Quarks as Knot-Like Topological Structures of the Elementary Charges

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Abstract

We show that a quark (anti-quark) is a topologically twisted positron (electron), that is a circulating longitudinal wavepacket of space contraction (dilation) namely positive charge (negative charge) [1] [2]. This approach explains the confinement of quarks, and enables us to derive and calculate the masses of the d and u quarks. Our results are consistent with the experimental data from CODATA 2014.

Mesons, baryons, protons and neutrons are made of quarks and hence are made of electrons and positrons.

Keywords: Quark, Meson, Baryon, Strong force, Anti-matter

1 Introduction

A.D. Sakharov, in his Collection of Scientific Works, suggested that: *The knot-like topological structure of elementary charges* [3], can yield models of elementary particles. In this paper we show that this idea works for Quarks.

We also suggest that the strong force, between quarks and between nucleons, is an electromagnetic force. In the case of nucleons, the force, as we show, is a result of Yukawa pion exchange. Our suggestion is based on Feynman's explanation of how an exchange of a particle can generate an attractive force [4].

2 Quarks

Fig. (1) shows a trio of d quarks which are sub tracks of a twisted electron at “rest” [2]. In translational motion the trio becomes a trio of spirals [2].

In our model of quarks, we assign charge to each sub track according to the time the electron (positron) spends on this sub track. We, of course, assume that the tangential velocity is c.

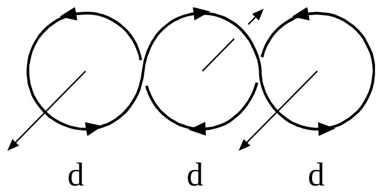


Fig. (1) d Quarks S = ½

The electron spends one third of its full revolution time in each of the sub-tracks. We therefore assign it a charge of 1/3 Q_0. The resultant spin of this trio of quarks is S = ½ , due to the individual spins of the quarks, as Fig. (1) shows. Each sub-track has the same spin as that of the electron. We refer to the sub-track of an electron as the quark, d, and to the sub-track of a positron as the anti-quark, $\tilde{d}$. It is still not fully clear why the track is twisted.

It is thus clear that quarks are **not** independent fundamental particles, and therefore individual quarks do not exist.

Fig. (2) again shows a trio of d quarks, but in this case with S = 3/2:

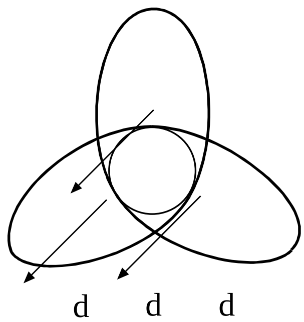


Fig. (2) d Quarks S = 3/2

If one twist in Fig. (1) opens up; we obtain the structures shown in Fig. (3) and Fig. (4), which represent **mesons**.

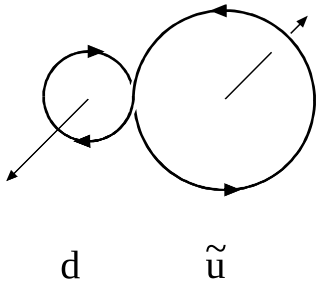


Fig. (3) Meson S = 0

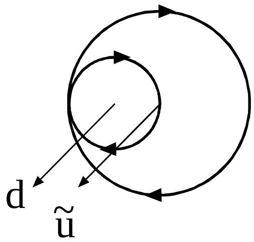


Fig. (4) Meson S = 1

An electron spends two thirds of its time in the sub-track with the double radius, therefore, we assign it a charge 2/3 Q_0 and refer to it as the quark ũ. For a positron, we refer to it as the quark u.

This simple model of quarks enables us to derive, for the first time, and accurately calculate their masses.

3 A Derivation and Calculation of the Quark Masses

We know the electron mass M_e, see [2]. From this mass, based on our quark model, we derive the masses $M_{\tilde{u}}$ and M_d of the first-generation quarks, which are also the masses M_u and $M_{\tilde{d}}$ of their anti-particles. The electron angular momentum $L = M_e R_e^2 \omega$ must be conserved. Hence it is the same L for each of the sub-tracks of the d quark, see Fig. (1). For the ũ quark it is 2L, since the L of its companion d quark points in the opposite direction, see Fig. (3). For the quarks, ω is the same, but R and M are different and conversely related. In a twisted track, which is a set of three quarks, ddd, the radius of each sub-track is $R = \frac{1}{3} R_e$.

The length of the electron wavepacket is conserved [5], hence: $2\pi R_e = 2\pi \frac{1}{3} R_e \times 3$.

The known relation L = MR^{2}ω gives:

$$M_d = \frac{L}{\omega R^2} = \frac{L}{\omega} \frac{1}{\left(\frac{1}{3} R_e\right)^2} = 9 \frac{L}{\omega R_e^2} = 9 M_e \tag{1}$$

For a twisted track of a pair of quarks, such as the $d\tilde{u}$, we get for $\tilde{u}$ a sub-track with $R = \frac{2}{3} R_e$, spin 2L and a mass:

$$M_{\tilde{u}} = 2 \frac{9}{4} M_e = 4.5\, M_e \tag{2}$$

From (1) and (2) and M_e = 0.51 MeV we obtain the following results (3) and (4):

$$M_d = 4.5 \text{ MeV} \tag{3}$$

A recent experimental value [6] is: M_d = 4.8 +/− 0.5 MeV.

$$M_{\tilde{u}} = 2.\ 25 \text{ MeV} \tag{4}$$

A recent experimental value [6] is: $M_{\tilde{u}}$ = 2.3 +/− 0.8 MeV.

4 The Mesons

Fig (3) and Fig. (4) show mesons, which are a twisted electron or positron with only one twist. Fig. (5) shows a meson composed of a twisted electron together with a twisted positron.

The overlapping dashed and solid circles represent the electromagnetic bond, of opposite charges, between the relevant quarks. These quarks that create a bond are **not considered,**

and hence numbered, as originating quarks of a particle, be it a meson, baryon or any other particle.

Note that in the particle diagrams a **solid line** indicates an electron, and a **dashed line** a positron.

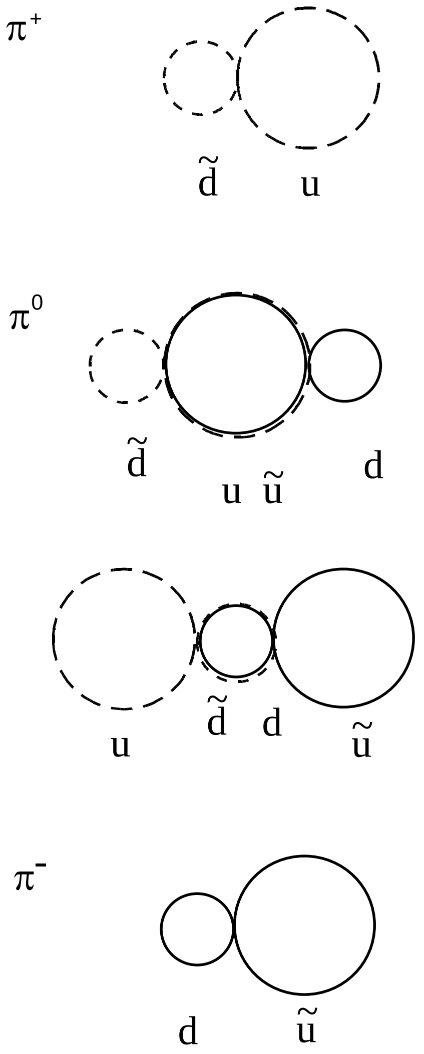
It seems that this electromagnetic bond, which has opposite charges, between the relevant quarks is the known “strong force”. However, in this paper, we do not provide any formal proof that this is indeed the case.

4.1 The Π Family with Spin S=0

A single twisted track has a very short life time, as observed for the Π^+ and Π^- mesons.

For the Π^0 meson, the life time is much shorter due to annihilation.

$$\pi^+ \to e^+ + \nu_e \quad 2.6 \cdot 10^{-8} \text{ sec}$$
$$\pi^0 \to 2\gamma \quad 0.8 \cdot 10^{-16} \text{ sec}$$



$\pi^+ = u\tilde{d}$

The coupling is due to the opposite charges of $\tilde{u}$ and u.

$$\pi^0 = \frac{1}{\sqrt{2}}\left(u\tilde{u} - d\tilde{d}\right)$$

The coupling due to the opposite charges of $\tilde{d}$ and d.

The current paradigm does not take the coupling quarks into consideration, nor do they appear in the notation.

$\pi^- = \tilde{u}d$

Fig. (5) The Π Mesons

A possible decay is:

$\pi^0 \rightarrow \gamma + e^+ + e^-$ and even:

$\pi^0 \rightarrow 2e^+ + 2e^-$ See the table in [6].

4.2 The ρ Family with Spin S=1

$$\rho^{+} = \tilde{d}u$$

$$\rho^{0} = \frac{1}{\sqrt{2}}\left(\tilde{u}u - \tilde{d}d\right)$$

$$\rho^{-} = \tilde{u}d$$

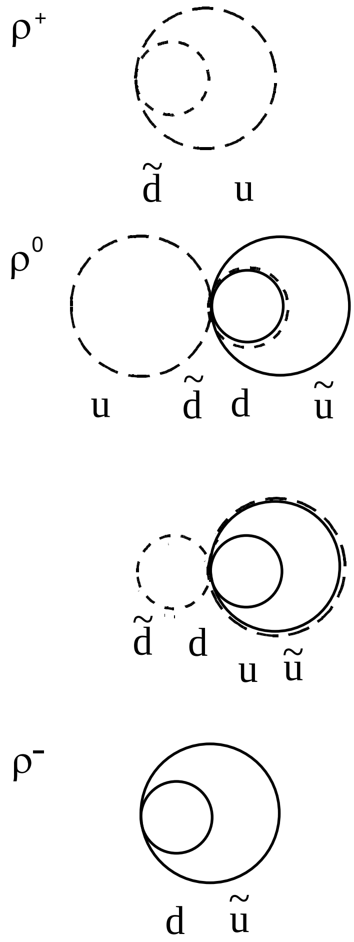
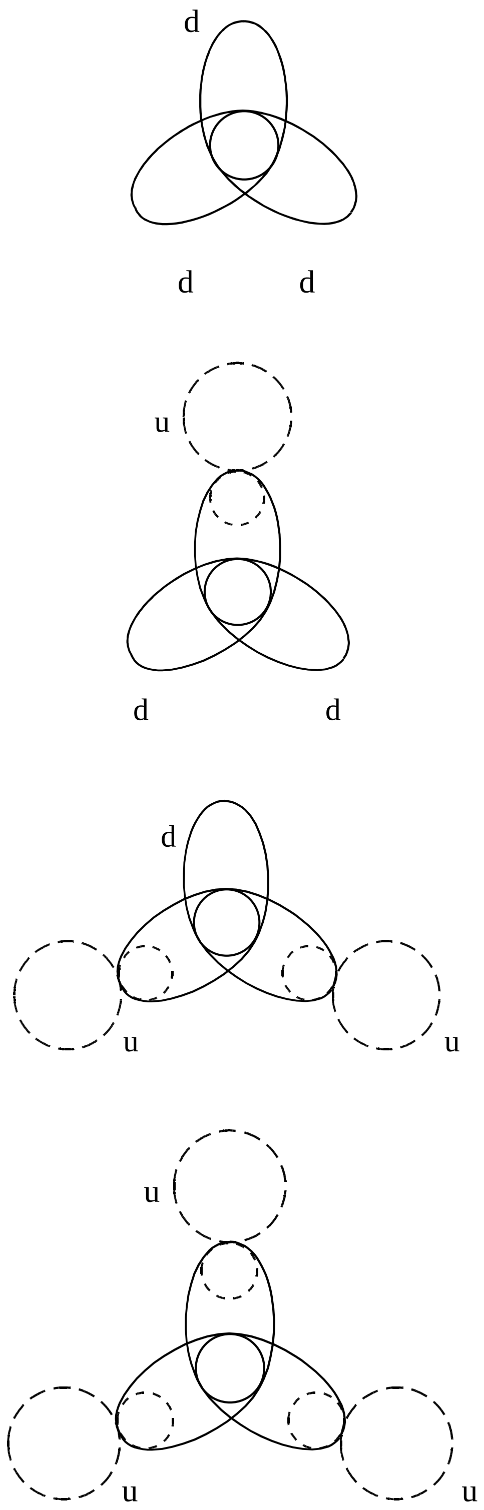


Fig. (6) The ρ Mesons

From the reaction $\pi^{+} \rightarrow e^{+} + \nu_{e}$ and similar reactions, it seems that a neutrino is incorporated in the π^{+} construction (as in similar particles). We speculate that this neutrino causes the electron (positron) to change from one sub-track to another, as if it circulates around the twist.

5 Baryons

The **baryons** are composed of three quarks. As an example, consider the family, with the members: Δ^{++} Δ^{+} Δ^{0} Δ^{-}, that have the spin S = 3/2.



Δ^- **Q = -1**

S = 3/2

ddd

Δ^0 **Q = 0**

S = 3/2

udd

Δ^+ **Q = +1**

S = 3/2

uud

Δ^{++} **Q = +2**

S = 3/2

uuu

Fig. (7) The Baryons Δ

6 In the Universe the Number of Electrons equals the Number of Positrons

A neutron consists of an equal number of electrons and positions (twisted topologically to become quarks). A proton consists of electrons and positrons, as is the Neutron, but has one fewer electron (three quarks). An atom is made of an equal number of protons and electrons

Hence, an atom is made of an equal number of positrons and electrons (as should be evident from the pair production process). In conclusion: in the universe **Matter equals Antimatter.**

7 Remarks on the Strong Force

7.1 The Force between Quarks

The figures in this paper, which represent mesons and baryons, show couples of sub-tracks of an electron and a positron, which construct a bond. This indicates that the holding force of these structures, the force between quarks, is **probably** electromagnetic.

7.2 The Force between a Proton and a Neutron, and between Two Protons

Fig. (8) shows how an electric field between three pairs of charges. This is **an attractive force only,** and is **spin independent** (ignoring weak magnetic interactions) as is the **strong force**.

Note that when the neutron and proton are far apart, the inner distribution of charge is blurred and the effective field decays rapidly, which explains the short range. Note also that according to our model of the electron (positron) [2][5] the radii r_e and R_e of the electron (positron) are reduced, at high velocities, by the relativistic factor γ, hence, close to their surface the field is stronger.

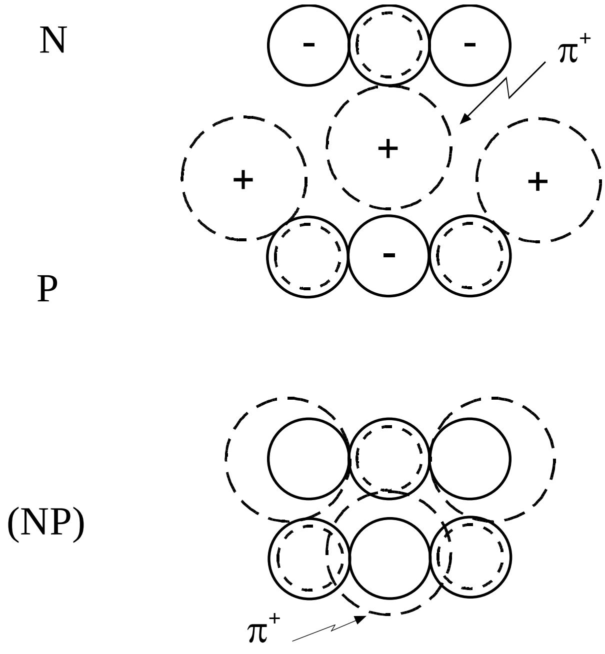


Fig. (8) The (NP) Strong Force

We now consider the force between two protons in Fig. (9).

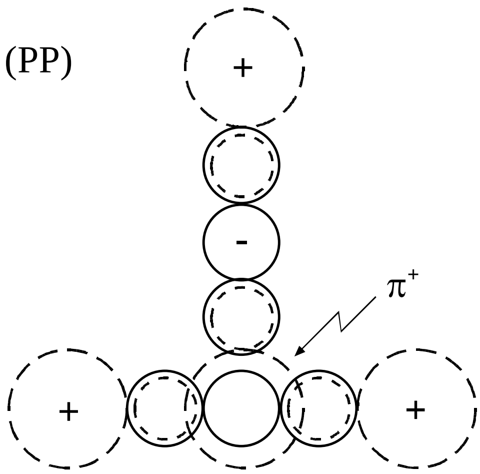


Fig. (9) The (PP) Strong Force

Here, as well, there is an attractive force in the short range, but as the distance increases this force becomes repulsive since the particles have the same charge sign.

We consider the binding force, for both the neutron and proton, and for the proton and proton cases, to be the result of a Π^+ meson exchange. This meson is merely a twisted positron, and its movement back and forth, is the “exchange”. This is the Yukawa theory of meson exchange, which is the source of the Strong Force.

Feynman [4] explains how an exchange of a particle can generate an attractive force. In Chapter 10-1, the force between two protons of the ion H_2^+ is described. This force is the result of the electron exchange between the protons. The reaction is:

$$(H\,,\,P)\underset{\leftarrow}{\overset{\rightarrow}{}}(P\,,\,H)$$

> *The attractive force comes from the reduced energy of the system due to the possibility of the electron jumping from one proton to the other. In such a jump the system changes from the configuration (hydrogen atom, proton) to the configuration (proton, hydrogen atom), or switches back.*

In Chapter 10-2, Feynman shows how the force between a proton and a neutron can be explained by the exchange of a Π^+ meson. Feynman concludes:

> *Now we might ask the following question: could it be that forces between other kinds of particles have an analogous origin? What about, for example, the nuclear force between a neutron and a proton, or between two protons? In an attempt to explain the nature of nuclear forces, Yukawa proposed that the force between two nucleons is due to a similar exchange effect - only, in this case, due to the virtual exchange, not of an electron, but of a new particle, which he called a meson.*

The exchange in this case is:

$$P^+ \underset{\leftarrow}{\overset{\rightarrow}{}} N^0 + \Pi^+$$

The Π^+ meson is emitted from the proton to convert it into a neutron, and by combining with the other neutron to convert it into a proton, and vice versa.

The Standard Model, however, considers meson exchange as a complex effect of color interactions, and not a primary cause.

Based on the above we suggest to reassess the idea of a Strong Force and to explore again the possibility that it is an electromagnetic force.

8 Summary

A.D. Sakharov suggested that: *the knot-like topological structure of elementary charges*, can yield models of elementary particles. In this paper we show that this idea works for Quarks. This explains their confinement, and enables us to derive and calculate the masses of the d and u quarks. We also suggest that the strong force, between quarks and between nucleons, is an electromagnetic force. In the case of nucleons, the force, as we show, is a result of a Yukawa pion exchange. Mesons, baryons, protons and neutrons are made of quarks and hence are made of electrons and positrons. In conclusion: all matter consists of an equal number of electrons and positrons – of matter and antimatter.

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Conflict of interest
The author declares no conflicts of interest.
Data available with the paper
The authors declare that the data supporting the findings of this study are available within the paper.

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