arXiv:physics/0008025v5 [physics.gen-ph] 22 Apr 2007

The "W" Particle and the Weak Force Mechanism
(for a more orthodox notation in the reactions, see the PDF version of this paper)
(revised April, 2007)

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http://www.people.cornell.edu/pages/jag8/index.html

(Readers unfamiliar with the particles in the reactions below should consult "The Particle Table". This paper is more technically oriented than most on my website, and may be of little interest to the general reader, in which case see the "guide" paper linked below. See also: "The Weak Force "Identity" Charge".)

(I recommend the reader consult the "preface" or "guide" to this paper, which may be found at "About the Papers: An Introduction"- Section IV).

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Introduction

The "W" Intermediate Vector Boson (IVB) is the "black box", as well as the "workhorse", of the weak force. The W mediates transformations of "identity" charge (also known as "number" or "flavor" charge) among the quarks and leptons, including their creation and destruction as "singlets", that is, when they are not paired with antimatter partners. The transformation, creation, and destruction of elementary particle "singlets" is the exclusive province of, and the rationale for, the weak force.

The W is very massive - about 90 times heavier than a proton. Because the large mass-energy of the W must be borrowed within the Heisenberg time limit for virtual particles, decays mediated by the W are both very short range and very slow - particles have to wait a long time for such a large amount of energy to become available as a quantum fluctuation within the temporal bounds of the Heisenberg "virtual interval". However, the decays of the weak force are slow only in relation to other nuclear processes. Typically, the lifetimes of particles undergoing weak reactions is around 10(-10) seconds (one 10 billionth of a second, or a tenth of a nanosecond), but this may nevertheless be ten billion times (or more) longer than typical strong force nuclear reactions. Because the W mediates so many different kinds of reactions, involving the decays of baryons, mesons, and leptons, with the production of so many different products, including photons, neutrinos, leptons, quarks, mesons, and baryons, one has to wonder what sort of transformation mechanism is operating inside the "black box" that is the "W" IVB.

In this paper I propose a very simple mechanism to explain the manifold transformations and

products of the "W" IVB. I begin by making an assumption about the nature of the W itself, a speculation concerning the origin of its great mass. This mass cannot be derived from quarks, the source of mass in ordinary particles. I suggest that the W and the other weak force "Intermediate Vector Bosons" (IVBs) (the "Z" and the hypothetical "X") are "metric" particles, composed simply of a very dense spacetime metric, similar to the spacetime of the very early, energy-dense Universe in the first moments of the Big Bang. The huge mass of the IVBs is due to the binding energy needed to compress, perhaps convolute, and maintain the metric of spacetime in these particular dense and heavy forms.

An IVB "metric particle", mediator, or catalyst functions by engulfing a particle ripe for transformation (referred to below as the "parent" particle), and combining it with one or more suitable particle-antiparticle pairs, these latter drawn from the infinitely varied resources of Heisenberg's virtual particle "sea", the quantum fluctuations of the vacuum. (The vacuum will be polarized by the presence of the "parent" particle, facilitating the production of suitable particle-antiparticle pairs.) The W works its transformations simply by virtue of its dense (and perhaps convoluted) metric. The dense metric brings particles so close together they can react with each other quickly and in ways which are impossible when they are separated by ordinary distances. In particular, particles can exchange charge, spin, momentum, and energy without violating the conservation laws, due to their intimate proximity (perhaps essentially "touching") within the embrace of the IVB's dense metric. The massive IVBs provide a "conservation containment" or "safe house" in which charge and energy can be transferred at very close range between "real" and virtual particles. The W acts simply as a "metric catalyst" while the virtual quantum "sea" provides the diversity of reactants.

The basic role of the IVBs is therefore to form a bridge between real particles and the virtual particle "sea" of the vacuum; the IVBs thus make available all the electric, number, color, and flavor charges (and spin) of the virtual particle "sea", so that "real" (temporal) particles can use them to accomplish transformations and decays, and to materialize and dematerialize as necessary. It is the ability of the IVBs to contact and materialize the virtual particle "sea" that is their distinguishing characteristic and that requires their unique structure. Because the real and virtual particles of today were once all part of the same primordial high energy "sea", it appears that the IVBs are simply reconnecting the manifest and unmanifest parts of the original "sea" by reconstituting the dense metric in which both were born.

The "safe house" or "conservation containment" interpretation of the "W" IVB function is a purely mechanistic perspective. It is complemented by what is perhaps a more theoretically satisfying interpretation in terms of force unification energy levels and symmetry states. In this regard, the IVB mass may be seen as a reconstruction of the original force unification symmetry state (the electroweak unification energy level), at which the transformations in question originally took place (in the "Big Bang") - simply as the normal course of events, typical of a specific force unification regime (see the table at the end of this paper).

Weak Force Creation of "Singlets"

Just as charge invariance is a critical issue for charge and symmetry conservation, so also must be the mechanism of elementary charge carrier transformation (transformations of quarks and leptons). The role of the weak force and the massive IVBs is to ensure that charge invariance, charge conservation, and energy conservation are all scrupulously observed in any transformation of elementary particle charge, mass, spin, and identity. Conservation demands that elementary particles created today or tomorrow be exactly the same in all respects as those created yesterday or in the "Big Bang". This is the conservation challenge posed to the weak force in the creation of "singlets", and is the reason for the great mass and unusual features of the IVBs.

The most significant feature of the massive IVBs is that they recreate the original conditions of the energy-dense primordial metric in which particles were first created and transformed during the early micro-moments of the "Big Bang". This recapitulation of a specific symmetry state or force unification regime ensures that the original and invariant values of charge, mass, spin, and energy are handed on to the next generation of elementary particles in the charge-transfer chain. The IVB mass not only provides a "conservation containment" where charge and energy transfers can take place safely, it simultaneously ensures that the appropriate alternative charge carriers (leptons, mesons, neutrinos) are present to accomplish the required transformations. The role of the Higgs boson in this process is to gauge or scale the IVBs to the proper energy level or mass so that they become part of a specific force unification regime where the transformations they perform are 1) a natural characteristic of the symmetry state; 2) consistent in their output. The IVBs are necessary to actually perform the transformations; the Higgs is necessary to ensure invariance in the performance.

There is a crucial difference between the electromagnetic (or strong force) creation of particles via particle-antiparticle formation, and the weak force creation of "singlets", or the transformation of existing particles to other elementary forms. In the case of electromagnetic pair creation, there can be no question of the suitability of either partner for a subsequent annihilation reaction, conserving symmetry (since they are referenced against each other, and gauged or scaled by universal physical constants such as c, e, and h). However, in the weak force creation of "singlets", or the transformation of an existing elementary particle to another form, alternative charge carriers must be used to balance charges, since using actual antiparticles for this purpose would only produce annihilation reactions. But how is the weak force to guarantee that the alternative charge carrier - which may be a meson, a neutrino, or a massive lepton - will have the correct charge in kind and magnitude to balance and conserve symmetry in some future reaction with an unknown partner which is not its antiparticle? Furthermore, quark charges are both partial and hidden (because they are confined), and number charges of the massive leptons and baryons are also hidden (because they are *implicit*). Neither color nor number charge has a long-range projection (such as the magnetic field of electric charge) to indicate to a potential reaction partner its relative energy state. Finally, unlike electric or color charge, neutrinos are linked with particles of a specific mass (the leptonic elementary spectrum), possibly also raising an energy conservation problem. Energy conservation combined with charge and symmetry conservation, hidden charges, and alternative charge carriers, all pose a unique challenge to the weak force transformation and/or creation of elementary, "singlet" particles. And this is to say nothing about such problems as relative motion, entropy, the passage of time, or the expansion of the Universe - all factors which could possibly affect the invariance of the physical parameters of elementary particles produced or transformed by the weak force.

However, all such conservation problems are solved or circumvented by a return to the original "Big Bang" conditions in which these particles and transformations were first created, much as we return and refer to the Bureau of Standards when we need to recalibrate our instruments. The necessity for charge invariance in the service of symmetry conservation therefore offers a plausible explanation for the otherwise enigmatic large mass of the weak force IVBs. The IVB mass serves to recreate the original environmental conditions - metric and energetic, particle and charge - in which the reactions they now mediate took place, ensuring charge invariance and symmetry conservation regardless of the type of alternative charge carrier or transformation involved. There is little *practical* difference between the theoretical "original metric" and the mechanical "conservation containment" explanations for the huge IVB mass; one effect cannot be distinguished from the other, and both may contribute to the transformation process. (See also: The Higgs Boson and the Weak Force IVBs.)

Weak Force Reactions

Below I list all the major examples of the slow or "weak" reactions as recorded in the "Stable Particle Table" of the 65th CRC Handbook of Chemistry and Physics. A typical way of writing a weak reaction might be as follows, illustrating the weak decay of a negative pion (ud-), producing a negative muon (u-) and an antimuon neutrino (νu) (antiparticles underlined):

ud-(W-) ---> νu + u-

I could write this reaction as:

ud-( )W- ---> νu + u-

suggesting there are virtual reactants in the empty parenthesis which actually make the reaction happen. For example:

ud-(u+ x u-)W- ---> νu + u-

Here I show the W joining a muon-antimuon particle pair (u+ x u-) drawn from the virtual vacuum "sea" with the negative pion (ud-) to produce the actual reaction and its products. In this example the electric charges of the antimuon and pion cancel each other, releasing the antimuon's neutrino. The original electric charge of the pion is conserved in the reaction's product by the muon; the pion's u and d quarks undergo a matter-antimatter annihilation, possible because their electric charge, momentum, and rest energy can be transferred to the product particles by their close proximity within the metric scaffold of the W (individual quark flavors are not strictly conserved).

All the reactions and their products listed below (essentially all the common weak force decays) can be produced by placing a suitably chosen particle-antiparticle pair (sometimes two) in the brackets between the reacting particle and the W. Since adding a particle-antiparticle pair (or two) to a reaction is like adding zero to a mathematics equation, it is no surprise that it works in every case. Still, I do not think this result is trivial. At least it gives us a plausible, specific mechanism and reaction pathway rather than the "black box" as the "W" appears to us now. In addition, notice that in the baryon decays a particular meson is always necessary to both annihilate and supply a specific quark flavor in the baryon being transformed. The antiparticle of this reacting meson always appears among the product particles, suggesting that the proposed mechanism is in fact the actual pathway. From this observation we deduce the two-stage "beta" decay of the neutron, which helps explain the enormous lifetime of this particle. While this observation always applies to baryons, it only sometimes applies to the decay pathways of the mesons themselves, as in mesons we are dealing with particle-antiparticle pairs which can eventually annihilate each other regardless of differences in their quark's flavors.

In reading the reactions below, notice that typically the first member of the particle-antiparticle pair reacts with the "parent" particle outside the brackets, while the second member of the pair usually goes straight to the product unaffected. A few reactions have three or four components and apparently two steps, but none are particularly complicated. The energy released in the transformation of the "parent" particle to a lower mass product (E = mcc) is used to manifest virtual particles, and appears in the reaction products as rest mass, momentum, and/or free energy.

In quantum mechanics, unless a process is expressly forbidden by some physical law, it is presumed to occur. Hence, unless the participation of virtual particle-antiparticle pairs in particle decays is for some reason forbidden, the reactions as written below, at least for the most part, should occur in nature. The only question would be the percentage of the total

pathway they represent, in cases (if any) where simpler routes exist.

Lepton Decays

I presume in these reactions that quarks annihilate only with antiquarks, and leptons annihilate only with antileptons. Thus, in the case of tau decay producing a negative pion, (as in reaction 2c below), the tau's and positive pion's electric charges cancel, allowing the quarks of the positive pion to self-annihilate, simultaneously releasing the tau neutrino. The considerable mass difference between the "parent" tau and the product pion supplies the energy to materialize the remaining negative pion of the virtual pair.

(u = muon, t = tau, *v* = neutrino, *y* = photon)
(antiparticles underlined; lifetimes in seconds (with exponents in brackets); mass in MeV)
(all reaction products, percentages, lifetimes, and masses are as reported in the 65th CRC Handbook, Stable Particle Table pages F214 - 220)

1) muon: u-, u+; mass 105.7, lifetime 2.2x10(-6) = 0.0000022 sec.

In a) and b), muons and positrons (e+) annihilate, canceling electric charge, and releasing both their neutrinos. The mass energy of the muon materializes the electron as the remaining member of the virtual positron x electron pairs, conserving electric charge. The charge of the W is always the same as the "orphaned" or product member of the particle-antiparticle pair.

Principle decay products:
a) muon neutrino, positron neutrino, electron (98.6%):

u-[e+ x e-]W- ---> *v*u + *v*e + e-

b) muon neutrino, positron neutrino, electron, photon (1.4%):

u-[e+ x e-]W- ---> *v*u + *v*e + e- + *y*

2) tau: t-, t+; mass 1784.2, lifetime 4.6x10(-13)

In a) and b), tau annihilates with antimuon or positron, releasing neutrinos. The mass energy of the tau materializes the muon or electron from the virtual particle x antiparticle pairs, conserving electric charge.

Principle decay products:
a) tau neutrino, muon antineutrino, muon (18.5%):

t-[u+ x u-]W- ---> *v*t + *v*u + u-

b) tau neutrino, positron neutrino, electron (16.2%):

t-[e+ x e-]W- ---> *v*t + *v*e + e-

In c) and d), tau and positive pion cancel electric charges, releasing the tau neutrino and allowing the positive pion(s) to self-annihilate. The mass energy of the tau materializes the remaining negative pion(s) from the virtual particle x antiparticle pairs, conserving electric charge.

c) hadron-, neutrino, (37%) similar to:

t-[u$\underline{d}$+ x $\underline{u}$d-]W- ---> νt + $\underline{u}$d-

d) 3 hadrons+-, neutrino, (28.4%) similar to:

t-[(u$\underline{d}$+ x $\underline{u}$d-)(u$\underline{d}$+ x $\underline{u}$d-)]W- ---> νt + $\underline{u}$d- + (u$\underline{d}$+ x $\underline{u}$d-)

Meson Decays

(Quark flavors and electric charges: u, c, t = +2/3; d, s, b = -1/3; charges reversed in antiparticles)

3) pion: u$\underline{d}$+, $\underline{u}$d-; mass 139.6, lifetime 2.6x10(-8)

In a) and b), pion/muon cancel electric charge, releasing the muon's neutrino and allowing the pion to self-annihilate. The energy of annihilation materializes the remaining muon from the virtual particle x antiparticle pair as a product, conserving electric charge.

Principle decay products:
a) muon neutrino, antimuon (100%):

u$\underline{d}$+[u- x $\underline{u}$+]$\underline{W}$+ ---> νu + $\underline{u}$+

b) muon antineutrino, muon (100%):

$\underline{u}$d-[$\underline{u}$+ x u-]W- ---> $\underline{\nu u}$ + u-

4) Kaon: u$\underline{s}$+, $\underline{u}$s-; mass 493.7, lifetime 1.2x10(-8)

In a), b), and c), kaons and leptons cancel electric charges, releasing lepton neutrinos and allowing kaons to self-annihilate. The energy of annihilation materializes all remaining leptons and pions from the virtual particle x antiparticle pairs, conserving electric charge.

Principle decay products:
a) antimuon neutrino, muon (63.5%)

$\underline{u}$s-[$\underline{u}$+ x u-]W- ---> $\underline{\nu u}$ + u-

b) antimuon neutrino, muon, neutral pion (3.2%):

$\underline{u}$s-[($\underline{u}$+ x u-) x u$\underline{u}$]W- ---> $\underline{\nu u}$ + u- + u$\underline{u}$

c) positron neutrino, electron, neutral pion (4.8%):

$\underline{u}$s-[($\underline{e}$+ x e-) x u$\underline{u}$]W- ---> $\underline{\nu e}$ + e- + u$\underline{u}$

In d), e), and f), kaons and pions annihilate each other. The energy of annihilation materializes all remaining virtual pions and particle x antiparticle pairs, conserving electric charge.

d) neutral pion, positive pion (21.2%):

u$\underline{s}$+[($\underline{u}$d- x u$\underline{d}$+) x u$\underline{u}$]$\underline{W}$+ ---> u$\underline{u}$ + u$\underline{d}$+

e) 2 positive pions, 1 negative pion (5.6%):

$$u\underline{s}+[\ (\underline{u}d- \times u\underline{d}+)\ \times\ (\underline{u}d- \times u\underline{d}+)\ ]\underline{W}+ \text{---> } u\underline{d}+ + (\underline{u}d- \times u\underline{d}+)$$

f) 1 positive pion, 2 neutral pions (1.7%):

$$u\underline{s}+[\ (\underline{u}d- \times u\underline{d}+)\ \times\ (u\underline{u} \times u\underline{u})\ ]\underline{W}+ \text{---> } u\underline{d}+ + (u\underline{u} \times u\underline{u})$$

5) neutral kaons: d$\underline{s}$, s$\underline{d}$; mass 497.7, lifetime "Short": 0.9x10(-10)

"Short" (referring to lifetime) neutral kaons annihilate with neutral pions, materializing charged or neutral pions from the virtual particle x antiparticle pairs, needed for absorbing and distributing momentum.

Principle decay modes d$\underline{s}$ or $\underline{d}$s ("Short"):
a) positive pion, negative pion (68.6%):

$$d\underline{s} \text{ or } \underline{d}s[\ d\underline{d} \times (\underline{u}d- \times u\underline{d}+)\ ]W \text{ ---> } (\underline{u}d- \times u\underline{d}+)$$

b) 2 neutral pions (31.4%):

$$d\underline{s} \text{ or } \underline{d}s[\ d\underline{d} \times (d\underline{d} \times d\underline{d})\ ]W \text{ ---> } (d\underline{d} \times d\underline{d})$$

6) Lifetime "Long": 5x10(-8); ("Long" is a superposition of d$\underline{s}$ and $\underline{d}$s)

In a) and b),"long" (referring to lifetime) neutral kaons self-annihilate, materializing charged and neutral pions from the virtual particle x antiparticle pairs, necessary for absorbing and distributing momentum. The "long" reaction pathway is more complex than the "short" reaction pathway; apparently the superposition d$\underline{s}$/$\underline{d}$s self-annihilates (why wouldn't it?) rather than reacting with the virtual pions; this evidently takes longer and requires more particles in the product to conserve momentum. Hence although the virtual particle x antiparticle complex is identical in both the "short" and "long" decay sequences, the products are different because the "short" annihilates one member of its virtual complex, whereas the "long" does not. In the decays of neutral particles, the problem is not so much charge conservation as momentum conservation.

Principle decay modes d$\underline{s}$/$\underline{d}$s ("Long"):
a) 3 neutral pions (21.5%):

$$d\underline{s}/\underline{d}s[\ d\underline{d} \times (d\underline{d} \times d\underline{d})\ ]W \text{ ---> } d\underline{d} + (d\underline{d} + d\underline{d})$$

b) 2 charged, 1 neutral pion (12.4%):

$$d\underline{s}/\underline{d}s[\ d\underline{d} \times (u\underline{d}+ \times \underline{u}d-)\ ]W \text{ ---> } d\underline{d} + (u\underline{d}+ \times \underline{u}d-)$$

In c) and d), "long" neutral kaons self-annihilate, materializing leptons and charged pions from the virtual particle x antiparticle pairs. The W complex includes both pion and lepton virtual particle-antiparticle pairs; the positive leptons react with a negative pion as seen previously in meson decay 3b. All products help absorb and distribute momentum.

c) charged pion, antimuon neutrino, muon (27.1%):

$$d\underline{s}/\underline{d}s[\ (u\underline{d}+ \times \underline{u}d-)(\underline{u}+ \times u-)\ ]W- \text{ ---> } u\underline{d}+ + \underline{\nu u} + u-$$

d) charged pion, positron neutrino, electron (38.7%):

ds/ds[(ud+ x ud-)(e+ x e-)]W- ---> ud+ + ve + e-

Baryon Decays

Mesons "come into their own" in baryon decays, where we discover their great utility as suppliers of quark flavors and colors to facilitate baryon transformations. Mesons function as alternative carriers of color charge and quark flavor, just as leptons (electrons and neutrinos) function as alternative carriers of electric charge and lepton number ("identity") charge, functions which allow baryons to transform, conserve, neutralize, and cancel their charges without suffering annihilation by antibaryons.

7) neutron: udd (neutral); mass 939.6, lifetime 9.25x10(2)

Neutron decay is very slow (half-life about 15 minutes), both because there is such a small bound energy difference between reactants and products, and because the reaction pathway is complex. The d quark of the virtual positive pion annihilates with the d quark in the neutron, replacing it with an up quark, creating the proton. Meanwhile, in a secondary reaction, the remaining negative pion and a positron from a second (leptonic) virtual pair undergo a typical charged pion decay, canceling each other's electric charge and releasing the positron's neutrino. The d and u quarks of the negative pion simply annihilate each other. The mass difference between the neutron and proton produces just enough energy to materialize the electron and positron neutrino, balancing the proton's electric charge, and the reaction's overall lepton "number" ("identity") charge.

Principle decay products ("beta" decay):
a) proton plus positron neutrino plus electron (100%):

udd[(du+ x du-)(e+ x e-)]W- ---> udu+ + ve + e-

8) lambda: dus (neutral); mass 1115.6, lifetime 2.6x10(-10)

A d quark of the virtual positive meson annihilates with the s quark of the lambda, and replaces it with an up quark in reaction a), creating a proton, and a d quark in reaction b), creating a neutron. The annihilation energy materializes the remaining virtual pion in both cases, conserving charge and/or momentum. This reaction is faster than reaction 1) because there is far more available energy from the decay of the heavy s quark, and the reaction pathway is simpler.

Principle decay products:
a) proton plus negative pion (64.2%):

dus[du+ x du-]W- ---> duu+ + du-

b) neutron plus neutral pion (35.8%):

dus[dd x dd]W ---> dud x dd

9) Sigma: uus+; mass 1189.4, lifetime 0.8x10(-10)

In a), a d quark in the virtual pion annihilates with the s quark of the sigma, replacing it with a d quark to create a proton and simultaneously materializing the remaining neutral pion. In b), both the negative and neutral pion react with sigma s and u quarks, replacing them with d quarks (first the intermediate lambda uds is formed, which then reacts with the neutral pion dd to produce the neutron udd). The remaining positive pion is materialized to balance electric

charge. In both a) and b) the mass energy difference between the s and d quarks fuels the reaction.

Principle decay products:
a) proton + neutral pion (51.6%):

uus+[$\underline{d}$d x $\underline{d}$d]$\underline{W}$+ ---> uud+ + $\underline{d}$d

b) neutron + positive pion (48.4%):

uus+[$\underline{d}$d x ($\underline{u}$d- x u$\underline{d}$+)]$\underline{W}$+ ---> udd + u$\underline{d}$+

10) Sigma: dds-; mass 1197, lifetime 1.5x10(-10)

The $\underline{d}$ quark of the positive pion annihilates the s quark in the sigma and replaces it with an up quark, forming a neutron and materializing the remaining negative pion, conserving electric charge.

Principle decay products:
a) neutron + negative pion (100%):

dds-[u$\underline{d}$+ x $\underline{u}$d-]W- ---> ddu + $\underline{u}$d-

11) Xi: uss (neutral); mass 1315, lifetime 2.9x10(-10)

A $\underline{d}$ quark from a neutral pion annihilates with the s quark in the xi, replacing it with a d quark; the annihilation energy materializes the remaining neutral pion of the virtual pair.

Principle decay products:
a) lambda plus neutral pion (100%):

uss[$\underline{d}$d x $\underline{d}$d]W ---> usd + $\underline{d}$d

12) Xi: dss-; mass 1321.3, lifetime 1.6x10(-10)

A $\underline{d}$ quark from a positive pion annihilates with the s quark in the xi, replacing it with an up quark; the annihilation energy materializes the remaining negative pion of the virtual pair, conserving electric charge.

Principle decay products:
a) lambda plus negative pion (100%):

dss-[u$\underline{d}$+ x $\underline{u}$d-]W- ---> dsu + $\underline{u}$d-

13) Omega: sss-; mass 1672.5, lifetime 0.8x10(-10)

In a), $\underline{s}$ and $\underline{d}$ quarks in the positive and neutral pions of the virtual complex annihilate with two s quarks in the omega, replacing them with u and d quarks; annihilation energy materializes the remaining negative pion, conserving electric charge. (This reaction pathway is similar to 9b, which also changes two quarks.) The intermediate product is the xi sus, which reacts with the neutral pion $\underline{d}$d to form the lambda sud.

In b), a $\underline{d}$ quark in the positive pion of the virtual pair annihilates with the s quark in the

omega, replacing it with an up quark; annihilation energy materializes the remaining negative pion, conserving electric charge.

In c), a $\underline{d}$ quark in one of the neutral virtual pions annihilates with the s quark in the omega, replacing it with a d quark and materializing the remaining neutral pion.

Note how naturally the virtual particle-antiparticle pair mechanism advocated here produces all the exotic products in the three decays of the omega listed below. Recall these are the experimentally observed products as listed in the CRC Handbook. This is strong evidence that the proposed mechanism is the actual pathway used by the W.

Reaction a) is favored overall in spite of its more complex pathway because two of the heavy s quarks can decay simultaneously (or sequentially), releasing more free energy to drive the reaction. Reaction b) is favored over c) because, as is evident from several other comparable decays (see 4 e, f; 5a, b; and 8 a, b) it is more difficult to assemble neutral particle pairs than charged particle pairs - all other things being equal.

Principle decay products:
a) lambda plus negative kaon (68.6%):

$$sss\text{-}[\ \underline{d}d \times (\underline{s}u^{+} \times s\underline{u}^{-})\ ]W^{-} \longrightarrow sud + s\underline{u}^{-}$$

b) xi (neutral) plus negative pion (23.4%):

$$sss\text{-}[\ u\underline{d}^{+} \times \underline{u}d^{-}\ ]W^{-} \longrightarrow ssu + \underline{u}d^{-}$$

c) Xi- plus neutral pion (8%):

$$sss\text{-}[\ \underline{d}d \times \underline{d}d\ ]W^{-} \longrightarrow ssd^{-} + \underline{d}d$$

Postscript to the Weak Force Mechanism Paper
(revised Sept., 2006)

The particle-antiparticle charge-carrying mechanism that works so well to illustrate the weak force decay pathways of leptons, mesons, and baryons (revealing as well the generic utility of mesons in hadron transformations), may also have some explanatory power for other types of transformations (especially electromagnetic transformations) - as we might expect of such a fundamental process, and in consideration of the electroweak unification.

I will consider only one example of such an electromagnetic transformation: when protons (uud)+ are bombarded with negative pions ($\underline{u}d$)-, a negative sigma (dds)- and a positive kaon ($u\underline{s}$)+ are readily produced, but the "reciprocal" product of a positive sigma (uus)+ and a negative kaon ($\underline{u}s$)- never occurs. Why this should be true may be seen in terms of the particle-antiparticle charge carrier mechanism (operating this time without the mediation of the weak force IVBs). An external source (the laboratory accelerator) supplies as much energy as is needed to achieve the reaction threshold.

Of the two products here considered (sigma- vs sigma+), there is a straightforward and simple electromagnetic reaction pathway only to the sigma-:

$$a)\ \underline{u}d^{-} + uud^{+}(\underline{u}s^{-} \times u\underline{s}^{+}) \longrightarrow dsd^{-} + u\underline{s}^{+}$$

In reaction a) the energy of collision between the negative pion and proton creates a kaon x antikaon particle pair; the negative member of this pair reacts with the proton, annihilating a

"u" quark in the proton with its anti "$\underline{u}$" quark, and replacing it with a "s" quark. The colliding negative pion similarly reacts with the proton, annihilating an "u" quark and replacing it with a "d" quark. These two (probably simultaneous) reactions produce the negative sigma and materialize the positive kaon of the particle-antiparticle pair, conserving electric charge.

Nothing is involved in this reaction beyond matter-antimatter annihilations of one quark flavor by its corresponding antiflavor, and the substitution of one quark for another from both the negative pion and the negative kaon. However, when we try to reach the sigma+ by an analogous pathway, we can do so only with difficulty. The "reciprocal" reaction we are trying to create is:

$$\underline{u}d- + uud+ \text{-----> } uus+ + \underline{u}s-$$

Reaction b), however, achieves the desired product only via a difficult two-step pathway:

$$b1)\ \underline{u}d- + uud+(\underline{d}s \times d\underline{s}) \text{-----> } dus + d\underline{s}$$

$$b2)\ dus(u\underline{s}+ \times \underline{u}s-) \text{-----> } uus+ + \underline{u}s-$$

In the second step, the "$\underline{s}$" quark of the antikaon would have to annihilate with the "d" quark of the baryon, rather than with the baryon's "s" quark, which it would much prefer (creating a proton). Clearly, this improbable two-step reaction cannot compete with the single step, straightforward reaction in a). Hence the particle-antiparticle charge-carrying mechanism does seem to have some explanatory power (beyond the weak force mechanism) regarding the pathways of transformation among elementary particles, both with regard to what does happen and what does not.

The Higgs Boson and The Rest of the Weak Force
(the weak force beyond the energy level of the "W" IVB family)
(April, 2007)

See:

Introduction to the Higgs Boson Papers
The Higgs Boson and the Weak Force IVBs: Part I
The Higgs Boson and the Weak Force IVBs: Parts II, III, IV
The Higgs Boson and the Weak Force IVBs: Table
The Higgs Boson and the Spacetime Metric

The table below presents a schematic or organizational chart for the (hypothetical) whole structure of the weak force and its relation to the "W" family of IVBs, as well as to the Higgs boson.

We strongly suspect that the "W" family of IVBs is only part of the overall weak force structure. Only the weak force can create "singlets" of matter, and while the "W" IVB family can create, destroy, and transform leptons, neutrinos, and mesons (the alternative charge carriers), it can only transform baryons, it cannot create or destroy them. Therefore, some more energetic weak force particle capable of creating matter and baryon "singlets" must exist, apparently at the force unification energy level next above the electroweak unification regime of the "W" IVBs. This next unification level is the GUT (Grand Unified Theory) energy level, in which the strong and electroweak forces are unified. We designate this energy and force symmetry level the "Leptoquark Era" or H2 energy regime, with its own Higgs boson (H2), and its own family of extra-massive IVBs, the "X" IVBs.

The "X" IVBs are massive enough to compress the quarks of baryons so strongly that their color charges sum to zero and self-annihilate (the limit of "asymptotic freedom" - Politzer,

Gross, Wilczek, 1973), reducing the baryons to the "colorless" condition of a heavy lepton - the so-called leptoquark. The asymmetric decay of electrically neutral leptoquark-antileptoquark pairs during the "Big Bang" is responsible for the creation of all the matter of our Universe. Leptoquark decay may also be the pathway of "proton decay". Leptoquark decay (and perhaps proton decay) is accomplished with the emission of leptoquark antineutrinos.

It is probable that a third family of "Y" IVBs and Higgs particles (H3) exists at the still higher "Planck" energy level at which gravity is united with the strong and electroweak forces. These "Y" IVBs (assisted by "quantum gravity") may be responsible for splitting primordial leptonic particles, forming the quarks, and producing particle mass. For a detailed discussion of these ideas, see the articles listed and linked at the beginning of this section.

This table is added to the original weak force paper to bring to the reader's attention the probable full scope, structure, and import of the weak force, and provide a context for the "W" IVB family and its functions - which are limited to the creation and destruction of alternative charge carriers (leptons, neutrinos, mesons), and the transformation of heavy leptons and baryons. We must look to the higher energy levels of the weak force for the creation and destruction of baryons (including the creation of matter), and the creation of quarks and particle mass.

Force Unification Regimes or Symmetry Eras of the "Big Bang"

"Multiverse": Non-dimensional "vacuum" source of undefined symmetric energy and creative potential - produces our universe as a quantum fluctuation of *no net energy or charge*, conserving energy, and with "life-friendly" physical constants ("Anthropic Principle"). Balanced positive-negative (gravitational) energy and matter-antimatter charge symmetry. "Big Bang": Cosmos devolves from "Multiverse".					
Unification Era (Symmetry Hierarchy)	**Higgs Boson (Scalar)**	**Intermediate Vector Bosons (Decay Path)**	**Type Field Vector (for Unity Era) Temp., Time**	**Charge (Symmetry Debt)**	**Era Role or Major Production**
Planck Era; TOE Theory of Everything (Gravity, Spacetime, Particles Unified)	Higgs 3 All Forces Unified	"Y" IVBs Creates Quarks, Partial Charges, Color Charges, Gluon Field, Particle Mass; (splits primordial leptonic particles)	Graviton (Gravitational Force) 10(32) k; 10(-43) sec.	"Location" (Time) (gravitational charge); Negative Energy; Total Energy = 0	Provides Negative Energy and Primordial Leptons; Creates Quarks, Particle Mass; ?Dark Matter? ?Inflation?
Leptoquark Era; GUT Grand Unified Theory (Quarks Unified with Leptons)	Higgs 2 Strong, E/W Forces Unified	"X" IVBs Symmetry-Breaking; Creates and Destroys Leptoquarks, Leptoquark Neutrinos, Matter,	Gluon (Strong Force) 10(28) k; 10(-35) sec.	Color; Total Color = 0	Asymmetric Weak Force Decay of Leptoquarks Creates Matter, Hyperons, Baryons,

		Hyperons, and Baryons; "Proton Decay"			Leptoquark Neutrinos
Hyperon Era; E/W Electroweak Unification (Quark Families Unified, Lepton Families Unified)	Higgs 1 E/W, E/M Forces Unified	"W" IVBs Creates and Destroys Alternative Charge Carriers; Transforms Hyperons and Heavy Leptons	IVB (Weak Force) 10(15) k; 10(-12) sec.	"Identity" ("Number" Charge); Total "Number" = 0	Creates Leptons, Neutrinos, Mesons; Transforms Hyperons and Heavy Leptons
Atomic Era; E/M Electromagnetic Unification (Electric and Magnetic Fields Unified)	"Ground State" Spacetime Metric (Scaled by c, G)	Photon Creates Space; Gravity Creates Historic Spacetime; Protons, Electrons, Photons Create Atoms	Photon (Electromagnetic Force) Temperature 2.7 K; Time 13.7 Billion Yr.	Electric; Total Electric Charge = 0	Creates Space and Historic Spacetime; Creates Atoms
Information and Biological Eras evolve as ground state "rebounds" from entropy-driven cascade. Rebound is driven by symmetry conservation, negentropic gravity, and evolutionary forces, creating planets, stars, galaxies, heavy elements, molecules, chemistry, life.					
J. A. Gowan and A. T. Jaccaci, April 2007 http://www.people.cornell.edu/pages/jag8/index.html					

Unification Eras (or Symmetry States) of the "Big Bang":

Multiverse Era: Timeless, non-dimensional, "vacuum" potential of undefined creative energy, producing infinitely many energy-conserving Universes (with various and unique natural constants) via quantum fluctuations of *no net energy or charge*, one of which (constrained by energy conservation and the "Anthropic Principle") becomes our own. Scalar Higgs particles, transformative IVB families, and field vectors of the four forces are listed for an entropy driven decay "cascade" of 4 sequential levels of force unification. Major roles and productions of the eras are also suggested. Each unification era corresponds to a specific temperature (absolute degrees Kelvin) and time period (after time zero) of the "Big Bang" decay sequence ("Standard Model" data. See: Brian Greene, *"The Fabric of the Cosmos"*, P. 270, Knopf, 2004). (*Creation of Universe*, "Big Bang".)

3) Planck Era. Y+, Y-, Y neutral, H3, (graviton) - TOE unity (Theory of Everything): unified positive and negative energy ("Yin-Yang"). All forces unified. 10(32)k; 10(-43) sec. Unified gravity, spacetime, and bound energy forms (primordial leptons and possibly "dark matter"). "Quantum gravity". Negative gravitational energy exactly balances positive energy of particles. Matter-antimatter symmetry. "Y" IVBs split primordial leptonic forms to create quarks, quark partial charges, the gluon field, and particle mass (with help of gravity). Decays to level 2 leptoquark era (via "Y" IVB family) with separation of spacetime (including gravity) from primordial particles and quarks. This

separation may correspond to the "inflationary" era of Guth and Linde. (*Creation of quarks, quark partial charges, gluon field, and particle mass*.)

2) Leptoquark Era. X+, X-, X neutral, H2, (gluon) - GUT unity (Grand Unified Theory): unified quarks and leptons with separate spacetime and gravity. Strong and electroweak forces unified. 10(28)k; 10(-35) sec. Entropy driven expansion and cooling of spacetime. Quark partial charges allow electrically neutral leptoquarks. "X" IVBs compress quarks into leptoquarks, vanishing color charges, and allowing weak force decay via leptoquark neutrinos. Asymmetric weak force decay of electrically neutral leptoquark-antileptoquark pairs (with emission of leptoquark neutrinos and antineutrinos) to level 1 Hyperon Era (via "X" IVB family) produces matter asymmetry of Cosmos. (*Creation of matter, hyperons, baryons, leptoquark neutrinos.)*

1) Hyperon Era. W+, W-, W neutral, H1, (IVBs) - E/W unity (Electroweak Unification): hyperons, heavy leptons, and particle "zoo" era. Electroweak and electromagnetic forces unified. 10(15k); 10(-12) sec. Matter dominated asymmetry. Leptons and quarks separate into unified lepton families and unified quark families. "W" IVBs transform quarks into other quarks and leptons into other leptons (but not leptons into quarks). Hyperons and heavy leptons decay (via "W" IVB family) to "ground state" proton, electron, and photon with emission of leptonic antineutrinos. Leptons, mesons, and neutrinos serve as alternative charge carriers for the decays of hyperons and heavy leptons, avoiding antimatter annihilation reactions. *(Creation of leptons, alternative charge carriers.)*

"Ground State") Atomic Era. Spacetime, bosons, leptons, hadrons, (photon) - E/M unity (Electromagnetic Unification). Electric and magnetic fields unified. Time 13.7 billion years, temperature 2.7 K. Separate photons, leptons, neutrinos, mesons, and baryons. Spacetime, light, and gravity remain unified, electric and magnetic fields remain unified. Photon separates from IVBs, creates and energizes space; gravity creates time from space, time creates history. Spacetime metric and photon are the ground state analogs of the Higgs and IVBs. Era of atomic matter, light, and historic spacetime. *(Creation of space, historic spacetime, and atoms.)*

Ground State "Rebound") Information and Biological Era. Driven by symmetry conservation, gravity, and evolutionary forces. Rebound begins with planets (ground state) and continues through stars (level H1), black holes (level H2), and cosmic collapse or "Big Crunch" (level H3). *Creation of planets, stars, galaxies, heavy elements, molecules, chemistry, life.* (See: "Nature's Fractal Pathway".)

We have previously (and correctly) understood the gravitational rationale from the point of view of: 1) energy, entropy, and causality conservation (the gravitational creation of time from space, providing the temporal entropy drive and causal linkages of bound energy); 2) the point of view of symmetry conservation (the gravitational conversion of bound to free energy, as in stars); 3) the source of negative energy (balancing positive energy) in the "Big Bang". (See: "Entropy, Gravitation, and Thermodynamics"). The gravitational recapitulation of force unification and symmetry states (culminating in the "Big Crunch") allows us to understand the gravitational rationale from a new, fourth perspective embracing only the four forces.

References:

CRC Handbook of Chemistry and Physics, 65th edition, 1984-5. CRC Press, Inc. Table

of Particle Properties (page F-214).
D. J. Gross and F. Wilczek. 1973. Ultraviolet Behavior of Non-Abelian Gauge Theories. Phys. Rev. Lett. 30: 1343.
H. D. Politzer. 1973. Phys. Rev. Lett. 30: 1346.
Gross, Politzer, Wilczek: Science: 15 October 2004 vol. 306 page 400: "Laurels to Three Who Tamed Equations of Quark Theory."

Links:

The "W" Particle and the Weak Force Mechanism (PDF format)
Introduction to the Weak Force
Identity Charge and the Weak Force
The Formation of Matter and the Origin of Information
Proton Decay and the "Heat Death" of the Cosmos
The System of Matter
Table of Particles
Global-Local Gauge Symmetries of the Weak Force
Symmetry Principles of the Unified Field Theory
Entropy, Gravitation, and Thermodynamics
Nature's Fractal Pathway
home page

Higgs Table

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