation, at the distance 2d from each other. Several basic charges of the opposite sign revolve about the axis in a circular orbit of radius r. The number N of revolving charges is specific for each structure. For all the structures to be in a dynamic equilibrium, the condition of zero net force on each charge located on the axis of rotation must be fulfilled. We assume that the force on each charge at rest is purely electrostatic, and this condition was used in [4] to determine the form factors (r/d) in the structures. The force on each revolving charge is the sum of all the electromagnetic forces acting on that particle. That resulting force must be non-zero and be directed toward the axis of rotation for the particle to move in a circular orbit. That condition determines the maximum number of revolving charges in the structures with two like charges on the axis of rotation. We determined in our previous paper [4] the relation between the geometric parameters (the ratio $\frac{r^2}{d^2}$ and the form factor $\frac{r}{d}$) of a structure with N revolving charges using the equation (2) for the zero net force on each charge located on the axis of rotation.

The condition for the zero net electrostatic force on any of two like charges on the axis of rotation in a structure with N revolving charges of opposite sign is:

$$F_{net\ z} = \frac{q^2}{4\pi\varepsilon(2d)^2} - N\frac{q^2}{4\pi\varepsilon(d^2+r^2)} \cdot \frac{d}{\sqrt{d^2+r^2}} = \frac{q^2}{4\pi\varepsilon d^2}\left(\frac{1}{4} - \frac{N}{\left(1+\frac{r^2}{d^2}\right)^{\frac{3}{2}}}\right) = 0 \qquad (2)$$

The axial potential function for the structure with 2 like basic charges on the axis separated by a distance 2d and N basic charges of the opposite sign at the distance r from the axis can be calculated as the sum of electric potentials from all the charges in the structure.

$$V_z(z) = \frac{q}{4\pi\varepsilon}\left(\frac{1}{|z-d|} + \frac{1}{|z+d|} - \frac{N}{\sqrt{z^2+r^2}}\right) = \frac{q}{4\pi\varepsilon d}\left(\frac{1}{\left|\frac{z}{d}-1\right|} + \frac{1}{\left|\frac{z}{d}+1\right|} - \frac{N}{\sqrt{\left(\frac{z}{d}\right)^2+\left(\frac{r}{d}\right)^2}}\right) \qquad (3)$$

In this equation, q is the charge on the axis (it is positive, +e/3, if the structure has 2 positive charges on the axis and N negative revolving charges. It is negative when the charges on the axis are negative, and the revolving charges are positive).

The $\left(\frac{r}{d}\right)^2$ values of the particles with 2 like charges on the axis and N revolving charges were calculated in [4] and can be used in equation (3) for determining the axial potentials for composite structures with different number of revolving charges N. One can also replace in the equation (3) the parameter *d* for the orbital radius *r* and express the axial potential as a function of the distance from the composite particle in units of *z/r*. For example, for the composite particle with 2

revolving charges, $d = \frac{r}{\sqrt{3}}$.

Table 1: $\left(\frac{r}{d}\right)^2$ values of the composite particles with 2 like charges on the axis and N revolving charges of the opposite sign [4]:

N	2	3	4	5
$\left(\frac{r}{d}\right)^2$	3	4.24	5.35	6.27

While the equation (3) gives the axial potential of any structure with two charges on the rotation axis, let us consider here a structure that can be of a special interest - a neutrino (a particle with zero total charge) because as it will be shown, the near-field axial potential of this neutral composite particle participating in the weak interaction processes is not zero at all.

2.1 **Neutrino as a spinning structure with two positive charges on the axis and two negative charges revolving about the axis**.

The total charge of this structure is zero, so the structure is neutral - It might be a neutrino. It has 2 charges on the axis of rotation, therefore let us call it ν_2 and show its composition as the numbers of positive and negative charges of magnitude e/3, as $\binom{+2}{-2}$.

In our paper [4], structural parameters of such composite particle with N =2 were determined as $\left(\frac{r}{d}\right)^2 = 3$ (the form factor of the structure is $\frac{r}{d} = \sqrt{3}$). The structure is a rhombus spinning about its short diagonal. An axial potential of ν_2 as a function of a distance z from the particle can be calculated using the equation (3) with q = +e/3, N = 2, and $\left(\frac{r}{d}\right)^2 = 3$.

Notice that the axial potential of a neutrino ν_2 is not zero but positive near the neutrino. The direction of the magnetic moment of ν_2 is opposite to its spin.

A variant with two negative charges on the axis and two positive charges revolving about the axis has the same arrangement but with the sign of every charge changed to the opposite. This particle can be an antineutrino $\bar{\nu}_2$, with the same composition $\binom{+2}{-2}$ but with 2 negative negative charges on the axis and two positive charges revolving about the axis. Near the particle, the axial potential of this model of an antineutrino (a neutral particle) is not zero but negative. The magnetic moment of $\bar{\nu}_2$ points in the direction of its spin.

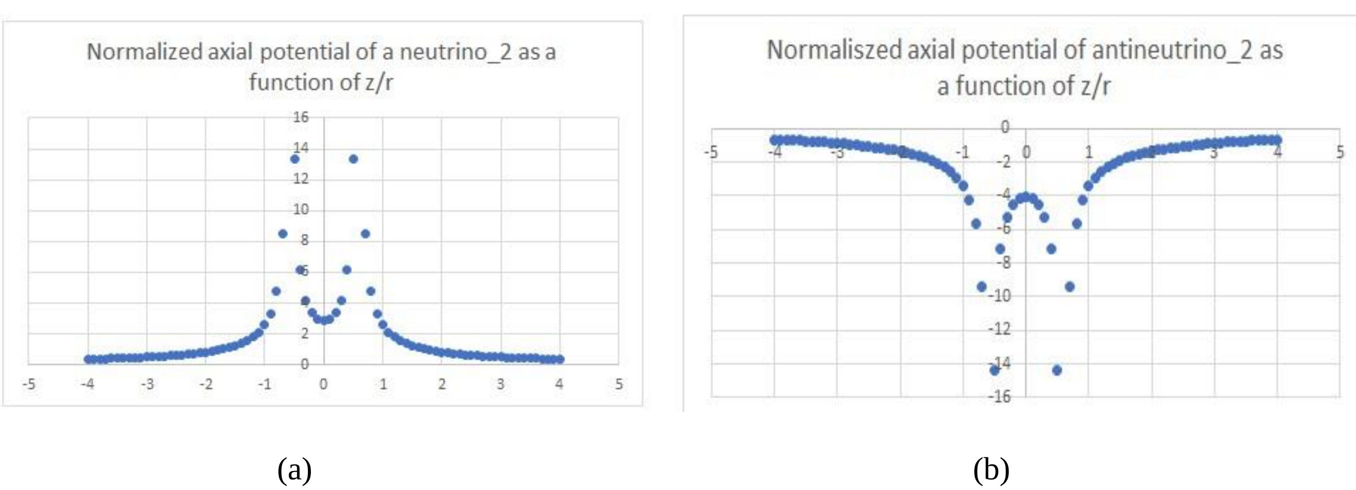


Fig 3. Calculated normalized axial potentials $V_z / \left(\frac{q}{4\pi\varepsilon r}\right)$ of a neutrino ν_2 (a) and an antineutrino $\bar{\nu}_2$ (b) as functions of the relative distance $^z/_r$ from the particle.

2. **Spinning structures with 3 like charges on the axis of rotation and N charges of opposite sign revolving about the axis.**

We determined in our previous paper [4] the relation between the geometric parameters (the ratio $\frac{r^2}{d^2}$) of structures with 3 like charges on the axis and N = 2, 3, 4, 5, 6 revolving charges of opposite sign using the condition of a zero net force on each charge located on the axis of rotation.

Due to symmetry considerations, the condition for the zero net electrostatic force on the central charge is fulfilled automatically for all the structures with 3 like charges on the axis of rotation and 2 or more revolving charges of opposite sign. But the net force on any of the other like charges on the axis depends on N, the number of revolving charges in the structure, and d, the distance between the basic charges on the axis. A common diagram of such a structure (with three like basic elementary charges on the axis, they can be all positive or all negative in a particular structure) is shown in Fig. 4. In the figure, only two revolving charges of the opposite sign are shown, but we can use the same figure for the cases of N>2 as well.

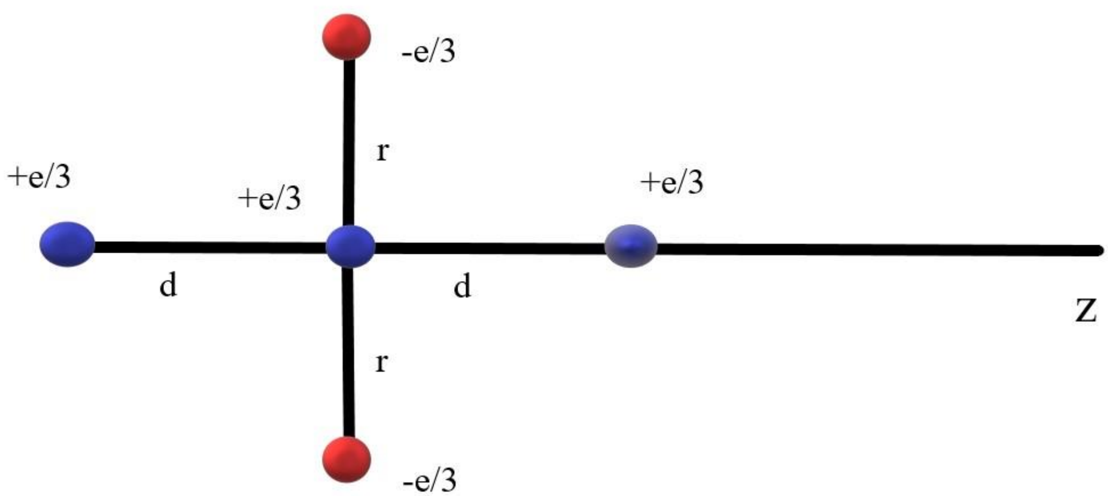


Fig 4. A structure with 3 like charges on the axis of rotation and N charges of opposite sign revolving about the axis. In the picture, only 2 revolving charges are shown, but it can be N charges symmetrically distributed around the axis.

The axial potential function for the structure with 3 like basic charges q on the axis and N basic charges of the opposite sign at the distance r from the axis can be calculated as the sum of potentials from all the charges in the structure.

$$V(z) = \frac{q}{4\pi\varepsilon}\left(\frac{1}{|z-d|} + \frac{1}{|z|} + \frac{1}{|z+d|} - \frac{N}{\sqrt{z^2+r^2}}\right) = \frac{q}{4\pi\varepsilon d}\left(\frac{1}{\left|\frac{z}{d}-1\right|} + \frac{1}{\left|\frac{z}{d}\right|} + \frac{1}{\left|\frac{z}{d}+1\right|} - \frac{N}{\sqrt{\left(\frac{z}{d}\right)^2+\left(\frac{r}{d}\right)^2}}\right) \qquad (4)$$

In this equation, q is the basic charge of magnitude e/3 on the axis (it is positive if the structure has 3 positive charges on the axis and N negative revolving charges). The $\left(\frac{r}{d}\right)^2$ values of the particles with 3 like charges on the axis and N revolving charges of the opposite sign were calculated in [4] and are shown in Table 2. The $\left(\frac{r}{d}\right)^2$ values from this table can be used in equation (4) for different composite structures. One can also use the data from Table 2 to express d via r in equation (4) so the axial potential will be expressed as a function of the distance from the composite particle in units of *z/r*. For example, for ν_3 and $\bar{\nu}_3$, the composite particles with 3 revolving charges, $d = \frac{r}{0.89}$.

Table 2: $\left(\frac{r}{d}\right)^2$ values of the composite particles with 3 like charges on the axis and N revolving charges of the opposite sign [3]:

N	2	3	4	5	6

$\left(\frac{r}{d}\right)^2$	0.37	0.79	1.17	1.52	1.85

We will now consider one of these structures, a neutrino as a composite particle with 3 negative basic charges on the z-axis and 3 revolving basic charges of the opposite sign.

2.1. **A structure with three negative charges on the axis and three positive charges revolving about the axis.**

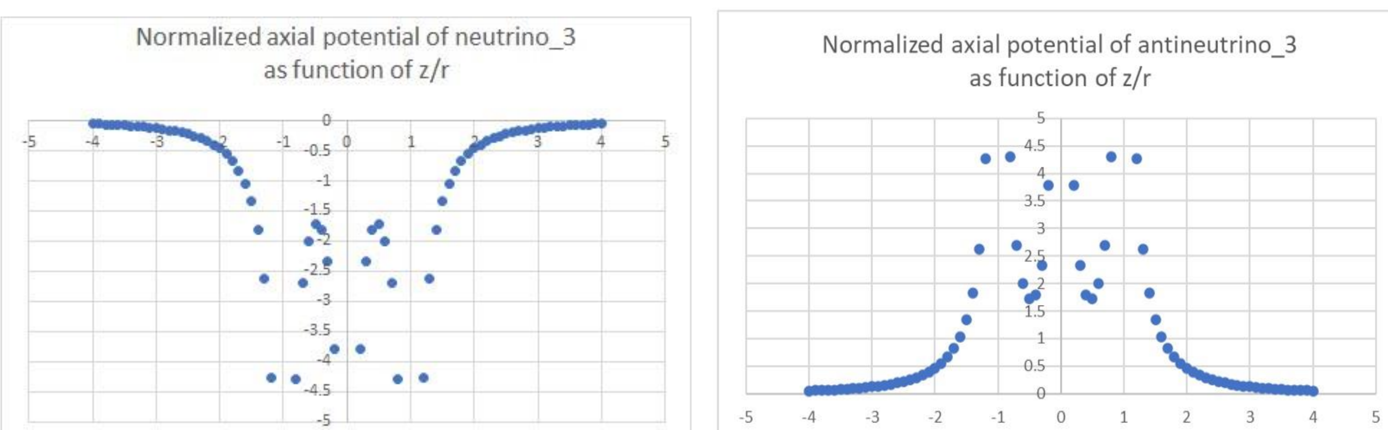
The total charge of the structure is zero. The structure is neutral so it can be a neutrino. Let us call it ν_3 and show its composition, the numbers of positive and negative charges of magnitude e/3, as $\binom{+3}{-3}$. Near the particle, the axial potential of this neutrino is not zero but negative.

A variant with three positive charges on the axis and three negative charges revolving about the axis has the same arrangement but with the sign of every charge changed to the opposite. This can be an antineutrino $\bar{\nu}_3$, with the same composition $\binom{+3}{-3}$. Near the particle, the axial potential of the antineutrino is not zero but positive.

With N = 3 in the structure, $\left(\frac{r}{d}\right)^2 = 0.79$, The ν_3 and $\bar{\nu}_3$ structure form factor $\frac{r}{d} = 0.89$.

The potential functions for the ν_3 and $\bar{\nu}_3$ composite structures can be calculated from equation (4) with N =3 and $\left(\frac{r}{d}\right)^2 = 0.79$.

Fig. 5 (a, b) shows the calculated axial potential functions (in units of $q/4\pi\varepsilon d$) for ν_3 and $\bar{\nu}_3$ along the axis z as a function of the distance (in units of z/r) from the center of the neutrino's model structure. The potential of the ν_3 is a short-range one, it is practically zero at the distances larger than 5r from the neutrino. But it is negative at short distances from the ν_3 neutrino and is positive near the $\bar{\nu}_3$ antineutrino. We can conclude that if a neutrino ν_3 comes very close to a particle with a positive potential, or an antineutrino $\bar{\nu}_3$ comes very close to a particle with a negative potential, the two particles can be attracted to each other.



(a) **(b)**

Fig. 5. Axial potential functions of ν_3 (a) and $\bar{\nu}_3$ (b) calculated with equation (4) (in units of $\frac{q}{4\pi\varepsilon d}$) along the spinning axis z as a function of the distance (in units of z/r) from the neutrino's center.

3. **A symmetrical structure with N negative charges revolving about the axis and one positive and two negative basic charges on the axis.**

We can use Fig.4 as a diagram of such structure with the only change - the charges to the left and to the right from the central charge would be -e/3.

The form factors of the structures can be determined from the condition of zero net force on each charge that is on the axis. Due to symmetry of the structure, the net force on the central charge is automatically zero. The condition for a zero net force on each of the other charges on the axis is, for the general case of N revolving negative charges,

$$|F_{net\,z}| = +\frac{q^2}{4\pi\varepsilon(2d)^2} - \frac{q^2}{4\pi\varepsilon(d)^2} + N\frac{q^2}{4\pi\varepsilon(d^2+r^2)}\cdot\frac{d}{\sqrt{d^2+r^2}} = \frac{q^2}{4\pi\varepsilon d^2}\left(-\frac{3}{4}+\frac{N}{\left(1+\frac{r^2}{d^2}\right)^{\frac{3}{2}}}\right) = 0 \qquad (5)$$

From this equation, $\left(\frac{r}{d}\right)^2 = \left(\frac{4}{3}N\right)^{\frac{2}{3}} - 1.$ (6)

The results of calculations for different values of N are shown in Table 3. While equation (6) is valid for any N, the maximum possible number of revolving charges in the structure must be independently checked on condition that the net force on each revolving charge must be a non-zero central force directed toward the axis of rotation. Such structure for the case of N = 2 was considered in [1] as one of possible structure variants of an electron. For this case, $\frac{r}{d}$ = 0.96 so the structure is a rhombus spinning about its long diagonal. We think that there are no stable structures with N>2 negative charges revolving about the axis where one positive and two negative basic charges reside.

Table 3: $\left(\frac{r}{d}\right)^2$ values calculated for the composite structures with one positive and two negative basic charges on the axis and N revolving negative charges.

N	2	3	4	5	6
$\left(\frac{r}{d}\right)^2$	0.92	1.52	2.05	2.54	3.00

Axial potential functions for the structures with one positive and two negative charges on the axis and N revolving negative charges can be calculated as

$$V(z) = \frac{q}{4\pi\varepsilon}\left(-\frac{1}{|z-d|}+\frac{1}{|z|}-\frac{1}{|z+d|}-\frac{N}{\sqrt{z^2+r^2}}\right) = \frac{q}{4\pi\varepsilon d}\left(-\frac{1}{\left|\frac{z}{d}-1\right|}+\frac{1}{\left|\frac{z}{d}\right|}-\frac{1}{\left|\frac{z}{d}+1\right|}-\frac{N}{\sqrt{\left(\frac{z}{d}\right)^2+\left(\frac{r}{d}\right)^2}}\right) \qquad (7)$$

where the $\left(\frac{r}{d}\right)^2$ values for the case of N revolving particles are known (see Table 3).

4. **On axial potential functions and interactions of different composite structures made of fractional basic charges +-e/3.**

The composite structures are not spherically symmetrical, and the potential functions of the composite structures are not spherically symmetrical as well. In [2], we calculated the axial potential functions of the simplest composite structures –a d-quark and a u-quark. An interesting result of the calculations was the fact that, at close distance from a composite particle of, for example, negative total charge, such as a d-quark, the electric potential can be not negative but positive, like a potential of a positive particle. We can say that the effective charge of a composite particle depends on the distance from the particle and can even change its sign as the distance changes.

It was shown that in some range of distances between the u-quark (of a total positive charge) and d-quark (of a total negative charge), the electrostatic force between these composite structures of unlike total charges can be not attractive but repulsive. We suggested in [2] that the strong interaction between quarks can be in fact the electromagnetic interaction between the composite structures of quarks as spinning structures made of basic elementary charges +- e/3. We suggested that the same approach might be expanded to all the elementary particles included in the Standard Model.

The EM interaction considered above is not restricted to the traditional quarks only. We suggested earlier [1] that all the elementary particles of the 1st generation such as quarks, electrons and neutrinos could be in fact the composite structures made of the basic elementary particles the same way. In other words, they all can be quarks if we define that a quark as a simple spinning composite structure made of positive and negative basic elementary charges of magnitude e/3. The EM interaction between composite particles could be the origin of interaction between any composite structures (quarks), including charged structures such as an electron and neutral structures such as neutrinos. Using equations (3), (4), and (7), axial electric potentials can be calculated for all composite particles considered above.

We think that interactions that include neutral particles (neutrinos) can be of a special interest. As shown above, the axial electric potentials of neutral composite particles are not zero at close distances from the particles. Hence, neutrinos

can electromagnetically interact with particles which could have an electric charge such as quarks and an electron, and with other neutrinos. This interaction is usually considered as being the weak interaction, one of four fundamental interactions. We think that the interaction in reactions where neutrinos take part is of EM origin, and it is not weak in a sense of strength, it is rather a short-range EM interaction of the same origin and strength as the strong interaction.

Conclusion

The equations of an axial electric potential are presented for the models of quarks, electron and neutrinos as spinning composite structures where 2 or 3 basic elementary charges are on the axis of rotation and the other N charges are revolving about the axis. The axial potential function for any composite structure was calculated as the sum of electric potentials from all the charges in the structure at given point on the axis of rotation.

We applied these general equations specifically to the cases of two types of neutral particles (neutrinos), one with 2 like charges on the axis and the other with 3 like charges on the axis. It is shown that the axial electric potentials of the composite particles of zero total charge (neutrinos) are not zero at the small distances from the particles. As a result, a neutrino can experience an attractive or a repulsive force if it comes close to a charged particle or to another neutrino. We suggest that the weak interaction is of electromagnetic origin.

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