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New Method for Extracting the Mass of Valence Quarks in Protons

—New Views on Protons

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Abstract

Protons are made up of quarks and gluons. The valence quarks in protons are divided into two up quarks and one down quark. In particle physics, there is no breakthrough in studying the mass relationship between three valence quarks in protons. Because: **(1)** Quarks are confined in protons, the mass of quarks cannot be obtained directly from experiments, so there is a lack of experimental basis for research. **(2)** The mass obtained by quarks through Higgs mechanism and vacuum condensation of **QCD** is not accurate, so there is a lack of theoretical data. **(3)** The mass of different quarks needs different extraction methods because of their different properties. There are many methods to extract quark mass, such as **QCD summation rule**, calculation of mass matrix elements, **Lattice QCD**, and high-energy collision experiment, which generally need to be finally determined through experimental data and theoretical calculation. Therefore, it is difficult for traditional methods to study the mass relationship between three valence quarks in protons. In this paper, **A new research method is found.** By finding the exact ratio of the mass of the up quark and the down quark, the relationship among the three valence quarks can be found. Based on the experimental results of **seaquest** carried out by **Fermilab** in **2021**, through analysis, the accurate ratio of up quark to down quark mass ($m_u/m_d = 0.707$) is obtained, and the mass triangle is established. It is deduced that the sum of squares of up quark mass in protons is equal to the square of down quark mass. The mathematical expression is: $m_u^2 + m_u^2 = m_d^2$; According to the observation of the decay law of other baryons, the quark law in baryons is obtained: except for protons, the heavy quarks in other baryons will decay into up quarks or down quarks, and the sum of squares of up quarks should be equal to the square of down quarks. According to $m_u^2 + m_u^2 = m_d^2$, it is deduced that there are **three** generations of protons in the universe. The core of the view that there are three generations of protons in the universe is that the proton in the center of the star and the proton valence quark on the surface are different. Using the viewpoint that there are three generations of protons in the universe, we can explain some unsolved mysteries of the sun, analyze the reasons for the expansion of the universe, and create conditions for the final cracking of dark matter and dark energy.

Keywords

Valence Quark, Quark Law, Three Generation Proton, Exact Ratio, New Method

1. Introduction

The **Standard Model Theory** and **QCD** have been born for decades, which have successfully explained many problems in particle physics. However, the value of quark mass given by the standard model is uncertain. Because the up quark and the down quark are confined in protons, the masses of the up quark and the down quark cannot be obtained directly from experiments. Based on the experimental results of seaquest in Fermi Laboratory in 2021, this paper successfully found the accurate mass ratio of up quark and down quark ($m_u/m_d = 0.707$), and skillfully established the mass triangle of up quark and down quark. The relation of three valence quarks in proton is deduced: $m_u^2 + m_u^2 = m_d^2$. It is pointed out that there are three generations of protons in the universe, and the proton valence quarks in the center of the star are different from those on the surface.

2. Experimental Purpose and Conclusion

In 2021, Fermilab carried out seaquest experiment to find the number ratio of anti-up quark to anti-down quark in proton.

The experimental conclusion is that **1** anti-up quark corresponds to **1.4** anti-down quarks [1].

3. Derivation of Mass Relation between Up Quark and Down Quark in Proton

Protons contain three valence quarks and a large number of sea quarks. The mass relationship of the three valence quarks was found through the **seaquest** experiment of Fermilab in 2021.

According to the experimental results of seaquest in Fermilab, **1** anti-up quark corresponds to **1.4** anti-down quarks. Therefore, in protons, the charge, mass and number of anti-up quark and anti-down quark are not equal.

Suppose that the product of charge, mass and number of the anti-up quark is equal to the product of charge, mass and number of the anti-down quark.

Because quarks and antiquarks have the same mass, the mass of anti-up quark and anti-down quark in **seaquest's experimental** results can be expressed according to the mass of up quark and down quark.

Because the products of the three are equal (the charges are all positive), the following relationship is obtained.

$$\frac{2}{3}\times 1.0\times m_u=\frac{1}{3}\times 1.4\times m_d$$

$$m_u/m_d=0.7$$

m_u : up quark mass; m_d : down quark mass.

There are two up quarks and one down quark in the proton. Assuming that the down quark mass is **1** and the up quark mass is **0.7**, A mass triangle is established (**Figure 1**).

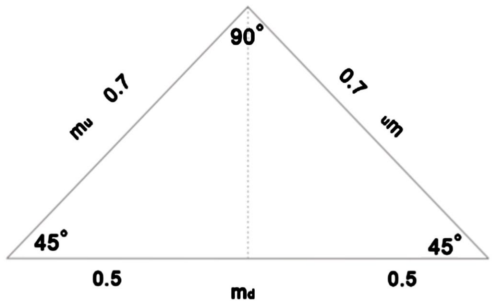

Figure 1. Triangular diagram of up quark and down quark.

$$\cos a=\frac{0.5}{0.7}=0.7142 \qquad \cos 45^\circ=0.7071$$

Considering the error of experimental data, it can be considered that $a=45^\circ$.

Therefore, the pattern is an isosceles right triangle. Two up quarks are right-angled sides and one down quark is hypotenuse.

So we get the following conclusion: $m_u^2+m_u^2=m_d^2$.

Described in physical terms as: the sum of squares of the up quark mass is equal to the square of the down quark mass.

According to the existing experimental data, the up quark has a mass of **(1.7~3.3) MeV** and the down quark has a mass of **(4.1~5.8) MeV**. The above conclusions are also within a reasonable range.

4. Results

(1) Although the exact mass of up quark and down quark in proton cannot be obtained, the exact mass ratio of up quark and down quark can be obtained through Seaquest experiment. $m_u/m_d=0.707$.

In Seaquest's experiment, **1** anti-up quark corresponds to **1.4** anti-down quarks. Considering the experimental error, the most accurate experimental result is that **1**anti-up quark corresponds to **1.414** anti-down quarks, so $m_u/m_d=0.707$.

(2) The sum of squares of the up quark mass in proton is equal to the square of

the down quark mass. $m_u^2 + m_u^2 = m_d^2$.

5. Discussion

(a) The popularization of $m_u^2 + m_u^2 = m_d^2$

(1) Multiply both sides of $m_u^2 + m_u^2 = m_d^2$ by (a^2) at the same time, and the relationship becomes $a^2 m_u^2 + a^2 m_u^2 = a^2 m_d^2$.

From the above relationship, we can draw the following conclusion: the mass of valence quarks changes by a factor at the same time, and the equation still holds. Considering the quantum characteristics of quarks, the values of are **1, 2, 3**.

The value of a should not be too large, otherwise the valence quark will be unstable. In addition, if the value of a is too large, the down quark will approach the mass of the second generation quark.

Reasonable values allow **three** generations of protons to exist in the universe. Charge,color,flavor are the same among all generations of protons. The difference is mainly that the valence quarks have different masses, and they exist in different environments, which are similar to the three isotopes **(H, D, T)** of hydrogen in nature.

Ordinary protons are the third generation protons, and valence quarks are the lightest. The center of the star is the first generation of protons, and the valence quark is the heaviest, which is three times that of ordinary protons. The inner layer of the star's surface is the second generation proton, and the valence quark is twice that of ordinary protons. Some cosmic rays also contain a small amount of second generation protons.

(2) In a star, from the first generation proton to the third generation proton, the valence quarks decay synchronously, which is obviously different from the existing baryon decay mode.

(3) When ***a*** **= 3**, it is the first generation proton. When a nuclear fusion reaction occurs in the center of a star, the first generation of protons must first decay into ordinary protons, and energy needs to be released in the process. The energy lost at this time provides the main power for the expansion of the universe.

Today, when dark energy is not clear, the energy released by the first generation proton decay becomes a source of dark energy.

(4) When ***a*** **= 2**, it is the second generation proton, mainly located below the surface layer of the star. The phenomenon of high temperature in the corona of the sun is mainly that the second generation protons decay into ordinary protons, releasing energy and heating the corona.

Cause analysis of super-ejection and super-flare in solar atmosphere. A small number of first-generation protons and second-generation protons in the solar atmosphere need to release a lot of energy because they want to decay into ordinary protons, and the original magnetic field can not be restrained, resulting in magnetic reconnection. Thus, the phenomena of super ejection and super flare are produced.

(b) Quark law in baryons

Because the three valence quarks in the proton satisfy $m_u^2 + m_u^2 = m_d^2$, there is no such relationship in other baryons. In particle physics, other baryons will eventually decay into protons.

According to the decay results of other baryons, the quark law in baryons is summarized.

Quark law in baryons: except protons, heavy quarks in other baryons will decay into up quark or down quark. The purpose is to keep the sum of squares of up quark mass equal to the square of down quark mass.

(c) In particle physics, quark mass mainly comes from two aspects: **Higgs mechanism** [2] and **vacuum condensation of QCD** [3]-[5], both of which have complicated discussions. The seaquest experiment in Fermilab provides a new idea for studying the quark mass.

The contribution of seaquest experiment in Fermilab to the study of quark mass is: on the premise that the exact mass of up quark and down quark cannot be obtained, the exact mass ratio of up quark and down quark is obtained by finding the quantitative ratio of anti-up quark and anti-down quark. This experiment transforms the uncertainty of quark mass into the exact ratio of up quark mass to down quark mass, which is a paradigm shift in research thinking. Therefore, it is meaningful to study the mass ratio between valence quarks in the same system, because quarks in the same system exist in the same environment and are affected by the same external conditions. The accurate mass ratio of up quark to down quark in proton ($m_u/m_d = 0.707$) was found by experiments, which provided an experimental basis for the discovery of $m_u^2 + m_u^2 = m_d^2$.

(d) In this paper, the extraction of quark mass in protons no longer depends on the exact mass of each quark, but seeks the exact mass ratio of quarks in the same system through experiments. Because in proton, based on **Seaquest** experiment, it is easier to extract the accurate mass ratio of up quark and down quark than to measure the accurate mass of up quark and down quark.

(e) This paper is based on the equal product of mass, number and charge of anti-up quark and anti-down quark in proton ($C \times M \times N$). The mass relation of three valence quarks in proton is successfully found: $m_u^2 + m_u^2 = m_d^2$. This relationship reveals the natural laws followed in the process of proton formation. It can solve many problems in particle physics and astronomy. Therefore, this assumption is reasonable.

6. Summary

The extraction method of quark mass is very important in particle physics. With regard to the extraction of quark mass in protons, based on experiments, the exact ratio of the mass of up quark to down quark in protons ($m_u/m_d = 0.707$) was obtained, and mass relations of three valence quarks were obtained: $m_u^2 + m_u^2 = m_d^2$. This is a new method to extract quark mass in protons, which is a supplement to the original method. At the same time, it is deduced that there are three generations of protons in the universe, and the proton valence quarks in the center of the star are different from those on the surface. Whether $m_u^2 + m_u^2 = m_d^2$ is a natural law left by protons needs to be tested by experiments and theories.

Conflicts of Interest

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

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