On the Quark model based on virtual spacetime and the origin of fractional charge

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Abstract: The quark model in the standard model is belong to real spacetime, so fractional charge is required. Since the quark model has obtained a lot of experimental support, although the fractional charge has not been detected yet, it is still reasonable. If we consider it from the perspective of the existence of virtual spacetime, we can better explain why the quark has a fractional charge. This paper assumes that each particle in real spacetime has a corresponding virtual spacetime particle in the virtual spacetime. The real spacetime proton corresponds to a magnetic monopole in the virtual spacetime, while the real spacetime three-generation six leptons corresponds to the corresponding three generations of six particles in the virtual spacetime. In addition to photons and the like, plus the respective anti-particles, there are 14 elementary particles in the virtual spacetime, which is basically consistent with the number of elementary particles in real spacetime. According to the requirements of virtual spacetime physics, the magnetic field and the electric field are exactly the same. Therefore, in the virtual spacetime reference system, the magnetic field of the magnetic monopole corresponds to the electric field of the proton. Starting from the symmetry requirement of virtual and real spacetime, the magnetic charge of the virtual spacetime magnetic monopole is also quantized. That is, the six particles' magnetic charges of virtual spacetime corresponding to the real spacetime three-generation leptons are also quantized, they take integers. Then, through the appropriate formula, 14 particles of virtual spacetime are combined according to certain requirements, and all six quarks can be obtained. The charge, isospin, lepton number, and baryon number of each quark can be determined according to the formula.

Key words: standard model; quark; virtual spacetime; fractional charge

1 Introduction

How to expand the quark model [1] is an important topic in theoretical physics. A number of new elementary particle models of the Beyond standard model have appeared [2~4]. These models cover the quark model and propose some new particles. However, it has encountered great difficulties in experimental testing. After the Higgs boson was discovered in the Large Hadron Collider in Europe, the subsequent series of work began to focus on exploring new particles beyond the standard model proposed by these Beyond standard models. However, after a few years of very detailed work, nothing has been achieved. It seems that the theory of these Beyond standard models needs further improvement.

From the theory of the quark model itself, there are actually some serious problems that need to be overcome. For example, the quark's fractional charge hypothesis has not found support for direct evidence. According to the energy region of the quark model, the up quark and the down quark only have a few MeV of energy. For existing accelerators, this energy is too small. However, even in the current human largest proton collider, nothing is achieved. Although it is barely able to explain it by assuming quark confinement and other measures, it is very confusing to show no signs at all.

The assumption of fractional charge is also in conflict with the theory of magnetic monopoles of Dirac, the founder of quantum electrodynamics. Because the condition of charge quantization can only be an integer multiple of charge. Despite the experimental results on the surface of fractional quantum Hall effect [5,6], the fractional charge seems to have a basis for existence, but such evidence seems to be far from the difference in the fractional charge of the quark.

In addition, the quark model also raises some new questions, such as why Leptons and Quarks have so many similar properties. Both have three generations, each with two corresponding particles, which can change the flavor. This also gives us a new question, why is Leptons and Quarks not the same particle?

Despite all of the above questions, at least in recent decades, the quark model has achieved many important results in predicting new particles. This shows that the quark model is supported by enough experiments. So, if there is a new theory to explain the origin of the fractional charge in the quark model, I believe it will be of interest to many people. This is exactly what this article is going to do. The hypothesis of virtual spacetime [7] provides the possibility to explain the fractional charge effect of quarks.

Since the theory of quark model is developed from a single spacetime, it is difficult to directly apply it to the application of virtual spacetime theory. Therefore, we first use the virtual spacetime particle model [7~9] to deal with the problems of these particles, and then see if we can smoothly include the quark model.

2 Particle pairs

Consider that each particle exists in the virtual and real spacetime at the same time, so each particle can be represented by a particle pair. The representation is as follows. For particle A, the corresponding virtual spacetime particle is b, then the particle pair can be expressed as

$$(A,\ b)$$

The left side of the brackets here is real spacetime, and the right side is virtual spacetime. Uppercase letters indicate baryons and lowercase letters indicate lepton. Usually, due to the asymmetry of mass, the virtual and real spacetime usually shows its combination as a baryon in one spacetime, and the other spacetime as a lepton, and vice versa. But this is only a theoretical agreement. Because the measurement methods of various physical quantities in virtual and real spacetime are exactly reciprocal to each other, the large mass measured in real spacetime is small in the virtual spacetime.

Therefore, the so-called lepton weight is relatively speaking. Here, it is agreed that the real spacetime baryon corresponds to the lepton of the virtual spacetime.

In the particle (*A, b*), *b* exhibits a magnetic field in the virtual spacetime (since the electric field and the magnetic field are identical, it can also be called the electric field of the virtual spacetime, but needs to be converted into a dimensionless physical quantity), and What is expressed in real spacetime is mass. *A* shows the electric field self-energy in real spacetime [7].

For example, for electrons, the complete form of the particle is (e, P_1), and the complete form of the proton is (P, m).

3 Real spacetime lepton and virtual spacetime baryon

Considering the symmetry of the virtual and real spacetime, the lepton of the virtual spacetime corresponds to the real spacetime baryon, and the real spacetime lepton corresponds to the baryon of the virtual spacetime. Then there are three generations of six kinds of lepton in real spacetime, and the corresponding virtual spacetime should have three generations and six kinds of baryons. Their combinations with lepton are

$$(e,\ P_1)$$

$$(\mu,\ P_2)$$

$$(\tau,\ P_3)$$

$$(v_e,\ V_1)$$

$$(v_\mu,\ V_2)$$

$$(v_\tau,\ V_3)$$

Here is only one kind of lepton in virtual spacetime.

$$(P, m)$$

Where *m* is the virtual spacetime magnetic monopole corresponding to proton *P*.

The antiparticles of all the above particles are directly represented by negative signs. For example, the representation method of positron is $(-e,\ -P_1)$. The advantage of this representation method is that it can directly constitute a relatively complete operation mode.

4 Decay of elementary particles

In the above elementary particles, except for electron and proton which are stable, other particles are unstable and can decay. So here is a brief discussion of how particles decay.

It is known that muon decays into an electron and an anti-electron neutrino, and releases a muon neutrino.

In real spacetime it can be expressed as

$$\mu = e - v_e + v_\mu$$

A new convention is used here, that is, the antiparticle is preceded by a negative sign. The above method satisfies the arithmetic rule of addition and subtraction, but does not satisfy the multiplication and division rule.

Then the complete representation of the virtual and real spacetime is

$$(\mu,\ P_2) = (e,\ P_1) + (-v_e,\ -V_1) + \left(v_\mu,\ V_2\right)$$

or

$$(\mu,\ P_2) = (e,\ P_1) - (v_e,\ V_1) + \left(v_\mu,\ V_2\right)$$

Since there is no multiplication rule, the virtual and real spacetime parameters will not affect each other. Therefore, the above formula actually contains the law of being expressed separately in the virtual spacetime, that is,

$$P_2 = P_1 - V_1 + V_2$$

5 Origin of quark fractional charge

For the charge regulation of the spacetime corresponding particle, considering that the proton's charge in the real spacetime is positive, it is also reasonable to agree that the *m*'s charge in the virtual spacetime is positive, so that the charge of P_i is negative. It can be seen that the charge symbol of the particles in virtual spacetime is consistent with the corresponding real spacetime charge symbol. Since all P_i charges are the same, all V_i charges are zero. Therefore, they can be uniformly identified as q_m, q_P and q_v

In order to avoid confusion, the real spacetime charge subscript is directly represented by the corresponding particle symbol. The charge of the electron is q_e, the charge of the proton is q_P or q_{Proton}, the charge of muon is q_μ and so on. For the sake of distinction, the subscripts of protons are indicated by capital letters.

For simplicity, all unit charges are expressed as 1 or -1

Then

$$q_m = 1, q_p = -1, q_v = 0$$

$$q_{-m} = -1, q_{-p} = 1, q_{-v} = 0$$

According to the virtual spacetime particle model [7,8], for real spacetime baryons, in addition to protons, each composite baryon at least consists of three particles, there are proton and two lepton.

The proton is detectable. The other two contain three generations of baryons in the virtual spacetime.

Combination can be expressed as$\left(Pxy,\ mX_iY_j\right)$

Pxy reflects the result of real spacetime decay results. And $mX_i\ Y_j$ reflects the combination of virtual spacetime, corresponding to the internal structure of the composite baryon.

In virtual spacetime, since there is only one *m*, it is constant, so different particles mainly rely on the combination of $X_i\ Y_j$.

And we know that there are three quarks, which are $Q_iQ_jQ_k$

From the aspect of conservation law, real spacetime includes conservation of lepton number, conservation of baryon number, and conservation of isospin. In virtual spacetime they are still established.

If setting an average parameter

$$\frac{\pm m \mp X_i \pm Y_j}{3}$$

Reflecting the addition and subtraction characteristics of the charge, since the charge of each particle can only take 1,0,-1, it can be found that the combination of all charges is

$$1, \frac{2}{3}, \frac{1}{3}, 0, -\frac{1}{3}, -\frac{2}{3}, -1$$

Considering the conservation of the real spacetime lepton number, a positive particle and an anti-particle will inevitably appear after a baryon decay. And *m* must be charged.

So, the actual combined charge is only five, respectively

$$\frac{2}{3}, \frac{1}{3}, 0, -\frac{1}{3}, -\frac{2}{3}$$

Of course, we can also agree that one of the two parameters X_i and Y_j is a charged lepton and the other is a corresponding uncharged antineutrino, so that the above combination will be less. As a result, we can get a combination of six new particles instead of $mX_i\ Y_j$.

For the first generation of particles, consider such a combination

$$u = \frac{m - P_1 + V_1}{3}$$

The corresponding charges are

$$q_u = \frac{q_m - q_p + q_v}{3}$$

Where

$$q_m = 1, q_p = -1, q_v = 0$$

In the above combination, there is no other combination than the sign changes in front of each particle. Therefore, another combination can be considered to increase the coefficient in front of the lepton. This way we can get another new particle

$$d = \frac{m + 2P_1 - 2V_1}{3}$$

It can be calculated that the charges of the two new particles are

$$q_u = \frac{2}{3}$$

$$q_d = -\frac{1}{3}$$

These two particles correspond to the up quark and the down quark. It can be seen that the quark has two fractional charges.

Quark d decay process will release an electron and an anti-electron neutrino.

$$d = \frac{m - P_1 + V_1}{3} + P_1 - V_1 = u + P_1 - V_1$$

Note that these are all components of virtual spacetime, so P_1 and $-V_1$ represent the combination of electron $(e,\ P_1)$ and anti−electron neutrino $(-v_e,\ -V_1)$ respectively. That is, a d quark will decay into a u quark plus an electron and an anti-electron neutrino.

This is the process by which neutron decay into proton. As pointed out in paper [9], such a structure can automatically satisfy the requirements of conservation of charge, conservation of isospin, conservation of baryon number, and conservation of lepton number.

For the structure of proton and neutron, some simple derivations can be made by the corresponding formula.

The structure of proton in virtual spacetime is

$$Proton = u + u + d = 2\frac{m - P_1 + V_1}{3} + \frac{m + 2P_1 - 2V_1}{3}$$

Through addition and subtraction, the component of proton in virtual spacetime can be obtained as

$$Proton = m$$

This is consistent with the assumption of the proton construction in this paper.

The structure of neutron in the virtual spacetime is

$$Neutron = u + d + d = \frac{m - P_1 + V_1}{3} + 2\frac{m + 2P_1 - 2V_1}{3}$$

Through the addition and subtraction operations, the component of the neutron in the virtual spacetime can be obtained as

$$Neutron = m + P_1 - V_1$$

It can be seen that the neutron will decay into a proton, an electron and an antineutrino in real spacetime.

The antiparticles corresponding to the above two quarks are

$$-u = -\frac{m - P_1 + V_1}{3}$$

$$-d = -\frac{m + 2P_1 - 2V_1}{3}$$

If the structure of the first generation of quarks can be analogized to the second and third generations, then we can get all the three generations of quarks of the combination of the virtual spacetime particles as below.

The first generation of particles is

$$u = \frac{m - P_1 + V_1}{3}$$

$$d = \frac{m+2P_1 - 2V_1}{3}$$

The second generation of particles is

$$c = \frac{m-P_2 + V_2}{3}$$

$$s = \frac{m+2P_2 - 2V_2}{3}$$

The third generation of particles is

$$t = \frac{m-P_3 + V_3}{3}$$

$$b = \frac{m+2P_3 - 2V_3}{3}$$

And their corresponding six anti-particles and so on.

The process of neutron decay into proton is briefly discussed above. For other particles, such as the structure of Kaon$^+$ particles $K^+ = u - s$, can be expressed as

$$K^+ = u - s = \frac{m-P_1 + V_1}{3} - \frac{m+2P_2 - 2V_2}{3}$$

That is

$$K^+ = \frac{-P_1 + V_1 - 2P_2 + 2V_2}{3}$$

This formula can reflect important parameters such as the charge, isospin, lepton number and baryon number of Kaon$^+$. In addition, from this formula, the particles produced after decay can also be estimated.

Since fractional charges cannot occur in the decay results, positron and electron neutrino pairs may occur as a result of the decay, and anti-muon and muon neutrino equivalence may also occur. The probability of decay results mainly depends on the probability that $(\mu,\ P_2)$ decays into $(e,\ P_2)$, or $(e,\ P_1)$ becomes $(\mu,\ P_2)$. The interaction between the two generations of lepton will also form intermediate particles such as pion.

6 Discussions

It can be seen from the above analysis that, after considering the virtual spacetime, the fractional charge of the quark can be combined in an appropriate manner by the virtual spacetime particles corresponding to the leptons in real spacetime. This combination can better explain why both the lepton and the quark have the same three generations, and each generation has two particles. From the experimental results of various aspects, the three generations of lepton and the three generations of quark have very similar properties in some respects. Including the change of flavor and so on.

Since the connection between the lepton and the quark is formed, some independent laws in the past should now be able to relate them to each other, and another law can be derived from one law. For example, can the neutrino's flavor transition matrix PMNS be derived from the quark's flavor transition matrix CKM? This is subject to further research to confirm.

In addition, in real spacetime, we found that leptons are separated from each other. That is, the electrons and electron neutrinos are not a whole united together, but two independent particles. Then, from the perspective of symmetry, the particles corresponding to the electrons and electron neutrinos in the virtual spacetime should also be separated. How do we combine to form a quark in real spacetime and eventually combine various weights? This is mainly due to the special structure of virtual and real spacetime. According to the theory of virtual spacetime physics [7], the length of the virtual spacetime is exactly inversely proportional to the length of the real spacetime. That is to say, in the virtual spacetime, the farther the two particles leave, the closer the two particles are in real spacetime. In this way, two particles that appear to be completely separated in one spacetime are completely tightly combined in another spacetime. The particularity of this spacetime structure also illustrates the necessity of introducing virtual spacetime, and it can indeed explain some phenomena that cannot be explained by existing theories.

It can also be seen from the analysis of this paper that the quark fractional charge is mainly derived from the different combinations of leptons' corresponding particles in the virtual spacetime. The formation of this fractional charge may be just a mathematical arrangement, so it is not necessary that it must be detected in the experiment. Of course, independent quarks do not necessarily need to appear in real spacetime. If such considerations are correct, then the quark confinement theory appears to be superfluous. And if a single quark and fractional charge are actually detected on the particle colliders in the future, it may indicate that the combination of the virtual spacetime particles may be related to some non-linear relationship of the interaction between the leptons, which will open up the basics of the deeper field of particle research.

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基于虚时空的夸克模型及分数电荷的起源

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摘要：标准模型中的夸克模型是实时空的，因此需要使用分数电荷。由于夸克模型获得了很多的实验支持，尽管目前尚未检测出分数电荷，但仍有其合理性。如果从存在虚时空的角度来进行考虑，则能够比较好地解释夸克为何具备分数电荷。本文假设了实时空的每个粒子在虚时空都有对应的虚时空粒子存在。实时空的质子对应了虚时空的一个磁单极子，而实时空的三代六个轻子则对应了虚时空相应的三代六个粒子。这样除了光子等以外，加上各自的反粒子，虚时空中存在的基本粒子就有 14 个，这与实时空的基本粒子数量基本一致。按照虚时空物理学的要求，磁场和电场是完全一样的。因此在虚时空参照系来看，磁单极子的磁场相当于质子的电场。从虚实时空的对称性要求出发，虚时空磁单极子的磁荷也是量子化的。即虚时空对应实时空三代轻子的六个粒子磁荷也是量子化，取整数的。然后通过适当的公式将虚时空 14 个粒子按照一定的要求组合在一起，就可以获得所有六个夸克，每个夸克的电荷、同位旋、轻子数、重子数都可以按照该公式来进行确定。
关键词：标准模型；夸克；虚时空；分数电荷

1 导言

如何拓展夸克模型[1]是现阶段理论物理学的一个重要课题。出现了很多 Beyond 标准模型的新的基本粒子模型[2~4]。这些模型涵盖了夸克模型，并提出了一些新的粒子。然而在实验检验方面却遇到了很大的困难。在欧洲大型强子对撞机发现了希格斯玻色子后，其后的系列工作开始着重于探索这些 Beyond 标准模型所提出的超出标准模型的新粒子。然而经过几年非常细致的工作，却一无所获。看起来这些 Beyond 标准模型的理论还需要进一步完善。

而从夸克模型本身的理论来看，其实也存在一些很严重的问题需要克服。比如夸克的分数电荷假设，至今没有找到直接证据的支持。按照夸克模型中夸克所处的能量区域来看，上夸克和下夸克只有几 MeV 的能量，对于现有的加速器来说，这样的能量实在是太小了。然而即便是在目前人类最大的质子对撞机上也是一无所获。虽然通过假设夸克禁闭等措施，勉强能够解释过去，但一点迹象都没有显示出来却是非常令人困惑的。

分数电荷的假设还与量子电动力学的奠基人狄拉克的磁单极子理论是有冲突的。因为电荷量子化的条件只能是整数倍电荷。尽管分数量子霍尔效应[5,6]等实验结果表面，分数电荷似乎也是有存在的基础的，但这样的证据似乎离发现夸克的分数电荷差距甚远。

另外夸克模型也提出了一些新的问题，比如为何轻子与夸克具有这么多相似的性质？二者都有三代，每一代都有两个相对应的粒子，都可以发生味的改变等。这也给我们提出了一个新的问题，为什么轻子和夸克不是相同的粒子？

尽管存在上述各种疑问，但至少在近几十年的时间中，夸克模型在预测新的粒子方面还是取

得了很多重要的成果。这说明夸克模型是有足够的实验支持的。因此如果能够有一个新的理论来解释夸克模型中的分数电荷起源，相信会令很多人感兴趣。这正是本文所要做的工作。虚时空的假设[7]为解释夸克的分数电荷效应提供了这样的可能。

由于夸克模型的理论是从单一时空发展而来，要直接对其应用虚时空理论来进行处理存在一定的困难。故这里先使用虚时空粒子模型来处理这些粒子的问题，然后看看能不能平稳地包含夸克模型。

2 粒子对

考虑每个粒子都同时存在于虚实时空中，因此每个粒子都可以用一个粒子对来表示。表示方法如下所示。对于粒子 A，其对应的虚时空的粒子为 b，则该粒子对可以表示为：

$$(A,\ b)$$

这里括号的左边为实时空，右边为虚时空。大写字母表示重子，小写字母表示轻子。通常虚实时空由于质量的不对称，导致其组合通常在一个时空表现为重子，另一个时空则表现为轻子，反之亦然。不过这只是一个理论上的约定而已。因为虚实时空各种物理量的度量方法正好互为倒数，在实时空测量到的大质量，在虚时空则表现为小质量。因此所谓的轻子重子之分是相对而言的。这里约定实时空的重子，对应了虚时空的轻子。

而在粒子$(A,\ b)$中，b 在虚时空表现出来的是磁场（由于电场和磁场一致，因此也可以称之为虚时空的电场，但是需要转换成无量纲的物理量）自能，而在实时空表现出来的是质量。A 在实时空表现出来的是电场自能[7]。

比如对于电子，其粒子的完整构成形式为$(e,\ P_1)$，质子的完整形式为(P, m)

3 实时空的轻子与虚时空的重子

考虑虚实时空的对称性，虚时空的轻子对应了实时空的重子，而实时空的轻子对应了虚时空的重子。那么实时空有三代六种轻子，而对应的虚时空就应该有三代六种重子, 它们与轻子的组合为

$$(e,\ P_1)$$

$$(\mu,\ P_2)$$

$$(\tau,\ P_3)$$

$$(v_e,\ V_1)$$

$$(v_\mu,\ V_2)$$

$$(v_\tau,\ V_3)$$

而虚时空只有一种轻子即

$$(P, m)$$

其中 m 为质子 P 对应的虚时空磁单极子。

上述所有粒子的反粒子都直接用负号表示。比如正电子的表示方法为$(-e,\ -P_1)$，这种表示方法的好处在于可以直接构成比较完整的运算方式。

4 基本粒子的衰变

上述基本粒子中，除了电子和质子是稳定的之外，其他粒子都是不稳定的，会产生衰变。因此这里简单探讨一下粒子的衰变方式。

已知 muon 会衰变成一个电子和一个反电子中微子，并释放一个 muon 中微子。

实时空可以表示为

$$\mu = e - v_e + v_\mu$$

这里用了新的约定，即反粒子前面用负号表示。上述方式满足加减法的运算规则，但是不满足乘除法规则。

则虚实时空的完整表示方法为

$$(\mu,\ P_2) = (e,\ P_1) + (-v_e,\ -V_1) + (v_\mu,\ V_2)$$

或者

$$(\mu,\ P_2) = (e,\ P_1) - (v_e,\ V_1) + (v_\mu,\ V_2)$$

由于没有乘法规则，虚实时空参数是不会互相影响的。因此上述公式实际上还包含了在虚时空中单独表示的规律，即

$$P_2 = P_1 - V_1 + V_2$$

5 夸克分数电荷的起源

对于虚时空对应粒子的电荷规定，考虑到质子在实时空中电荷为正，因此也可以约定虚时空中 m 电荷为正，这样 P_i 的电荷就是负。可以看出粒子虚时空的电荷符号与对应实时空的电荷符号就是一致的了。由于所有的 P_i 电荷都是一样，所有 Vi 的电荷都是零。因此都可以统

一标识为 q_m, q_p 和 q_v

为了避免出现混淆，实时空的电荷下标直接用对应的粒子符号来表示。电子的电荷为q_e，质子的电荷为q_P或者q_{Proton}，muon 的电荷为q_μ等等。为了有所区别，质子的下标用大写字母表示。

为简单起见，所有单位电荷都表示为 1 或者-1

这样

$$q_m = 1, q_p = -1, q_v = 0$$

$$q_{-m} = -1, q_{-p} = 1, q_{-v} = 0$$

按照虚时空粒子模型[7,8]，对于实时空的重子，除了质子之外，每个复合重子由三个粒子构成，分别是质子和两个轻子。

其中一个质子是可以检测到的。另外两个包含了虚时空的三代重子。

组合方式可以表示为$(Pxy,\ mX_iY_j)$

其中 Pxy 反映出实时空衰变的结果。而mX_iY_j反映出虚时空的组合，对应了复合重子的内部结构。

在虚时空中，由于 m 只有一个，是不变的，因此不同的粒子主要依赖X_iY_j的组合。

而我们已知夸克则有三个，分别是$Q_iQ_jQ_k$

守恒规律方面来看，实时空包括轻子数守恒、重子数守恒、同位旋守恒。在虚时空仍然成立。

如果设置一个平均参数：

$$\frac{\pm m \mp X_i \pm Y_j}{3}$$

反映出电荷的加减特性，由于每个粒子的电荷只能够取 1，0，-1，可以发现所有的电荷的组合为

$$1, \frac{2}{3}, \frac{1}{3}, 0, -\frac{1}{3}, -\frac{2}{3}, -1$$

考虑到实时空的轻子数守恒，对于一个重子衰变之后，必然会出现一个正粒子和一个反粒子。而 m 必然带电荷。

因此实际的组合电荷只有五个，分别是

$$\frac{2}{3},\frac{1}{3},0,-\frac{1}{3},-\frac{2}{3}$$

当然我们还可以再约定一下，X_i和Y_j两个参数中，一个为带电荷的轻子，另一个为对应的不带电荷的反中微子，这样上述组合形式会更少一些。结果我们可以得到用六个新的粒子代替mX_iY_j的组合。

对于第一代粒子，可以考虑这样的组合

$$u=\frac{m-P_1+V_1}{3}$$

对应的电荷分别为：

$$q_u=\frac{q_m-q_p+q_v}{3}$$

其中

$$q_m=1,q_p=-1,q_v=0$$

上述组合中，除了每个粒子前面的符号可以产生变化之外，已经没有其他的组合了。因此另一个组合可以考虑增加轻子前面的系数。这样可以获得另一个新的粒子

$$d=\frac{m+2P_1-2V_1}{3}$$

可以计算出两个新粒子的电荷分别为

$$q_u=\frac{2}{3}$$

$$q_d=-\frac{1}{3}$$

这两个粒子对应了上夸克和下夸克。可以看出夸克具备了两种分数电荷。

夸克 d 衰变将释放出一个电子和一个反电子中微子.

$$d=\frac{m-P_1+V_1}{3}+P_1-V_1=u+P_1-V_1$$

注意到这些全部都是虚时空的分量，因此P_1和$-V_1$分别表示电子$(e,\ P_1)$和反电子中微子$(-v_e,\ -V_1)$的组合。即一个 d 夸克将会衰变成一个 u 夸克加上一个电子和一个反电子中微子。

这正是中子衰变成质子的过程。如文献[9]指出的那样，这样的结构可以自动满足电荷守恒、同位旋守恒、重子数守恒、轻子数守恒的要求。

对于质子和中子的结构，还可以通过对应的公式进行一些简单的推导。

对于质子，其虚时空的结构为

$$Proton = u + u + d = 2\frac{m - P_1 + V_1}{3} + \frac{m + 2P_1 - 2V_1}{3}$$

通过加减运算，可以得到质子在虚时空的分量为

$$Proton = m$$

这与开头质子的假设是一致的。

而对于中子，其虚时空的结构为：

$$Neutron = u + d + d = \frac{m - P_1 + V_1}{3} + 2\frac{m + 2P_1 - 2V_1}{3}$$

通过加减运算，可以得到中子在虚时空的分量为

$$Neutron = m + P_1 - V_1$$

可以看出中子在实时空将衰变成一个质子、一个电子和一个反中微子。

上述两个夸克对应的反粒子为

$$-u = -\frac{m - P_1 + V_1}{3}$$

$$-d = -\frac{m + 2P_1 - 2V_1}{3}$$

如果第一代夸克的结构可以类推到第二代和第三代，则我们可以得到所有三代夸克的虚时空粒子组合方式为

第一代粒子为

$$u = \frac{m - P_1 + V_1}{3}$$

$$d = \frac{m + 2P_1 - 2V_1}{3}$$

第二代粒子为

$$c = \frac{m - P_2 + V_2}{3}$$

$$s = \frac{m + 2P_2 - 2V_2}{3}$$

第三代粒子为

$$t = \frac{m - P_3 + V_3}{3}$$

$$b = \frac{m + 2P_3 - 2V_3}{3}$$

以及它们对应的 6 个反粒子等。

上面简单讨论了中子衰变成质子的过程。而对于其他的粒子，比如 Kaon$^+$粒子的结构$K^+ = u - s$，可以表示为

$$K^+ = u - s = \frac{m - P_1 + V_1}{3} - \frac{m + 2P_2 - 2V_2}{3}$$

即

$$K^+ = \frac{-P_1 + V_1 - 2P_2 + 2V_2}{3}$$

这个公式可以反映出 Kaon$^+$的电荷、同位旋、轻子数和重子数等重要参数。另外从该公式也可以估计出衰变后产生的粒子结果。

因为衰变结果中不能出现分数电荷，所以衰变结果就可能出现正电子和电子中微子对，也可能出现反 muon 和 muon 中微子对等。衰变结果的几率主要看$(\mu,\ P_2)$衰变成$(e,\ P_2)$，或者$(e,\ P_1)$转变成$(\mu,\ P_2)$的概率。而两代轻子的相互作用，也会形成 Pion 等中间粒子等。

6 讨论

从上述分析可以看出，考虑到了虚时空之后，可以用轻子对应的虚时空粒子通过适当的方式组合出夸克的分数电荷。这种组合方式能够比较好地解释为何轻子和夸克都有相同的三代，且每一代都有两个粒子。从各方面的实验结果来看，三代轻子和三代夸克在某些方面具有非常类似的性质。包括味的转变等。

由于形成了轻子和夸克之间的联系，则过去一些相互独立的规律现在应该都可以将它们互相

联系在一起，由一种规律推导出另一种规律。比如是否能够由夸克的味转变矩阵 CKM 推导出中微子的味转变矩阵 PMNS？这都有待于进一步的研究进行确认。

另外在实时空我们发现轻子都是相互分离的。即电子和电子中微子并不是结合在一起的一个整体，而是两个相互独立的粒子。那么从对称性考虑，虚时空中，电子和电子中微子对应的粒子也应该是分离开来的。如何在实时空中组合在一起形成夸克，并最终复合出各种重子？这主要源自虚实时空的特殊结构导致的。按照虚时空物理学[7]的观点，虚时空的长度正好与实时空的长度形成反比关系。也就是说在虚时空中，两个粒子离开的越远，在实时空看起来，两个粒子反而是靠得越近。这样在一个时空看起来是完全独立分离的两个粒子，在另一个时空中则是完全紧密结合在一起的。这种时空结构的特殊性也正好说明引入虚时空的必要性，它确实能够解释一些那些依赖已有的理论无法解释的现象。

从本文的分析还可以看出，夸克分数电荷主要是源自轻子在虚时空对应粒子的不同组合方式形成的，这种分数电荷的形成或许只是一种数学上的安排而已，因此并不需要一定能够在实验中检测到。当然独立的夸克也并不一定需要在实时空出现。如果这样的考虑是正确的，那么夸克禁闭理论就显得是多余的了。而如果今后在粒子对撞机上真的检测到了单个夸克以及分数电荷，也许说明这种虚时空粒子的组合可能跟轻子之间相互作用的某种非线性关系有联系，那这又将开辟基本粒子研究的一个更深层次的领域。

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