Structure of the Quarks and a New Model of Protons and Neutrons: Answer to Some Open Questions

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ABSTRACT

The described structural model tries to answer some open questions such as: Why do quarks not exist in the open state? Where are the antiparticles from the Big Bang?

1. INTRODUCTION

After the Big Bang, each of the elementary particles formed during nucleon synthesis has an antiparticle counterpart, and these are believed to have been produced in equal proportions. However, it is an unresolved question why, according to our current knowledge, our known world is made up of only the former, and it is not known where the antiparticles, that is, the antimatter that is made up of them, can be found.

Of the currently known elementary parts, only the electron (e^-) and its antiparticle positron (e^+) and the neutrinos (ν) with their antiparticle pairs have proven to be truly stable. The other particles known today can be decomposed or spontaneously decomposed. In all cases, the final products of the decomposition processes are the above stable elementary particles.

The free-standing neutron decomposes spontaneously, so it is not an elementary particle, but protons have long been thought to be stable. In the early 1960s, high-energy scattering experiments detected a wide variety of particles. Mr. Gell-Mann and Mr. Zweig independently concluded (1964) that the new particles observed, and including the proton and neutron can be constructed from only three elementary components, quarks [1-4].

Scattering experiments have shown that the proton is not an elementary particle, but a triple structure. The proton can also be constructed from three particles (u, u and d) quarks, the charge of which is +2/3, +2/3 and −1/3 electron charge, giving a unit positive charge of the proton.

However, there is only indirect information for quarks, since they cannot be detected separately, that is, they do not exist on their own only in a bound state. The question is why the individual quarks do not exist freely. A similar question can be asked about the gluons that hold quarks together.

Experiments have shown that only a small percentage of quarks' mass is rest mass, and their sum does not account for the total mass of the proton or neutron that is made up of them, indicating that the greater part of their total mass is binding energy.

In 1968-1969, deep inelastic scattering experiments showed that the proton contained much smaller, point-like objects, calling them “partons” by R. P. Feynman [5-7].

In this work, we propose a new model of the structure of protons and neutrons, which answers some other open questions too, such as the taste vibration of neutrinos, the life time of neutrons, and the interpretation of complex quark states [8-15].

2. A NEW MODEL OF THE STRUCTURE OF PROTONS AND NEUTRONS

Why do quarks not exist in the open state? (*Where is the antimatter*?)

It is known that particles are destroyed by colliding with their antiparticle counterparts (e.g. e^- and e^+) at high energies [16, 17], but there is no evidence that this happens even in a bound state. Scattering experiments have shown that protons are not elementary particles because they have a three parts internal structure. The three particles (named quarks) that make up the proton cannot be detected individually, they exist only in a bound state.

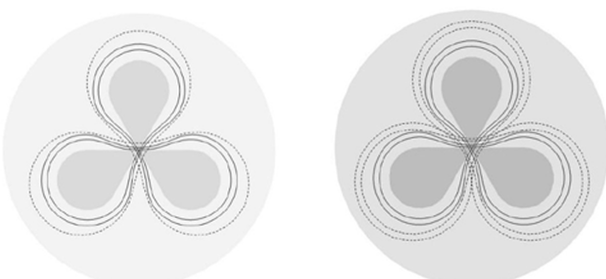
According to our hypothesize protons and neutrons including quarks are ultimately made of stable elementary particles, *i.e.* electrons, positrons and neutrinos, because in collision experiments they are always found at the end of the decomposition line.

The new structural model of the proton is presented in **Figure 1(a)**. The outer two orbits filled by positrons (thick lines) and one by electron (dotted line) can only be seen in two dimensional schematic picture. The tracks can also be considered the outer shell of the three quarks. The inner core of the quarks made up of electrons, positrons and neutrinos too is illustrated by the charged circles and they are also connected to each other through the inner shells, but the structure of the inner shells has not been depicted due to transparency.

The new model assumes only whole charges, which also means that the number of positrons with a unit of positive charge is proportional to the amount of positive charges, while the number of electrons is proportional to the negative charges and the corresponding charge densities. In order to remember the fractional charge values assigned to quarks, it is worth pointing out (only as an interesting fact) that in the case of a proton with a triple parts, this means that the two positrons that fill the outer shells surrounding the three quarks represent an average charge of +2/3 in time, while the electron represents −1/3 charge for each quark.

Imagine the structure of the neutron in a similar way. Schematic picture of **Figure 1(b)** shows the orbits of two positrons and two electrons moving on the outer shells enclosing the inner parts of the three quarks.

It is known from the collision experiments that during the decomposition processes, an antineutrino is always removed along with the electron, and the positron is with the normal electron neutrino. In our opinion, they move together with the positron and electron and play an important role in the stabilization of the structure, but for the clarity of the figure, their orbits have not been indicated.



(a) (b)

Figure 1. Structural model of proton (a) and neutron (b), where only the outer loaded shells of quarks are indicated (Schematic diagram). A continuous line indicates the positron, the dotted line of electron orbits in two dimensions.

Neutrinos are also likely to play an important role in the formation of protons and neutrons because they promote their heterogeneous nucleation. According to the experimental results and the new model, positrons occur in decomposition processes with neutrinos and electrons occur with antineutrinos, so their resulting spin contribution on the outer loaded shells is 0. So the resulting 1/2 spin of the proton and neutron may have come only from neutrinos of an extra one or an odd number (e.g. ↑ ↓ ↑). Therefore, the new model assumes that the nucleus contains an odd number of excess neutrinos, which facilitated the formation of quark nodes, *i.e.* heterogeneous nucleation of protons and neutrons.

The mass of quarks can only be estimated, since they do not exist freely. From the indirect information, the rest mass of the u and d quarks is only a small fraction of the mass of the protons and neutrons that are made up of them, the missing part is due to the bounding (kinetic) energy of the bound quarks. It is assumed that the inner shells are similarly structured and are moved by light elementary particles with high kinetic energy.

The proton and neutron size are 5 orders of magnitude smaller and quarks are 9 orders of magnitude smaller than atomic diameters, so if we take into account the square increase in Coulomb force with a decrease in distance, we can say that with such small dimensions, electrical interaction is already considered a strong force. Due to the electrical interaction, which becomes very strong at short distances, and the stabilizing effect of complex morphology of the structure, there is no need for gluons to hold quarks together.

Another problem with the original quark model is that for 3 fermions in the same state, what about the Pauli exclusion-principle? To ensure that the quark model conforms to the Pauli principle, the concept of color charge and color dynamics have been introduced. The new model automatically corresponds to the Pauli principle, because here the fermions are not in the same state, so there is no need to introduce color charges.

3. KNOWN PROCESSES IN THE LIGHT OF THE NEW MODEL

3.1. Decomposition of Neutrons and Protons

In the free-state, the neutron spontaneously decomposes into proton relatively soon by emitting electron and antineutrino (1).

Neutron decomposition process:

$$n^0 \rightarrow p^+ + e^- + \nu_e \tag{1}$$

Structural changes during the decomposition process are illustrated in schematic Figure 2. As it can be seen from the new model, the electron loosely bound on the outermost shell and the antineutrino that moves with it are released during spontaneous decomposition. The particle left behind corresponds to the structure of the proton (Figure 1(a)), since only an external electron shell is occupied.

Proton decomposition can only be observed during high-energy collisions. The process involves the release of positron and electron-neutrino, and neutron is formed (2).

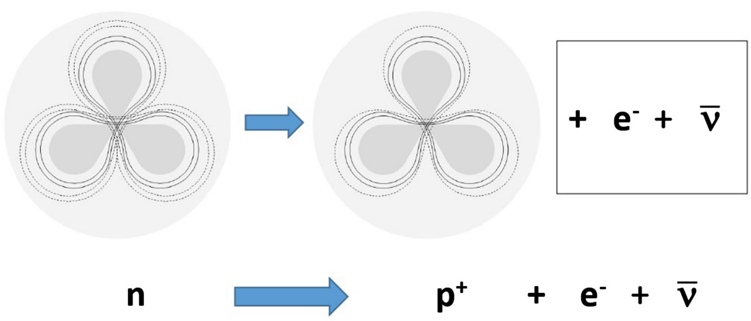


Figure 2. During the spontaneous decomposition of the neutron, an electron and the antineutrino that moves with it are released, leaving only one electron on the outer shell of the residual proton.

Proton decomposition process:

$$p \rightarrow n^{0'} + e^{+} + \nu_{e} \quad (2)$$

The structural change during decomposition is illustrated in schematic **Figure 3**. It can be seen that during a high-energy collision, the positron and the neutrino moving with it are pushed out of the inner stable shell according to the model, and thus it is understandable that this decomposition process can only occur at high energy, as opposed to the case of the neutron, where a loosely bound electron escapes from the outer shell.

Note that the structure of the neutral neutron ($n^{0'}$) produced during the decomposition of the proton is not identical to the structure shown in **Figure 1(b)**, because it contains only a positron and an electron on the outer shell, so it is unsaturated. A neutron with this structure is probably less stable than a neutron with fully loaded outer shells. In the case of their mixed occurrence, it is difficult to get a clear value for the lifetime of the neutron. This may be reflected in neutron lifetime measurements, as the average value of slow neutron life measurements is 888.1s and the lifetime of trapped ultra-cold neutrons is 879.37 s.

3.2. Antiproton Structure

According to the model, the neutron contains more than a proton with an electron and antineutrino. If a positron is removed from the inner shell of the neutron with the neutrino moving with it, an antiproton of the same mass but with the opposite charge is obtained (See **Figure 4**). Its mass is the same as that of the proton, but its charge is the opposite, that is positive. This process can only occur at very high energies, so it is understandable that we do not encounter antiprotons in everyday life.

For clarity, in **Table 1**, we summarized the number of outer filed shells of quarks in case of proton, neutron (saturated and unsaturated) and antiproton.

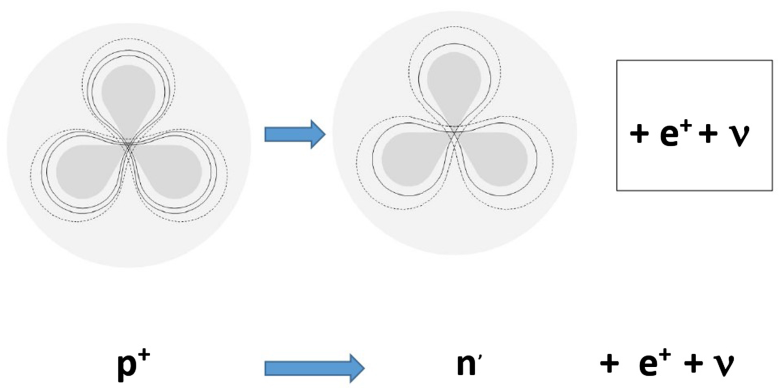


Figure 3. During the decomposition of the proton at high energy, a positron and the neutrino moving with it are removed from the inner shell, but the residual neutral neutron (n') has only one positron and electron on the outer shells.

Table 1. The number of loaded outer shells of quarks for proton, neutrons and antiproton.

	positron (e^{+})	electron (e^{-})	neutrino	antineutrino
proton	2	1	2	1
neutron	2	2	2	2
neutron'	1	1	1	1
antiproton	1	2	1	2

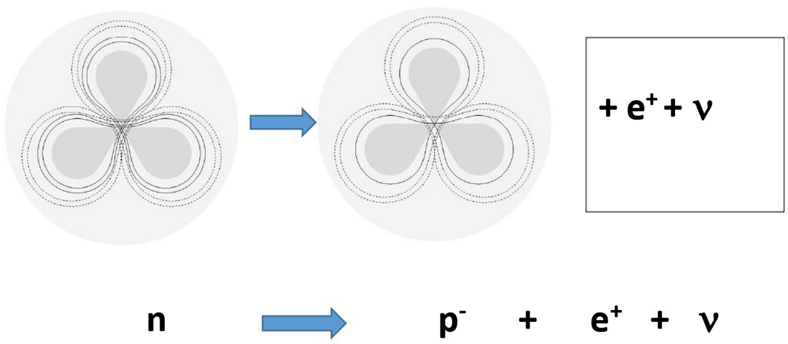


Figure 4. A negatively charged antiproton is generated when a positron and the neutrino moving with it leave the neutron in a high-energy collision, while the two outer electron shells remain loaded. Its mass is the same as that of the proton, while it is counter-charged.

3.3. Taste Oscillation of Neutrinos

Nowadays, there is a great deal of interest in the taste oscillation phenomenon of neutrinos, because it does not fit into the Standard Model. During experiments, the most important scattering process by which neutrinos can be detected is as follows (3):

$$\nu_{\mu} + \mathrm{n} \to \mu^{-} + \mathrm{p}^{+} \tag{3}$$

where the muon-neutrino is scattered on neutron, and a muon and a proton are formed. It is known that the resulting muon continues to decompose (4):

$$\mu^{-} \to \mathrm{e}^{-} + \nu_{\mathrm{e}} + \nu_{\mu} \tag{4}$$

Analyzing the two-stage process in the light of the new model, we can say that the muon-neutrino, during the collision, extrude the outer loosely bound electron together with the anti-electron-neutrino from the outer shell of the neutron, forming a short-lived, metastable muon with negative charge and then breaking it down into its elements. It means that during the collision, the muon-neutrino facilitates the decomposition of the neutron by forming a metastable transitional muon with the falling electron and antineutrino, and after its decomposition, we get the original muon-neutrino back too.

3.4. Complex Quark States

Of the complex quark states, there must be a hexa-quark, or deuteron, which is the molecular-like bound state of proton and neutron. The relatively weak bond is understandable from the new model, considering that the loosely bound electron is used on the outer shell of the three bound quarks in the neutron together with the three quarks in the bound state in the proton. The resulting two protons form hexa-quarks, which are held together by the loosely bound electron of the neutron.

Neutrons may have a similar role in larger nucleus, holding protons together through the common use of the external loosely bound electrons of neutrons. Neutrons are therefore important not only because of their gravitational effect in overcoming the electrical repulsion of protons.

According to the new model, molecular-like groups can form in nuclei, so it is closest to the Bloch-Brink cluster (knot) model among the nuclei models and can help to interpret it.

The model is also likely to help us understand the phenomenon of anomalous pair-raising detected in the case of nuclei, we have also concluded the interpretation of the anomalous (e^{-} e^{+}) pair-raising observed in the excited states of ^{8}Be and ^{4}He [18-20].

3.5. Formation of Deuterium

It is known that hydrogen fusion in the sun first produces deuterium. In the process, plasma-state protons (H nuclei) merge into deuterium nuclei while positron and neutrino are "formed", as follows:

$$p^+ + p^+ \rightarrow \left(p^+ - n\right) + e^+ + \nu$$

The question arises rightly as to how and why positron and neutrino are formed during the collision. Based on the new model, this is understandable. The positron and neutrino are not formed, but ejected from the inner shell of one of the protons during the high-energy collision, leaving behind a neutral but unsaturated neutron containing only one positron and one electron on the outer shell. In the equation above, n' should be written instead of n.

3.6. Hadron Formation

According to current ideas, when electrons and positrons are collided with high enough energy, quarks are formed from the vacuum, which, by quark blockage, create hadrons, that is, hadron formation.

In the new model, the quark knots that make up hadrons are made up of a web of electrons and positrons shells, so in such high-energy collisions, quarks, or more precisely quark knots, are not formed from vacuum, but from electrons and positrons colliding with high energy.

4. CONCLUSIONS

The most well-known of dynamic models dealing with quark closure is the string model, which assumes that the quarks are held together by some kind of string. At quite high energy, the strings can overhang and break. New quarks (antiquarks) are formed at the torn ends, and the quarks connected by the resulting string form a new hadron with quark closure.

The advantage of the string model compared to the statistical description is that it gives a specific idea of hadron formation processes. The weakness of the model is that its important parameters, such as the strength of the strings and the force at which they break, can only be counted from the experimentally measurable quantities. However, the question of what strings hold the quarks together is not answered by the model.

According to the new model, the strings that hold the quarks together are nothing more than the interconnected intricate shell structure of the quark nodes and the movement of the positrons, electrons and neutrinos that fill them.

The new model can be compared to the previous "quark-parton" model [1, 5] and explains the results of both the low and high energy deep inelastic scattering experiments. It is understandable that in the case of low-energy collisions, the quark knots do not fall apart, and the scattering experiments only detect their triple parts, *i.e.* that the proton consists of three parts (3 quarks). In the case of deep inelastic scattering experiments, however, scattering occurs already on the stable elementary particles (e^+, e^-, ν) that make up quark knots, *i.e.* on the "partons".

5. SUMMARY

The new structural model of protons and neutrons answers some open questions, such as: where are the antiparticles, why quarks and gluons cannot be detected independently.

The Standard Model describes the elementary particles detected to this day. Of these, however, only electrons, positrons and neutrinos no longer decompose, they are stable and they are the final product of the decomposition process of all other particles. So, ultimately, they're all made up of them.

Each of the 3 quarks that make up the proton and neutron consists of a convoluted structure of the above stable elementary particles, so that their movement (trajectory) organically connects the three parts (three quarks). It is understandable that in the event of the decomposition of protons and neutrons, quarks cannot be detected separately, *i.e.* they do not exist freely on their own.

The intense movement of the elementary parts with a small rest mass above also explains the experience of why most of the total mass of protons and neutrons does not come from the very small rest mass of quarks, but from the bonding energy caused by the complex shell structure and intense movement of stable particles, electrons, positrons and neutrinos.

The above model also solves the open question of where are the antiparticles, *i.e.* antimatter, have become among the particles produced in equal proportions during the Big Bang.

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CONFLICTS OF INTEREST

The author declares no conflicts of interest regarding the publication of this paper.

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