Suffolk University
Digital Collections @ Suffolk

College of Arts & Sciences Faculty Works College of Arts & Sciences

Winter 1-19-2024

Beyond Standard Model: Structure Factors of Models of Different Quarks and Neutrinos as Spinning Structures Made of Basic Fractional Charges +- e/3

Polievkt Perov
pperov@suffolk.edu

Follow this and additional works at: https://dc.suffolk.edu/cas-faculty

Part of the Elementary Particles and Fields and String Theory Commons, and the Nuclear Commons

Recommended Citation
Perov, Polievkt, "Beyond Standard Model: Structure Factors of Models of Different Quarks and Neutrinos as Spinning Structures Made of Basic Fractional Charges +- e/3" (2024). *College of Arts & Sciences Faculty Works*. 19.
https://dc.suffolk.edu/cas-faculty/19

This Working Paper is brought to you for free and open access by the College of Arts & Sciences at Digital Collections @ Suffolk. It has been accepted for inclusion in College of Arts & Sciences Faculty Works by an authorized administrator of Digital Collections @ Suffolk. For more information, please contact dct@suffolk.edu.

Beyond Standard Model: Structure Factors of Models of Different Quarks and Neutrinos as Spinning Structures Made of Basic Fractional Charges +- e/3

Polievkt Perov

Suffolk University, 8 Ashburton Pl, Boston, MA 02108

Abstract

We consider a possible line of “elementary” particles as composite spinning structures made of just two basic elementary particles of charges + e/3 and -e/3. In considered structures, up to 3 basic charges can be on the axis of rotation and other charges can be in a revolving motion about the axis. In addition to the simplest structures of quarks, an electron and a neutral particle containing mostly one or no charges on the axis of rotation, suggested initially in [4], we analyze possible spatial structures of spinning composite particles having 2 or 3 charges on the axis of rotation. The net force on any charge that is on the axis of rotation must be zero. The net force on any charge revolving in circular orbits about the axis must be non-zero and be directed toward the axis of rotation. Considering that all the forces in the suggested structures are of EM origin, we calculated form factors of spatial arrangements of different spinning structures of the total charges of -e/3 (similar to a d-quark), +2e/3 (similar to a u-quark), -e (similar to an electron), and 0e (assumed to be neutrinos). All the considered structures but one have a non-zero angular momentum (spin) due to a rotational motion of particles and non-zero magnetic moments due to rotational motion of electric charges so they are fermions. One composite structure has a non-zero spin but zero electric charge and zero magnetic moment, so it is likely a boson.

Introduction: Interaction between elementary particles as structures composed of basic elementary charges +-e/3.

Quarks are very essential building blocks of matter. In the Standard Model, they are considered elementary particles with charge, spin, and magnetic moment. A review of the history of quarks as particles with fractional charges was presented by George Zweig [1], one of the authors of the concept of quarks.

The idea that the smallest observed magnitude of a +e charge for a proton can be in fact a combination of even smaller charges (of magnitude -e/3 and +2e/3) was revolutionary. While the simple division of a proton +e charge into 3 equal parts of the same sign and putting them back together in a composite structure would not produce any stable or quasi-stable structure due to inevitable repulsion between like fractional charges, the composition of two +2e/3 positive quarks and one -e/3 negative quark was shown to result in a stable proton structure with the total charge +e. The same approach was used to produce a neutron as a combination of one +2e/3 quark and two -e/3 quarks, with zero total charge of the structure. Each pair of quarks with unlike charges apply an attractive force to each other, but there must also be some repulsion between the unlike charges of the quarks preventing them from bumping into each other.

In the Standard Model, those attractive and repulsive forces between quarks are considered as being supplied by the strong interaction, the source of one of four fundamental forces in nature, acting exclusively between quarks but not between any other particles. In that model, the attractive and repulsive forces between the nucleons in a nucleus are supplied by the residual strong interaction.

We suggested in our paper [2] that the combination of two electromagnetic forces – the electrostatic force between charges and the magnetic force between magnetic moments that can be attractive or repulsive - can explain the stable or quasi-stable structures of a proton and a neutron.

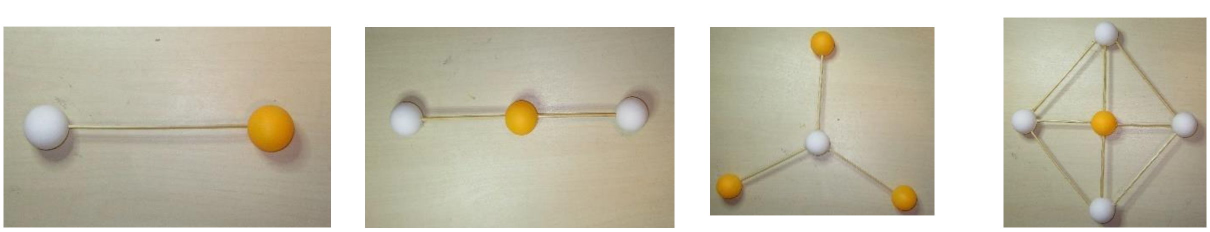
The same combination of electromagnetic forces can provide the attraction between a proton and a neutron, and, at the

same time, keep them at some equilibrium distance from each other. Note that this type of combined electromagnetic interaction can result in an equilibrium distance between any particles with both the electric charge and the magnetic moment, so it is not specific to quarks only. In our paper [3], we applied this approach to the electron-positron pair, with the result that the pair can be in static equilibrium at some equilibrium distance from each other. Essential parameters of the electrostatic and magnetic interaction (the permittivity and permeability values at such small distances) can be considered as adjusting parameters that can be determined from available experimental data.

Following the fruitful concept of quarks with their fractional charges composing protons and neutrons with whole charges, we came out with the suggestion that an electron, with its whole charge -e, can be a spinning structure composed of positive and negative fractional charges by such a way that the total charge of the structure be -e. But going further that same way, we suggested [4] that the fractional charge of +2e/3 of an up-quark can be a stable spinning composition of positive and negative charges of magnitude e/3, that the fractional charge -e/3 of a down quark can be a stable spinning combination of positive and negative charges of magnitude e/3, and that a neutral particles (such as neutrinos) can also be stable spinning compositions of positive and negative charges of magnitude e/3. As a result, we suggested that all the charged and neutral particles listed in the Standard Model as the 1st generation elementary particles are not elementary, but compositions made of some number of just two elementary particles, of charge +e/3 and -e/3. While we considered in [4] only the 1st generation of elementary particles presented in the Standard model, it looks feasible to expand the fractional charge concept to determine the composite structure of other elementary particles.

In our paper [5], it was shown that the electrostatic interaction alone between composite quark structures of opposite sign such as a u-quark and a d-quark can result in not only attraction but also in repulsion between the quarks, depending on the distance between the quarks.

In this paper, we consider the possible line of “elementary” particles as composite spinning structures made of just two basic elementary particles of charges + e/3 and -e/3. In all feasible 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 all electrostatic forces from all the other charges in the structure, and it must be zero. The net force on any revolving charge is the sum of all electromagnetic forces (Lorentz forces) applied to that charge by the other charges in the structure. The net force on any revolving charge in the spinning structure must be non-zero and be directed toward the axis of rotation.
The simplest variants of the structures with fractional basic charges are the planar spinning structures considered in [4], see Fig.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 circle and passing through a mid-point between the two charges. This structure has a non-zero angular momentum due to revolving motion of particles with mass, but its total electric charge and its magnetic moment are both zero. This structure is unlikely to interact with other particles and matter.
- the structure with two -e/3 charges revolving about one +e/3 charge (a down quark);
- the planar trigonal structure with three +e/3 charges revolving about one -e/3 charge (an up quark);
- the 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 (if any) that is on the axis of rotation is automatically zero due to a symmetry of the structures.



(a) (b) (c) (d)

Fig. 1 (from [4]). Quark models as structures made of the basic charge and its antiparticle. (a) – a neutral particle as a quark made of one negative and one positive basic charge; (b) – d-quark made of one positive basic charge and two negative basic charges; (c) - u-quark made of one negative and 3 positive basic charges; (d) – electron as a quark made

of one positive and 4 negative basic charges. Positive basic charges are shown as orange balls, and negative basic charges are represented by white balls.

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. In the structures with two basic charges on the axis of rotation, the charges on the axis are of the same sign, at the distance 2d between them. 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 each structure, 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 Coulomb force, and this condition will be used to determine the geometric parameters in the structure. The equation for the Coulomb force at small nuclear-size distances can be different from the regular Coulomb law equation experimentally proved for the cases of large distances, though. The parameters of electromagnetic interaction (such as permittivity) value can be used as adjustment parameters when comparing different calculated values with the experimental data.

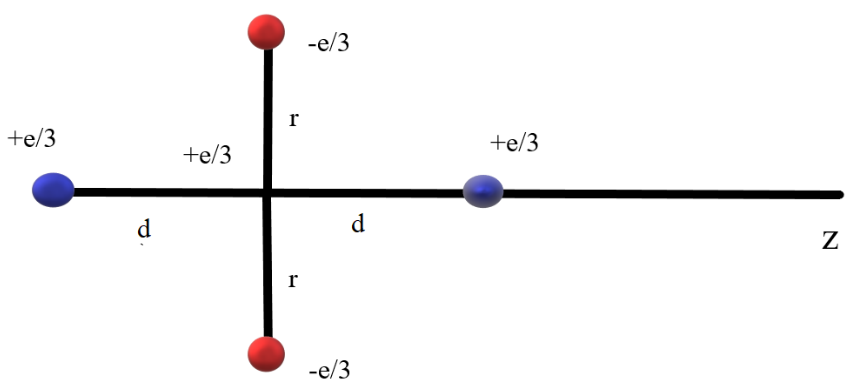


Fig 2. A structure with 2 like charges on the axis of rotation positioned at the distance 2d from each other and N charges of opposite sign revolving about the axis in a circle of radius r. In the picture, only 2 revolving charges are shown, but it can be N charges symmetrically distributed around the axis.

The force on each revolving charge is the sum of all the electromagnetic Lorentz forces acting on that particle. That resulting force must be directed toward the axis of rotation for the particle to move in a circular orbit. That condition determines the maximum number of revolving particles in the structures with a specific number of charges on the axis of rotation. While determining the maximum possible number of revolving charges is an important task, our goal in this paper is to determine first the relation between geometric parameters of structures with different N, the number of revolving charges.

Let us select the z-axis along the axis of rotation. Then the x- and y-components of the net force on any charge located on the z-axis are automatically zero due to a symmetry considerations. The condition for the zero net electrostatic force on any of two charges on the axis of rotation is reduced to the condition of the z-component of the force to be zero.

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

Let us consider several possible structures with two like charges (both positive or both negative) on the axis of rotation. From considerations of symmetry, the number of revolving charges cannot be less than 2.

Solving this equation for $\left(\frac{r}{d}\right)^2$, we get the general expressions that allow determining the form factor of the structure:

$$\frac{r^2}{d^2} = (4N)^{\frac{2}{3}}\text{-}1 \qquad (2)$$

$$\frac{r}{d} = \sqrt{(4N)^{\frac{2}{3}} - 1} \qquad (3)$$

1.1. **A structure with two negative charges on the axis and two positive charges revolving about the axis**. The total charge of this structure is zero, so it is neutral - It might be a neutrino. Let us call it ν_2 and show its composition as the numbers of positive and negative charges of magnitude e/3, as $\left(\frac{+2}{-2}\right)$.

From equation (2) with N = 2, we get $\left(\frac{r}{d}\right)^2 = 3$. The structure is a rhombus spinning about its short diagonal, with the form factor $\frac{r}{d} = \sqrt{3}$.

A variant with two positive charges on the axis and two negative charges revolving about the axis has the same arrangement but with the sign of every charge changed to the opposite. This structure can be an antineutrino $\bar{\nu}_2$, with the same composition $\left(\frac{+2}{-2}\right)$.

1.2. **A structure with two positive charges on the axis and three negative charges revolving about the axis.** A schematic diagram of such structure is like the one in Fig. 2 but the two basic charges on the axis of rotation are positive, and there are 3 negative charges revolve about the axis. The total charge of the structure is -e/3, and the composition is $\left(\frac{+2}{-3}\right)$. This structure has the same total charge as the d-quark structure considered in [4] (see Fig 1, b), but the number of charges and their spatial arrangement are different.

From equation (2) with N = 3, we get $\left(\frac{r}{d}\right)^2 = 4.24$. The structure's form factor $\frac{r}{d} = 2.06$.

1.3. **A structure with two negative charges on the axis and four positive charges revolving about the axis.** A schematic diagram of such structure is like the one in Fig. 2 but with two negative charges on the axis and 4 positive charges revolving about the axis. Its total charge is +2e/3, and the composition is $\left(\frac{+4}{-2}\right)$. This structure has the same total charge as the u-quark considered in [4] (see Fig 1, c), but the number of charges and their spatial arrangement are different from the u-quark. The condition for the zero net electrostatic force on any of two charges on the axis of rotation is given by equation (1) with N = 4.

From equation (2) with N = 4, we get $\left(\frac{r}{d}\right)^2 = 5.35$. The structure's form factor $\frac{r}{d} = 2.31$.

1.4. **A structure with two positive charges on the axis and five negative charges revolving about the axis.** A schematic diagram of a structure is like the one in Fig. 2 but with not 2 but 5 revolving negative charges and two positive basic charges on the axis of rotation. Its total charge is -e, and the composition is $\left(\frac{+2}{-5}\right)$. This structure has the same total charge as an electron structure considered in [4] (see Fig. 1), but the number of charges and their spatial arrangement are different from the structure of an electron. The condition for the zero net electrostatic force on any of two charges on the axis of rotation is given by equation (1) with N = 5.

From equation (2) with N = 5, we get $\left(\frac{r}{d}\right)^2 = 6.37$. The structure's form factor $\frac{r}{d} = 2.52$.

1.5. **Are structures with 2 like basic charges on the axis of rotation feasible if N>5?** Equation (2) can be solved for N>5, but the condition that the net Lorentz force on each revolving charge must be a central **attractive** force should be checked. We can expect that there is a definite restriction on the maximum number of revolving charges, but at this time we will not do any calculations to determine it.

2. **Spinning structures with 3 like charges on the axis of rotation and N charges of opposite sign revolving about the axis.**
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 due to symmetry considerations. But the net force on any of the other two like charges on the axis depends on N, the number of revolving charges in the structure. A common diagram of such a structure (with three like basic elementary charges on the axis) is shown in Fig. 3. In the figure, only two revolving charges are shown, but we can use the same figure for the cases of N>2 as well. We will now consider just some of possible structures – with N = 2, 3, 4, 5, and 6, in view of searching for structures as possible candidates for the elementary particles of next generations.

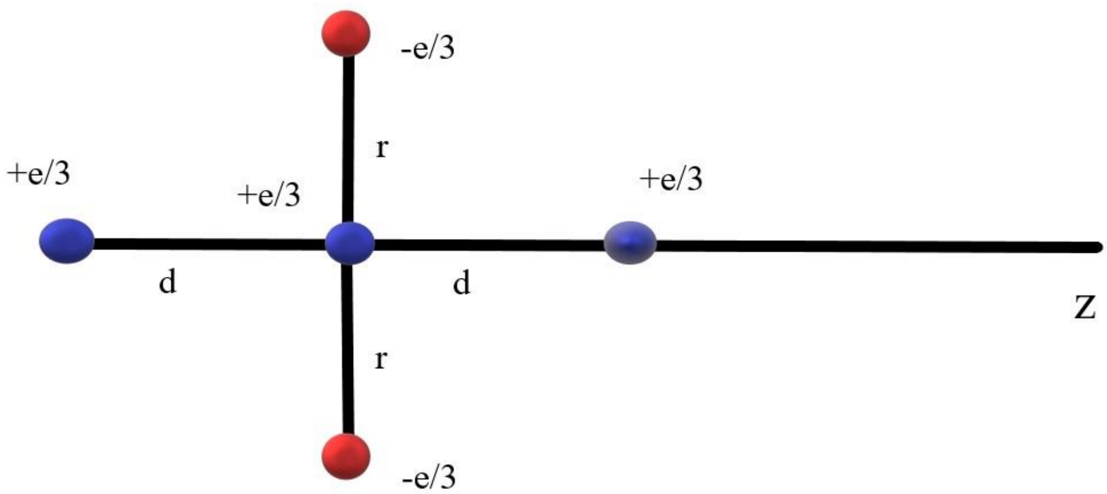


Fig 3. A structure with 3 like charges on the axis of rotation and N charges of opposite sign revolving about the axis. In the picture, only 2 revolving charges are shown, but it can be N charges symmetrically distributed around the axis.

The net force on any of two charges (other than the central charge) on the axis of rotation is:

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

Solving this equation for structures with different number N of revolving charges, we can determine the form factors of those structures:

$$\frac{r^2}{d^2} = \left(\frac{4N}{5}\right)^{\frac{2}{3}}\text{-}1 \qquad (5)$$

$$\frac{r}{d} = \sqrt{\left(\frac{4N}{5}\right)^{\frac{2}{3}} - 1} \qquad (6)$$

2.1. **A structure with three negative charges on the axis and two positive charges revolving about the axis.** The total charge of the structure is -e/3. This structure has the same total charge as the d-quark considered in [4] (see Fig. 1, b), but the number of charges and their spatial arrangement are different. Its composition is $\left(\frac{+2}{-3}\right)$.

With N = 2 in the equation (5), we get $\left(\frac{r}{d}\right)^2 = 0.37$. The structure form factor $\frac{r}{d} = 0.61$.

2.2. **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 as the numbers of positive and negative charges of magnitude e/3 in the structure as $\left(\frac{+3}{-3}\right)$. Changing sigs of each charge for the opposite, we get an antineutrino $\bar{\nu}_3$, with the same composition but with the charges on the axis being positive.

With N = 3 in the equation (5), we get $\left(\frac{r}{d}\right)^2 = 0.79$. The ν_3 and $\bar{\nu}_3$ structure form factor $\frac{r}{d} = 0.89$.

2.3. **A structure with 3 positive charges on the axis and 4 negative charges revolving in a circle of radius r about the axis**. Its total charge is -e/3, and the composition is $\left(\frac{+3}{-4}\right)$. This structure has the same total charge as the d-quark ([4], see Fig. 1, b), but the number of charges and their spatial arrangement are different.

With N = 4 in the equation (5), we get $\left(\frac{r}{d}\right)^2 = 1.17$. The structure's form factor $\frac{r}{d} = 1.08$.

2.4. A **structure with 3 negative charges on the axis and 5 positive charges revolving in a circle of radius r about the axis**. Its total charge is +2e/3, and the composition is $\left(\frac{+5}{-3}\right)$. This structure has the same total charge as the u-quark considered in [4] (see Fig. 1), but the numbers of charges and their spatial arrangement are different. With N = 5 in equation (5), we get $\left(\frac{r}{d}\right)^2 = 1.52$. The structure's form factor $\frac{r}{d} = 1.23$.

2.5. **A structure with 3 positive charges on the axis and 6 negative charges revolving in a circle of radius r about the axis**. Its total charge is -e, and the composition is $\left(\frac{+3}{-6}\right)$. This structure has the same total charge as an electron structure considered in [4], but the numbers of charges and their spatial arrangement are different.

With N = 6 in the equation (5), we get $\left(\frac{r}{d}\right)^2 = 1.85$. The structure's form factor $\frac{r}{d} = 1.36$.

3. **Spinning structures with 3 like basic charges on the axis of rotation (one, positive or negative, in the center and two basic charges of the opposite sign at both sides from the central charge) and N charges of the sign opposite to the sign of the central charge revolving about the axis.**

The condition for the zero net electrostatic force on the central charge is fulfilled automatically for all the structures of this type due to symmetry considerations. But the net force on any of the other two charges on the axis depends on N, the number of revolving charges in the structure. A common diagram of such a structure is shown in Fig. 4. In the figure, only two revolving charges are shown, but we can use the same figure for the cases of N>2 as well. We will now consider just some of possible structures – with N = 2, 3, 4, 5, and 6, in view of searching for structures as possible candidates for the elementary particles of next generations.

The net force on any of two charges (other than the central charge) on the axis of rotation is:

$$|F_{net\ z}| = \frac{q^2}{4\pi\varepsilon(d)^2} - \frac{q^2}{4\pi\varepsilon(2d)^2} - N\frac{q^2}{4\pi\varepsilon(d^2+r^2)} \cdot \frac{d}{\sqrt{d^2+r^2}} = \frac{q^2}{4\pi\varepsilon d^2}\left(\frac{3}{4} - \frac{N}{\left(1+\frac{r^2}{d^2}\right)^{\frac{3}{2}}}\right) = 0 \quad (7)$$

Solving this equation for structures with different number N of revolving charges, we can determine the form factors of those structures:

$$\frac{r^2}{d^2} = \left(\frac{4N}{3}\right)^{\frac{2}{3}} - 1 \quad (8)$$

$$\frac{r}{d} = \sqrt{\left(\frac{4N}{3}\right)^{\frac{2}{3}} - 1} \quad (9)$$

3.1. **A structure with a positive central charge and two negative charges revolving about the axis.** This structure was considered in our paper [4] as a possible model of an electron. The total charge of the structure is -e. This structure has the same total charge as the planar centered square structure of an electron, with the same composition $\left(\frac{+1}{-4}\right)$. The structure is a rhombus spinning about its long diagonal.

With N = 2 in the equation (7), we get $\left(\frac{r}{d}\right)^2 = 0.92$. The structure form factor $\frac{r}{d} = 0.96$.

A structure with the negative central charge and two positive revolving charges has the same form factor 0.96. It might be a positron, with the composition $\left(\frac{-1}{+4}\right)$.

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

In [5], we calculated the potential functions of the simplest composite structures – the ones of a d-quark and a u-

quark structures shown in Fig. 1. The composite structures are not spherically symmetrical, and the potential functions of the composite structures are not spherically symmetrical as well. The electric potential along the axis of rotation (the axial electric potential of a structure) was evaluated in [5] for the d-quark and u-quark structures. An interesting result of the calculations is 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) in the structure, the electrostatic force between these unlike charges can be not attractive but repulsive. We suggested that the strong interaction between quarks can be in fact the electromagnetic interaction between the quarks as structures made of basic elementary charges +- e/3. We suggested that the same approach can be expanded to all the elementary particles included in the Standard Model.

The interaction considered above is not restricted to the traditional quarks only. We suggested earlier [4] that all the elementary particles of the 1st generation such as quarks, electron 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 is a simple composite structure made of positive and negative basic elementary +-e/3 charges. The EM interaction between composite particles could be the origin of interaction between any composite structures (quarks), including integer charge structures (such as an electron) and neutral structures such as neutrinos.

Axial electric potentials can be calculated for all composite particles considered above. For example, the axial potential function for the structure with two like charges on the axis of rotation and N basic charges of the opposite sign revolving about the axis at the distance r from the axis can be calculated as the sum of potentials from all the charges in the structure, as

$$V(z) = \frac{q}{4\pi\varepsilon}\left(\frac{1}{|z-d|} + \frac{1}{|z+d|} - \frac{N}{\sqrt{z^2+r^2}}\right) = \frac{q}{4\pi\varepsilon d}\left(\frac{1}{\left|\frac{z}{d}-1\right|} + \frac{1}{\left|\frac{z}{d}+1\right|} - \frac{N}{\sqrt{\left(\frac{z}{d}\right)^2+\left(\frac{r}{d}\right)^2}}\right) \tag{10}$$

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

$$V(z) = \frac{q}{4\pi\varepsilon}\left(\frac{1}{|z-d|} + \frac{1}{|z|} + \frac{1}{|z+d|} - \frac{N}{\sqrt{z^2+r^2}}\right) = \frac{q}{4\pi\varepsilon d}\left(\frac{1}{\left|\frac{z}{d}-1\right|} + \frac{1}{\left|\frac{z}{d}\right|} + \frac{1}{\left|\frac{z}{d}+1\right|} - \frac{N}{\sqrt{\left(\frac{z}{d}\right)^2+\left(\frac{r}{d}\right)^2}}\right) \tag{11}$$

In these equations, q is the charge on the axis (it is positive if the structure has 3 positive charges on the axis and N negative revolving charges). The form factor r/d depends on N and is specific for each structure as calculated above.

We think that interactions that include neutral particles (neutrinos - the structures with 2 like charges on the axis and N = 2 and the structures with 3 like charges on the axis and N = 3)) can be of special interest. We can expect that the weak interaction describing nuclear reactions that include neutrinos can be described by the same approach, by calculating electric potentials of neutral particles. We can show that the electric potential of a neutral composite particle is not zero at close distances from it, explaining the weak interaction between particles as the EM interaction between composite structures of the particles. We will present our calculations and conclusions on interactions between composite particles that include neutrinos in our next paper.

In our calculations, we used the original Coulomb law equation proved by experiments on macro-scale. But the EM interaction parameters at nuclear-size distances might differ from the one's at large distances, so they can be used as adjustment values while comparing the calculated and experimental data that involve the EM interaction between elementary particles. For example, the Coulomb law equation can be modified to include a multiplier that does not change the $1/r^2$dependence of the electrostatic force at large distances but changes the dependence at small distances. We can suggest that the modified Coulomb law equation could be as

$$\vec{F} = \frac{Q_1 Q_2}{4\pi\varepsilon r^2}\hat{r} \cdot \frac{1}{\left(1 - e^{-\left(\frac{r}{r_0}\right)^{\sigma}}\right)} \tag{12}$$

where r_0 and σ are the adjustment parameters.

Conclusion

A possible line of "elementary" particles as composite spinning structures made of some number of just two basic elementary particles of charges + e/3 and -e/3 is considered. In composite spinning structures, some basic charges can be on the axis of rotation and other charges are in a revolving motion about the axis. In addition to the simplest structures of quarks, an electron and a neutral particle containing mostly one or none charges on the axis of rotation, suggested initially in [4], we analyze possible spatial structures of spinning composite particles having 2 or 3 l charges on the axis of rotation. The net force on any charge that is on the axis of rotation must be zero. Considering that all the forces in the suggested structures are of EM origin, we calculated form factors of spatial arrangements of different spinning structures of the total charges of -e/3 (similar to a d-quark), +2e/3 (similar to a u-quark), -e (similar to an electron), and 0e (assumed to be neutrinos). All the considered structures have a non-zero angular momentum (spin) due to a rotational motion of particles with mass, and all the structures except one have non-zero magnetic moments due to rotational motion of electric charges. The structure shown in Fig. 1, a has a non-zero spin, but its charge and its magnetic moment are both zero, so the structure is likely not interacting with particles of the same type and other particles, so it is likely a boson.

References

1. Zweig, George, "Concrete Quarks – The Beginning Of The End". EPJ Web of Conferences, 71, 00146 (2014). 2nd International Conference on New Frontiers in Physics. https://doi.org/10.1051/epjconf/20147100146
2. Perov, Polievkt, "Proton, Neutron, and Nuclei Models Without Strong Nuclear Force" 2023. College of Art and Sciences Faculty Works. 6. https://dc.suffolk.edu/cas-faculty/6/
3. Perov, Polievkt, "Equilibrium State of Electron-Positron Pair" (2023), College of Art and Sciences faculty works.5. https://dc.suffolk.edu/cas-faculty/5
4. Perov, Polievkt, "Electron and Other Quarks As Particles Made Of Elementary Particles of Charge e/3 And Mass m_e/6" (2023). College of Art and Sciences faculty works.7. https://dc.suffolk.edu/cas-faculty/7
5. Perov, Polievkt, "Beyond Standard Model: Electromagnetic Origin of Strong Interaction between Composite Structures Made of Basic Elementary ±e/3 Charges" (2023). College of Art and Sciences faculty works.18. https://dc.suffolk.edu/cas-faculty/18