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Parity Violation in Weak Nuclear Interactions

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Abstract

The treatment of parity violations in the weak nuclear interactions is discussed within the frameworks of both the Standard Model (SM) and the Generation Model (GM) of particle physics. It will be demonstrated that several important differences between these two models lead to the SM merely *describing* the parity violations, while the GM provides an understanding of the *cause* of the parity violations in weak nuclear interactions. The significant differences arising from several dubious assumptions made during the development of the SM, lead to very different conclusions concerning the nature of the parity violations in the two models. While the SM is able to *describe* the observed parity violations in terms of a "V-A" theory of the weak nuclear interactions, the GM is also able to demonstrate the *cause* of the observed parity violations: in the GM, the observed parity violations arise as a consequence of the *negative* intrinsic parity of both the *W* massive bosons, which mediate these so-called charge-changing (CC) weak nuclear interactions.

Keywords

Standard Model, Generation Model, Parity Violation

1. Introduction

The main purpose of this paper is to indicate why the Standard Model (SM) of particle physics [1] [2] [3] [4] failed to provide a *cause* for the violation of parity in weak nuclear interactions: the SM is able to *describe* the parity violations but is unable to *explain* them.

This failure of the SM, emphasized in Ref. [2], arises from several *dubious assumptions* made during the long-term development, 1932-2000, of the SM. It will be demonstrated that the development of an alternative model, termed the Generation Model (GM) of particle physics [5], during the years 2002-2019 in which these dubious assumptions are corrected, leads to an explanation, *i.e.* the cause, of the parity violations in weak nuclear interactions.

Both the SM and the GM are attempts to understand the composition and the structure of the Universe, which depend primarily upon two properties: 1) the nature of the building blocks, *i.e.* elementary particles, of the constituent matter and 2) the nature of the forces acting between these elementary particles.

The SM, based primarily upon observations, was essentially completed during the 20th century, and was developed employing two theories, *relativity theory* and *quantum theory* that originated in the earlier years of the 20th century.

Today, scientists still describe the Universe mainly in terms of two theories: (i) Einstein's general theory of relativity, which describes the force of gravity and the large-scale structure of the Universe; and (ii) quantum theory, which describes the physics of the very small, within the framework of the SM.

Unfortunately, as emphasized by Stephen Hawking and others, these two theories are known to be *inconsistent* with each other. This *incompatibility* of general relativity (Einstein's theory of gravity) and quantum theory means that at least one of these theories is *incomplete*, leading to possible problems for the SM.

Indeed, the SM is based upon quantum theory and although this model recognizes four fundamental forces in nature: the gravitational force, the electromagnetic force, the weak nuclear force and the strong nuclear force, described in almost every modern physics text book, it does not provide any understanding of the gravitational force, since this force is so much weaker than the other three fundamental forces and is considered to play no role in particle physics.

Today, most physicists consider that the SM is *incomplete* in the sense that it provides no understanding of several empirical observations, while enjoying considerable success in describing the interactions of the elementary leptons and the multitude of hadrons, composed of elementary quarks, as well as the decay modes of the unstable leptons and hadrons.

This inability of the SM to provide an understanding of important empirical observations such as: the existence of three generations of the elementary leptons and quarks, which apart from mass have similar properties; the mass hierarchy of the elementary leptons and quarks, which form the basis of the SM; the nature of the gravitational interaction; and the origin of parity violation in weak nuclear interactions, led to the development of an alternative model, the GM, which successfully overcomes several dubious assumptions made during the development of the SM. Furthermore, the GM provides an understanding of the above empirical observations, which are described in a recent book entitled "Understanding Gravity: The Generation Model Approach" [6].

The SM and the GM differ in several significant ways that have a major impact upon parity violation in weak nuclear interactions.

First, the SM is considered to have twelve *massive* elementary particles, six leptons and six quarks, while the GM has only two *massless* elementary particles, one charged rishon and one neutral rishon.

Second, the classification of the *elementary* leptons and quarks of the SM and the *composite* leptons and quarks of the GM, in terms of additive quantum numbers, are quite different.

Third, the treatment of the *universality* of the weak nuclear force differs considerably within the two models.

In the following two Sections, the treatment of parity violations in the weak nuclear interactions will be discussed within both frameworks of the SM and the GM. It will be seen that the above significant differences between the two models lead to the SM merely *describing* the parity violations, while the GM provides an understanding of the *cause* of the parity violations in weak nuclear interactions. The significant differences, arising from the dubious assumptions made during the development of the SM, lead to very different conclusions concerning the nature of the parity violation in weak nuclear interactions in the two models. While the SM is able to *describe* the observed parity violations in terms of a "V-A" theory of the weak nuclear interactions, the GM is also able to demonstrate the *cause* of the observed parity violations: in the GM, the observed parity violations arise as a consequence of the *negative* intrinsic parity of both the W massive bosons, which mediate these so-called charge-changing (CC) weak nuclear interactions. It should be noted that the SM is unable to determine the parity of the W bosons, since the "V-A" theory of the CC weak nuclear interactions describes the observed parity violations in terms of both a vector interaction (V) with negative parity and an axial vector interaction (A) with positive parity.

2. The SM and Parity Violation in CC Weak Nuclear Interactions

The first weak nuclear interaction process, nuclear β-decay, was discovered by Ernest Rutherford as early as 1898 in the radioactive process in which electrons are emitted from a uranium salt.

In 1930 Wolfgang Pauli proposed that the observed continuous energy spectra of the electrons emitted in several such radioactive decays, could be understood if a neutron decayed to a proton with the emission of both an electron and another particle, later termed an electron antineutrino:

$$n^0 \to p^+ + e^- + \bar{\nu}_e \,. \tag{1}$$

In 1934 Enrico Fermi [7] proposed that in β-decay, a neutron decays to a proton in a manner analogous to the emission of a photon in an electromagnetic interaction. The β-decay process was described in terms of two interacting vector currents, analogous to the Dirac electromagnetic current:

$$j_{em}^{\mu} = \bar{\psi}\alpha_{\mu}\psi \,, \tag{2}$$

where ψ is the electron field and α_{μ} are Dirac matrices [6], so that the matrix element describing the process could be written as:

$$M = \frac{F}{\sqrt{2}} j_1^{\mu} j_2^{\mu} \,, \tag{3}$$

where F is the Fermi weak coupling constant and j_1^μ and j_2^μ are given by

$$j_1^\mu = \bar{\psi}_p \alpha_\mu \psi_n, \quad j_2^\mu = \bar{\psi}_\nu \alpha_\mu \psi_e . \tag{4}$$

Fermi's theory assumed that the decay process took place at a single spacetime point, corresponding to the short-range nature of the underlying weak nuclear interaction. However, in a radiative transition the photon is the mediating particle of the electromagnetic interaction, but it was difficult to understand how the corresponding electron-antineutrino pair could be the weak nuclear interaction quantum.

In 1938 Oskar Klein suggested that the weak nuclear interaction could be mediated by massive charged bosons, now called W^+ and W^- bosons that had properties similar to those of photons. He termed them "electrically charged photons" but unlike photons, they were *massive* in order to satisfy the very short-range nature of the weak nuclear interactions. Thus, β-decay could be considered to be a two-step process:

$$n^0 \to p^+ + W^-, \quad W^- \to e^- + \bar{\nu}_e , \tag{5}$$

provided the large mass of the W^- boson and its short lifetime were compatible with Heisenberg's uncertainty principle. Such weak nuclear interactions, involving charged W mediating bosons are known as charge-changing (CC) weak nuclear interactions.

Between 1947 and 1953 several new particles were discovered in cosmic rays. In particular, two of these new particles then known as the tau particle, which decayed into three pions:

$$\tau^+ \to \pi^+ + \pi^+ + \pi^- , \tag{6}$$

and the theta particle, which decayed into two pions:

$$\theta^+ \to \pi^+ + \pi^0 , \tag{7}$$

presented a problem. Both particles decayed via a CC weak nuclear interaction and were *indistinguishable* apart from their decay mode, since their masses and lifetimes were found to be about the same.

The essential problem was that the τ^+ particle would have parity $P = -1$, while the θ^+ particle would have parity $P = +1$, if the pions had parity $P = -1$, as was generally believed at that time. Hence, if conservation of parity holds, the theta having parity $P = +1$, and the tau having parity $P = -1$, could not be the same particle. This was known as the *theta-tau puzzle*.

In 1956 Tsung-Dao Lee and Chen-Ning Yang, in order to resolve the theta-tau puzzle, proposed [8] that parity conservation may be violated in CC weak nuclear interactions.

The first experiment [9] to investigate parity conservation in CC weak nuclear interactions was carried out by Chien-Shiung Wu and collaborators in late 1956 employing the β-decay of polarized Co^{60} nuclei:

$$\mathrm{Co}^{60} \to \mathrm{Ni}^{60} + e^- + \bar{\nu}_e, \tag{8}$$

and noting the direction of emission of the electrons with respect to the direction of the spin of the Ni^{60} nuclei. If parity was conserved, it was anticipated that an equal number of electrons would be emitted both parallel and antiparallel to the spin of the Ni^{60} nucleus. The final result was that many more electrons were emitted in the antiparallel direction than in the parallel direction, so that parity symmetry was *violated*. This experiment implied that electrons were left-handed and electron antineutrinos were right-handed. The experiment also confirmed that the theta and tau mesons were indeed the same meson (later termed K^+) with different decay modes.

The 1957 discovery of parity violation in CC weak nuclear interaction processes was in contradiction with the original Fermi model, which only involved vector currents.

One of the cornerstones of modern physics is the principle of *special relativity*, which requires that the fundamental laws of physics are the *same* in all inertial frames of reference, *i.e.* those in which an isolated object, experiencing no force, moves along a straight line with uniform velocity. This implies that the laws of physics are *invariant* under a change of inertial reference frames, corresponding to a *Lorentz transformation* [6].

Lorentz covariance allows Fermi's theory to be generalized to include four additional currents: scalar (S), tensor (T), axial vector (A) and pseudovector (P); in terms of Dirac matrices these replace α_μ by 1 (S), $\sigma_{\mu\nu} = \mathrm{i}\left(\alpha_\mu \alpha_\nu - \alpha_\nu \alpha_\mu\right)/2$ (T), $\alpha_5 \alpha_\mu$ (A) and α_5 (P), respectively.

In 1956 Lee and Yang had encouraged theorists to look for models that could incorporate parity violation in CC weak nuclear interaction processes. Indeed in 1957 both Abdus Salam [10] and Lev Landau [11] proposed that parity violation may be related to the *vanishing* of the electron neutrino mass, corresponding to the left-handed nature of the electron and the right-handed nature of the electron antineutrino observed in the Wu experiment.

The above generalization suggested two new hypotheses to describe parity violation in CC weak interaction processes: 1) the two-component electron neutrino in 1957 and 2) the CC nuclear interaction involves only left-handed fermions and right-handed antifermions in 1958.

The two-component electron hypothesis requires the neutrino to be *massless*. In this case the electron neutrino (N.B. in 1957 this was the only neutrino known) will exist in a state of *definite* helicity. Helicity is the projection of spin along the direction of motion and spin-$\frac{1}{2}$ particles such as the electron neutrino occur with helicity $\pm\frac{1}{2}$, corresponding to spin projection parallel (called right-handed) or antiparallel (called left-handed) to the direction of motion, respectively.

In 1958, the helicity of the electron neutrino, participating in a CC weak nuclear interaction was measured by Maurice Goldhaber and collaborators [12] and was found to be *negative* and the electron neutrino *left-handed*, *i.e.* had intrinsic parity $P = -1$. At the time this was taken as confirmation of the two-component hypothesis. However, in more recent years, evidence has been found [13] that all three kinds of neutrinos have *mass*, albeit very small. Thus, the left-handed nature of the electron neutrino was attributed to the CC weak nuclear interaction rather than to the electron neutrino itself, *i.e.* it arises as a consequence of the second hypothesis above.

Fermi's original theory, involving only vector currents is given in Equations (3) and (4). Unfortunately, this four-fermion point contact model *failed* to describe later experimental data of CC weak nuclear interaction processes. This led to a generalization of the currents, as indicated above. This allowed all the available β-decay data at the time to be *described*.

If the second hypothesis is adopted, the matrix element describing the β-decay CC weak nuclear interaction processes may be written as in Equation (3) but now the interacting currents become

$$j_1^\mu = \bar{\psi}_p \bar{\Gamma} \alpha_\mu \Gamma \psi_n = \bar{\psi}_p \alpha_\mu \Gamma \psi_n, \tag{9}$$

and

$$j_2^\mu = \bar{\psi}_e \alpha_\mu \Gamma \psi_\nu, \tag{10}$$

since

$$\bar{\Gamma} = \frac{1}{2}(1+\alpha_5), \ \bar{\Gamma}\alpha_\mu = \alpha_\mu \Gamma, \ \Gamma^2 = \Gamma = \frac{1}{2}(1-\alpha_5), \tag{11}$$

and

$$\alpha_5 = \begin{pmatrix} -1_2 & 0_2 \\ 0_2 & 1_2 \end{pmatrix}. \tag{12}$$

Here the presence of the projection operator Γ ensures that only the left-handed components of the fermion fields are involved, and since $\bar{\Gamma}\Gamma = 0$ that any scalar, tensor and pseudoscalar interactions are *forbidden*. This led to the "V-A" hypothesis that in fact *only the left-handed components of all four fermion fields* take part in the CC weak nuclear interaction processes.

During 1957 it was shown that the "V-A" theory of the CC weak nuclear interaction, developed by George Sudarshan and Robert Marshak [14] described the observed parity violations in terms of a vector (V) interaction with negative parity and an axial vector (A) interaction with positive parity. In 1958 Richard Feynman and Murray Gell-Mann published a similar V-A theory of the CC weak nuclear interaction [15].

To summarize: within the framework of the SM, parity violations in CC weak nuclear interaction processes are able to be *described* in terms of the V-A theory. However, the SM fails to provide an understanding of the *cause* of parity violations in CC weak nuclear interaction processes. In Ref. [2], Abraham Pais concludes on page 542 that "we do not understand why parity is violated if, and only if, weak interactions intervene, and none of the great advances of unified gauge theories have shed any light on this problem: these theories incorporate the parity violations but do not explain them." In the following Section 3, it will be shown how the GM provides an understanding of the *cause* of the observed parity violations.

3. The GM and Parity Violation in CC Weak Nuclear Interactions

The development of a successful alternative to the SM, the GM, took place from 2002-2019 and is described in Ref. 6. As indicated earlier, the SM and the GM differ in several significant ways that have a major impact upon parity violation in CC weak nuclear interactions: these differences arise from several *dubious assumptions* made within the framework of the SM during its long-term development.

The essential problems of the SM that are important for understanding the *cause* of parity violation in CC weak nuclear interactions are the following: 1) the assumption that the six leptons and the six quarks are elementary particles, while there exists considerable indirect evidence that they are composite particles; 2) the assumption of a *nonunified* and complicated classification of the elementary leptons and quarks in terms of additive quantum numbers, some of which are *not* conserved in CC weak nuclear interaction processes; and 3) the treatment of the *universality* of the CC weak nuclear interaction in terms of Cabibbo quark mixing [16], which assumes that the weak interaction is shared between strangeness-conserving and strangeness-changing transition amplitudes.

The indirect evidence for composite leptons and quarks is the following. First, the electric charges of the electron and the proton are opposite in sign but are *exactly* equal in magnitude, so that atoms with the same number of electrons and protons are neutral. Consequently, in a proton consisting of three quarks, the electric charges of the quarks are intimately related to that of the electron. These relations are readily comprehensible, if leptons and quarks are composed of the same kinds of particles. Second, in the SM the six leptons and the six quarks can be grouped into three *generations*: (i) (e^-, ν_e, u, d), (ii) (μ^-, ν_μ, c, s) and (iii) (τ^-, ν_τ, t, b). Each generation contains particles, which have similar properties other than mass. The existence of three repeating patterns suggests that the members of each generation are composite particles, analogous to the composite elements in the same vertical column of the Mendeleev periodic table that have similar chemical properties apart from mass.

Table 1 shows the SM classification scheme for the elementary leptons and quarks, in terms of additive quantum numbers. The Table shows that, except for charge Q, leptons and quarks have *different* kinds of additive quantum numbers, so that this classification scheme is *nonunified*. It is also a complicated system involving four additive quantum numbers, charge Q, lepton number L, muon lepton number L_μ and tau lepton number L_τ for leptons; and six additive quantum numbers, charge Q, baryon number A, strangeness S, charm C, bottomness B and topness T for quarks. This nonunified classification scheme of the elementary particles of the SM presented a major stumbling block for the development of a composite model of these particles.

Table 1. SM additive quantum numbers for leptons and quarks.

particle	Q	L	L_e	L_μ	L_τ	A	S	C	B	T
ν_e	0	1	1	0	0	0	0	0	0	0
e^-	−1	1	1	0	0	0	0	0	0	0
ν_μ	0	1	0	1	0	0	0	0	0	0
μ^-	−1	1	0	1	0	0	0	0	0	0
ν_τ	0	1	0	0	1	0	0	0	0	0
τ^-	−1	1	0	0	1	0	0	0	0	0
u	$+\frac{2}{3}$	0	0	0	0	$\frac{1}{3}$	0	0	0	0
d	$-\frac{1}{3}$	0	0	0	0	$\frac{1}{3}$	0	0	0	0
c	$+\frac{2}{3}$	0	0	0	0	$\frac{1}{3}$	0	1	0	0
s	$-\frac{1}{3}$	0	0	0	0	$\frac{1}{3}$	−1	0	0	0
t	$+\frac{2}{3}$	0	0	0	0	$\frac{1}{3}$	0	0	0	1
b	$-\frac{1}{3}$	0	0	0	0	$\frac{1}{3}$	0	0	−1	0

In the SM, the additive quantum numbers Q and A are assumed to be conserved in the electromagnetic and both the strong and CC weak nuclear interactions. The lepton numbers L, L_e, L_μ and L_τ are not involved in the strong nuclear interaction but are strictly conserved in both the electromagnetic and CC weak nuclear interactions. The remainder, S, C, B and T are strictly conserved only in the strong nuclear and electromagnetic interactions but may undergo a change of one unit in the CC weak nuclear interactions.

The introduction of a "partially conserved" additive quantum number such as strangeness S during the development of the SM was a very *dubious assumption*. In quantum mechanics, quantum numbers are usually conserved quantities and the nature of the CC weak nuclear interactions is "weak" because it is mediated by very massive W bosons not because the strangeness quantum number is not conserved. This strangeness assumption led to several problems for the development of the SM, associated with both the classification scheme of the elementary particles and the nature of the *universality* of the CC weak nuclear interaction.

The SM was essentially finalized in the mid-1970s following the experimental confirmation of quarks in 1969, although the last elementary particle, the tau neutrino was not discovered until 2000. However several factors: the *incompleteness* of the SM, the *nonunified* and *complex* classification scheme (**Table 1**) of the elementary particles of the SM, which contained several partially conserved additive quantum numbers and furthermore provided no physical basis for the scheme, led scientists to contemplate new models, which considered the leptons and quarks of the SM to be *composite* particles [17]. The underlying reason for this was that twelve elementary particles of the SM, the six leptons and the six quarks, was considered too many basic particles.

In 2002, development of the GM commenced. First it was demonstrated [18] that a new *simpler* and *unified* classification scheme for the leptons and quarks was feasible. This scheme involved only *three* additive quantum numbers: charge Q, particle number p and generation quantum number g, which are conserved in *all* interactions, provided that each force mediating particle had $p = g = 0$.

The charge quantum number Q was introduced into the SM to describe the conservation of electric charge: in the GM, the charge quantum number serves the same purpose. The particle quantum number p replaces both the baryon number A of quarks and the lepton number L of leptons in the SM, so that $p = \frac{1}{3}$ for quarks and $p = -1$ for leptons, essentially in agreement with the corresponding quantum numbers of the SM. The generation quantum number g replaces the remaining six additive quantum numbers of the SM: L_μ, L_τ, S, C, B and T.

Thus the GM overcame the first major problem of the SM, involving a complicated nonunified classification scheme that presented a major stumbling block to the development of a composite model of the elementary leptons and quarks of the SM. Indeed, many such composite models had been proposed prior to 1983 but these had met with little success, primarily because it was difficult to relate the composite models to the complicated nonunified classification scheme of the relatively successful SM.

Second, the GM replaced another dubious assumption of the SM that the u and c quarks form weak isospin doublets with the CC weak nuclear interaction eigenstate quarks, d' and s', respectively, where

$$d' = d\cos\theta_c + s\sin\theta_c \tag{13}$$

and

$$s' = -d\sin\theta_c + s\cos\theta_c. \tag{14}$$

and θ_c is the Cabibbo angle involved in Cabibbo quark mixing [16], by placing the quark mixing in the quark states (wave functions) rather than in the CC weak nuclear interactions as proposed by Cabibbo.

In the GM, it is postulated that the mass eigenstate quarks of the same generation form weak isospin doublets, e.g. (u, d), and couple with the full strength of the CC weak nuclear interaction like the lepton doublets, e.g. (ν_e, e^-). Contrary to the SM, the GM requires that there is no coupling between mass eigenstate quarks from different generations. This latter requirement corresponds to the conservation of the generation quantum number g in the CC weak nuclear interaction processes [19].

The development of a composite model of leptons and quarks within the framework of the GM was completed in 2011. The structure of the first generation of leptons and quarks of the SM, within the GM is based partly upon the two-particle models of Haim Harari and Michael Shupe. Both these models [20] [21] proposed in 1979 are very similar and provide a simple and economical description of the first generation of leptons and quarks, and their antiparticles in the SM. The Harari-Shupe model treats the leptons and quarks as composites of only two kinds of *massless* spin-$\frac{1}{2}$ particles, which Harari named "rishons" from the Hebrew word for primary. This name was adopted for the elementary constituents of the leptons and quarks in the GM [5].

The two kinds of rishons employed to construct the leptons and quarks of the first generation in the GM are (i) a *T*-rishon with electric charge $Q=+\frac{1}{3}$ and (ii) a *V*-rishon with $Q=0$, and their antiparticles: (iii) a $\bar{T}$ -antirishon with $Q=-\frac{1}{3}$ and (iv) a $\bar{V}$ -antirishon with $Q=0$. The Harari-Shupe model described the electric charge character of the first generation of particles, assuming that each spin-$\frac{1}{2}$ lepton and quark was composed of three rishons/antirishons.

In the GM, it is assumed that all three rishons carry a single color charge, red, green or blue, while their antiparticles carry a single anticolor charge, antired, antigreen or antiblue. The GM assumes a strong color-type interaction corresponding to a local gauged $SU(3)_C$ color symmetry (analogous to QCD) mediated by massless neutral spin-1 *hypergluons*, to be responsible for binding rishons and antirishons together to form colorless leptons and colored quarks.

In the GM each lepton of the first generation (see **Table 2**) is assumed to be colorless, consisting of three rishons (or antirishons), each with a different color

Table 2. GM of first generation of leptons and quarks.

particle	*structure*	*Q*	*p*	*g*
e^+	TTT	+1	+1	0
u	$TT\bar{V}$	$+\frac{2}{3}$	$+\frac{1}{3}$	0
$\bar{d}$	$T\bar{V}\bar{V}$	$+\frac{1}{3}$	$-\frac{1}{3}$	0
ν_e	$\bar{V}\bar{V}\bar{V}$	0	−1	0
$\bar{\nu}_e$	VVV	0	+1	0
d	$\bar{T}VV$	$-\frac{1}{3}$	$+\frac{1}{3}$	0
$\bar{u}$	$\bar{T}\bar{T}V$	$-\frac{2}{3}$	$-\frac{1}{3}$	0
e^-	$\bar{T}\bar{T}\bar{T}$	−1	−1	0

charge (or anticolor charge), analogous to the baryons (or antibaryons) of the SM. These leptons are built out of *T*-rishons and *V*-rishons or their antiparticles $\bar{T}$ and $\bar{V}$, all of which have generation quantum number $g = 0$.

In the GM, it is assumed that each quark of the first generation is a composite of a colored rishon and a colorless rishon-antirishon pair, ($T\bar{V}$) or ($V\bar{T}$), so that the quarks carry a color charge. Similarly, the antiquarks are a composite of an anticolored antirishon and a colorless rishon-antirishon pair, so that the antiquarks carry an anticolor charge. The proposed structures of the quarks of the first generation require the composite quarks to have a color charge so that the dominant residual interaction between such quarks is essentially the same as that between rishons, and consequently these composite quarks behave very like the elementary quarks of the SM. In the GM the term "hypergluon" is retained as the mediator of the strong color interaction, rather than the term "gluon" employed in the SM, because it is the rishons rather than the quarks that carry an elementary color charge.

In order to preserve the universality of the CC weak nuclear interaction processes involving first generation quarks, e.g. the transition $d \to u + W^-$, it is assumed that the first generation quarks have the general color structures:

$$\text{up quark}: T_C\left(T_{C'}\bar{V}_{\bar{C}'}\right), \quad \text{down quark}: V_C\left(V_{C'}\bar{T}_{\bar{C}'}\right), \quad \text{with } C' \neq C. \tag{15}$$

Thus a red *u*-quark and a red *d*-quark have the general color structures:

$$u_r = T_r\left(T_g\bar{V}_{\bar{g}} + T_b\bar{V}_{\bar{b}}\right)/\sqrt{2}, \tag{16}$$

and

$$d_r = V_r\left(V_g\bar{T}_{\bar{g}} + V_b\bar{T}_{\bar{b}}\right)/\sqrt{2}, \tag{17}$$

respectively. For $d_r \to u_r + W^-$, conserving color, one has the two transitions:

$$V_rV_g\bar{T}_{\bar{g}} \to T_rT_b\bar{V}_{\bar{b}} + V_rV_gV_b\bar{T}_{\bar{r}}\bar{T}_{\bar{g}}\bar{T}_{\bar{b}} \tag{18}$$

and

$$V_rV_b\bar{T}_{\bar{b}} \to T_rT_g\bar{V}_{\bar{g}} + V_rV_gV_b\bar{T}_{\bar{r}}\bar{T}_{\bar{g}}\bar{T}_{\bar{b}}, \tag{19}$$

which take place with equal probabilities. In these transitions, the W^- boson is assumed to be a three $\bar{T}$-antirishon and a three *V*-rishon colorless composite particle with additive quantum numbers $Q = -1$, $p = g = 0$. The corresponding W^+ boson has the structure [$T_rT_gT_b\bar{V}_{\bar{r}}\bar{V}_{\bar{g}}\bar{V}_{\bar{b}}$], consisting of a colorless set of three *T*-rishons and a colorless set of three $\bar{V}$-antirishons with additive quantum numbers $Q = +1$, $p = g = 0$.

There is one additional important point to make concerning the composite versions of the GM: the building blocks of the GM are assumed to be *massless* spin-$\frac{1}{2}$ rishons and antirishons, which have intrinsic parity +1 and −1, respectively. This implies that all the composite leptons and quarks also have an intrinsic parity ±1, depending upon the number of rishons and the number of antirishons comprising each composite particle, provided that it is assumed that each rishon and antirishon exists in an s state. Thus, e.g. the electron and the electron neutrino both have negative intrinsic parity and are left-handed particles, while the muon and the muon neutrino both have positive intrinsic parity and are right-handed antiparticles. Consequently, the right-handed electron and the right-handed electron neutrino, and similarly the left-handed muon and the left-handed muon neutrino, do not exist in the GM. Furthermore, the down quark and the up quark both have negative intrinsic parity and are left-handed particles, while the strange quark and the charmed quark both have positive intrinsic parity and are right-handed antiparticles.

To summarize: in general, the universal CC weak nuclear force, mediated by the W bosons, acts between the two particles of the six weak isospin doublets: (e^-, ν_e), (μ^-, ν_μ), (τ^-, ν_τ), (d, u), (s, c) and (b, t), which have the same intrinsic parity, causing each interaction to violate parity as a consequence of the negative intrinsic parity of both the W^+ and W^- bosons. At low energies, this parity violation is almost 100%, since the W boson's large mass ensures that the W boson exists essentially in an S state, in agreement with experiment. In the GM, the assumption of a unified classification scheme permitted the development of a composite model of the elementary particles of the SM. Furthermore, the GM postulates that the mass eigenstate quarks of the same generation form weak isospin doublets and couple with the full strength of the CC weak nuclear interaction like the lepton weak isospin doublets. The GM also postulates that hadrons are composed of weak eigenstate quarks such as d' and s', rather than the corresponding mass eigenstate quarks, d and s, as in the SM. This corresponds to placing the quark mixing in the quark wave functions, rather than in the CC weak nuclear interactions as proposed by Cabibbo, thereby conserving the generation quantum number in the CC weak nuclear force processes.

4. Conclusions and Discussion

The development of the GM as a successful alternative to the SM, which was considered to be *incomplete*, depended upon overcoming several dubious assumptions made during the long-term development of the SM. This led to significant differences between the GM and the SM, which in turn led to an understanding of parity violation in CC weak nuclear interactions.

The main dubious assumptions of the SM that are important for understanding the *cause* of parity violation in CC weak nuclear interactions are the following: 1) the assumption that the six leptons and the six quarks are *elementary* particles, while there exists considerable indirect evidence that they are *composite* particles; 2) the assumption of a *nonunified* and complicated classification scheme of the elementary leptons and quarks in terms of additive quantum numbers, some of which are *not* conserved in CC weak nuclear interaction processes; and 3) the treatment of the *universality* of the CC weak nuclear interaction in terms of Cabibbo quark mixing, which assumes that the weak interaction is *shared* between strangeness-conserving and strangeness-changing transition amplitudes.

The GM replaces each of the above dubious assumptions by different ones: 1) the leptons and quarks are *composite* particles, composed of two kinds of *massless* spin-$\frac{1}{2}$ particles, (i) a *T*-rishon with electric charge $Q=+\frac{1}{3}$ and (ii) a *V*-rishon with $Q=0$, and their antiparticles: (iii) a $\bar{T}$-antirishon with $Q=-\frac{1}{3}$ and (iv) a $\bar{V}$-antirishon with $Q=0$; 2) the classification scheme of the leptons and quarks involved only *three* additive quantum numbers: charge *Q*, particle number *p* and generation quantum number *g*, which are conserved in *all* interactions, provided that each force mediating particle has $p=g=0$; 3) the mass eigenstate quarks of the same generation form weak isospin doublets, e.g. (*d*, *u*), and couple with the full strength of the CC weak nuclear interaction like the lepton doublets, e.g. (ν_e, e^-).

The development of a *unified* and simpler classification scheme of additive quantum numbers in the GM enabled a successful composite model of the elementary leptons and quarks of the SM, to be developed. In particular, the GM led to an understanding of the three generations of leptons and quarks that have the same properties except for mass in the SM.

In the GM, the mass eigenstate quarks of the same generation, e.g. (*d*, *u*), form weak isospin doublets and couple with the full strength of the CC weak nuclear interaction, so that there is no coupling between mass eigenstate quarks from different generations. This corresponds to the conservation of the generation quantum number *g* in CC weak nuclear interaction processes. Essentially, in the GM, quark mixing is placed in the wave functions rather than in the interactions as in the Cabibbo quark mixing technique [16], assumed in the SM, as a consequence of the assumption of the "partially conserved" strangeness quantum number *S*.

The building blocks of the GM are assumed to be *massless* spin-$\frac{1}{2}$ rishons and antirishons, which have intrinsic parity $P=+1$ and $P=-1$, respectively. This implies that all the composite leptons and quarks also have intrinsic parity $P=\pm 1$, depending upon the number of rishons and the number of antirishons comprising each composite particle, provided each rishon and antirishon exists in an s state. Thus, e.g. the electron and the electron antineutrino both have $P=-1$ and are left-handed in agreement with experiment (see **Table 2**). Similarly, the down quark and the up quark both have parity $P=-1$.

Furthermore, since both the up and down quarks have intrinsic parity $P=-1$, both the neutron and the proton have intrinsic parity $P=-1$, since both these nucleons are composed of three up/down quarks, assumed to be in an s state. In Section 3, both the W^+ and W^- bosons, which mediate the CC weak nuclear interactions are also determined to have intrinsic parity $P=-1$. Consequently, at low energies, for which the *W* boson's large mass ensures that the *W* boson exists essentially in an S state, the parity violation in CC weak nuclear interaction processes is almost 100%, in agreement with experiment. In the GM, the same parity violation occurs for similar CC weak nuclear interactions involving higher generation leptons or quarks. This essentially provides the *cause* of parity violations in CC weak nuclear interactions.

Conflicts of Interest

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

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