The "W" Intermediate Vector Boson and the Weak Force Mechanism

(revised Dec., 2012)

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This paper has been translated into French (click here)

Many thanks to Anna Chekovsky! http://www.teilestore.de/edu/?p=1839

home page

(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 lesser 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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Abstract

Elementary particles created today must be the same in every respect as those created eons ago during the "Big Bang". The conservation requirement of elementary particle invariance constrains the mechanism of weak force particle creation and transformation. Weak force transformations recreate primordial symmetric energy states of the "Big Bang" force-unification eras (in the case of the "W", the electroweak force unification era) to accomplish the invariant creation and transformation of *single* elementary particles.

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, especially their creation and destruction as "singlets", that is, when they are not paired with antimatter partners. The transformation, creation, and destruction of *single* elementary particles is the exclusive province of, and the rationale for, the weak force.

The W is very massive - about 80 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 (relatively) long time for such a large amount of energy to become available as a quantum fluctuation within the temporal bounds of the Heisenberg "virtual reality 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 of the "Standard Model".

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 nuclear 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 micro-moments of the Big Bang - similar, in fact, to the energy density of the primordial environment in which these transformations first occurred - the "electroweak" force unification era. 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. In fact, the "W" IVB mass recreates the energy density of the primordial, symmetric, electroweak force-unification energy state. This is the essential secret of the W's ability to cause elementary particle transformations, for within this symmetric energy state of the unified electroweak force, lepton-lepton and quark-quark transformations are simply the normal course of events - as "species" level lepton or quark identities are incorporated into "genus" level collective identities (all leptons become equivalent, all quarks become equivalent).

The actual transformation mechanism is envisioned as follows: 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 the Dirac/Heisenberg 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 charges, spin, momentum, and energy without violating (or even threatening) 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 conservation requires. 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 mass and structure. Because the real and virtual particles of today were once all part of the same primordial high energy particle "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" force-unification energy level), at which the transformations in question originally took place (during 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).

Even the surprisingly large mass of the top quark (about 170 GEV) is not a problem for the transformation mechanism proposed here. The "W" IVB does not create the "parent" particle in any reaction. The parent particle is always provided by the environment; only the mass of the reactive particle-antiparticle pair must be provided by the IVB. In the decay of the top quark, the mediating virtual pair is (at most) a bottom-antibottom meson; since the bottom quark mass is only about 4 GEV, this meson is readily produced by the 80 GEV "W".

Weak Force Creation of "Singlets"

To the extent that charge and mass invariance is a critical issue for charge, symmetry, and energy conservation, so also must be the mechanism of elementary charge-carrier transformations (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, and/or spin. 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" (elementary particles of matter not paired with antimatter partners), and is the reason for the great mass and unusual features of the IVBs (and the scalar Higgs boson). (CERN announced discovery of the 126 GEV Higgs boson on 4 July, 2012. See: *Science* 13 July, 2012 page 141; see also: *Scientific American* Oct., 2012 pages 68-73.)

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 (the "electroweak" force unification era, in the case of the "W" IVB) ensures that the original and invariant values of charge, mass, spin, and energy are handed on to a new generation of elementary particles. 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) invariant in their output. The IVBs are necessary to actually perform the transformations; the Higgs is necessary to select the proper IVB "family" (there are probably three), and to ensure the invariance of their product. Transformations of "species" identity within a given "genus" are accomplished readily, since all species are equivalent. It is because the Higgs and IVBs recreate this "generic" level of particle symmetry and force unity that the weak force transformations can be so readily accomplished.

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 as to 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 and metric 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 elementary 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" to moot the parity conservation issue). 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.

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 in any time or place after their original creation in the "Big Bang". This would not be a problem if elementary particles were produced just once during the "Big Bang" and never again. However, elementary particles are still produced today (leptons, neutrinos, mesons, quarks), and they must be indistinguishable from the originals created almost 14 billion years ago.

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 re-calibrate our instruments. The necessity for charge and mass invariance, in the service of symmetry and energy 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 and mass invariance, and symmetry and energy conservation, regardless of the type of elementary particle, alternative charge carrier, or transformation involved. There is little *practical* difference between the theoretical "original metric" and the mechanical "safe house" explanations for the huge IVB mass; one effect can hardly be distinguished from the other, and both may be necessary to adequately explain the transformation process. Finally, we note that the mass of a particle is not affected by the entropic expansion of the Cosmos, and can be readily quantized - hence the massive weak force mechanism (Higgs, IVBs) is a natural choice to maintain invariant the conserved parameters of the elementary particles over the lifetime of the Universe. (See also: The Higgs Boson and the Weak Force IVBs.)

As to why the Z is heavier the the W, I suggest is because the W has only to accommodate the quarks and massive leptons (since only they bear electrical charges), but the Z has to account for the neutrinos in addition. The family of particles "under the Z's wing", as it were, is therefore larger, requiring more energy to conjure from the vacuum.

Weak Force Reactions

Below I list all the major examples of the weak force 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 ($\underline{u}$d-), producing a negative muon (u-) and an antimuon neutrino ($\underline{\nu u}$) (antiparticles underlined):

$\underline{u}$d-(W-) ---> $\underline{\nu u}$ + u-

I could write this reaction as:

$\underline{u}$d-( )W- ---> $\underline{\nu u}$ + u-

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

$\underline{u}$d-($\underline{u}$+ x u-)W- ---> $\underline{\nu u}$ + u-

Here I show the "W" IVB joining a muon-antimuon particle pair ($\underline{u}$+ x u-) drawn from the virtual vacuum "sea", with the negative pion ($\underline{u}$d-) 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 containment 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 specific meson is always necessary to both annihilate and supply a specific quark flavor in the baryon being transformed. The antiparticle of this specific 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.

Because mesons are the only alternative charge carriers which can carry the partial charges of quarks, mesons are instrumental to both weak and strong force transformations of baryons and quark flavors. In the strong force, mesons serve as the "Yukawa" field of exchange particles binding protons and neutrons ("nucleons") into compound atomic nuclei. This long-recognized (since 1934) strong force meson role lends credence to the weak force meson role hypothesized in this paper. (See: "The Strong Force: Two Expressions".)

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 (photons).

In quantum mechanics, unless a process is expressly forbidden by some physical conservation 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, alternative, or multiple decay pathways 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>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-[$\underline{e}$+ x e-]W- ---> *v*u + $\underline{ve}$ + e-

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

u-[$\underline{e}$+ x e-]W- ---> *v*u + $\underline{ve}$ + e- + *y*

2) tau: t-, $\underline{t}$+; 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-[$\underline{u}$+ x u-]W- ---> *v*t + $\underline{vu}$ + u-

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

t-[$\underline{e}$+ x e-]W- ---> *v*t + $\underline{ve}$ + 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- ---> *v*t + $\underline{u}$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- ---> *v*t + $\underline{u}$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- x u$\underline{d}$+) x ($\underline{u}$d- x u$\underline{d}$+)]$\underline{W}$+ ---> u$\underline{d}$+ + ($\underline{u}$d- x u$\underline{d}$+)

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

u$\underline{s}$+[($\underline{u}$d- x u$\underline{d}$+) x (u$\underline{u}$ x u$\underline{u}$)]$\underline{W}$+ ---> u$\underline{d}$+ + (u$\underline{u}$ x 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 ds or ds ("Short"):
a) positive pion, negative pion (68.6%):

ds or ds[dd x (ud- x ud+)]W ---> (ud- x ud+)

b) 2 neutral pions (31.4%):

ds or ds[dd x (dd x dd)]W ---> (dd x dd)

6) Lifetime "Long": 5x10(-8); ("Long" is a superposition of ds and ds)

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 ds/ds 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 ds/ds ("Long"):
a) 3 neutral pions (21.5%):

ds/ds[dd x (dd x dd)]W ---> dd + (dd + dd)

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

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

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%):

ds/ds[(ud+ x ud-)(u+ x u-)]W- ---> ud+ + *v*u + u-

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

ds/ds[(ud+ x ud-)(e+ x e-)]W- ---> ud+ + *v*e + 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 (a role they also perform in the "Yukawa" strong force of compound atomic nuclei and the creation of "nucleons"). 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+ + *νe* + 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+[dd x dd]W+ ---> uud+ + dd

b) neutron + positive pion (48.4%):

uus+[dd x (ud- x ud+)]W+ ---> udd + ud+

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

The 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-[ud+ x ud-]W- ---> ddu + ud-

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

A 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[dd x dd]W ---> usd + dd

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

A 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-[ud+ x ud-]W- ---> dsu + ud-

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

In a), s and 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 dd 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-[$\underline{d}$d x ($\underline{s}$u+ x s$\underline{u}$-)]W- ---> sud + s$\underline{u}$-

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

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

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

sss-[$\underline{d}$d x $\underline{d}$d]W- ---> ssd- + $\underline{d}$d

Postscript to the Weak Force Mechanism Paper

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. (No single elementary particles (leptons) are created or destroyed in these reactions, which would require the mediation of the weak force IVBs.)

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- x u$\underline{s}$+) -----> 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:

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

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

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

b2) dus(u$\underline{s}$+ x $\underline{u}$s-) -----> uus+ + $\underline{u}$s- (highly unlikely)

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.

Alternative Pathways for Weak Force Reactions (section below added April 2014)

The leptonic spectrum of elementary particles is clearly some sort of resonant series. In this case it appears to be a resonant series of the combined electromagnetic and weak forces. The leptonic series identifies the mass-energy at which the electromagnetic/photon and weak force/neutrino frequencies are in "sympathetic" vibration - the leptonic particle series delineates the nodes of sympathetic vibration or resonance between these two forces at the electroweak energy level. The electromagnetic force can probably produce particles of any rest-mass energy, but it is only at the nodes of the resonance series where these two forces are in sympathetic vibration that massive particles can be paired with neutrino "identity" charges. This joining of forces is necessary to produce particles that can be conserved in the sense that they can be exactly reproduced at any time and place, matching up precisely with others of their kind, including annihilation reactions with their antiparticles.

While the electromagnetic and weak forces are "in resonance" at the electroweak "force-unity" energy level, the massive leptons of the electromagnetic force (such as the electron) and its neutrino, or "identity charge" of the weak force, are joined together at a "generic identity" level, in which they freely exchange identities without restriction. It is during this period of exchange, and because of it, that the massive lepton acquires its "hidden" identity charge, or is in some way prepared to acquire and carry one. Such is also the case for the entire "leptonic spectrum" - the electron, muon, tau, and presumably the leptoquark also. Of (infinitely?) many possible rest-mass energies that can be produced by the electromagnetic force, just these four are compatible with the weak force to the degree that instead of a massive electromagnetic particle-antiparticle pair being produced (such as an electron-positron pair), in the electroweak "resonance" a mixed pair is produced instead - the electron-neutrino pair (actually a positron neutrino, balancing the electron identity charge). In the decay of a neutron to a proton, it is just this electron-positron neutrino pair which we find accompanying the proton as products of the decay - the electron and proton balancing each others' electric charges. The "resonance nodes" are just the rest mass energies of the leptonic spectrum, and they delineate the frequencies at which the massive electromagnetic leptons and the weak force neutrinos can form these mixed lepton-neutrino pairs in place of the usual particle-antiparticle pairs of the pure electromagnetic force - conferring "hidden" charges upon those few suitable members of the "leptonic spectrum". The neutrino match assures conservation is possible because the particles and their antiparticles can be perfectly reproduced and annihilated at any future time. It is this conservation possibility which allows these particles to eventually materialize.

The electroweak union is remarkable for its "leptonic spectrum", which at the highest energy level involves the leptoquark and the strong force in a "grand unified" energy level. In this, the too-massive leptoquark divides under its own self-repulsion to more stable, lower energy configurations of three quarks, held together by the gluon field of the strong force, the latter arising naturally among the quark subunits, holding them together in whole quantum units of charge (including the zero charge of a neutron-like configuration). Electrically neutral leptoquarks are subject to asymmetric weak force decays (because of their long lives), producing the matter-only atomic constituents of our cosmos. "Lepton number" or "hidden" identity charges of the massive leptons and baryons are balanced by the explicit identity charges of neutrinos, one for each type of lepton and anti-lepton (including the presumed leptoquark neutrinos). Electrical charges of the baryons are the same as those of the leptons because baryons are derived from the leptonic spectrum via the leptoquark, and the leptons are therefore able to act as alternative charge carriers for the baryon's electric charges (or for other leptons or mesons).

If all this seems too complex, it is nevertheless the bare minimum needed to break the electromagnetic symmetry of the primordial universe, ending with a completely conserved system of energy, particles, charges, and symmetry debts, fully capable of replicating itself and returning to its original state of symmetry - with or without gravity (because of the possibility of proton decay).

The positively charged meson involved in the "beta decay" of a neutron is fully absorbed by the product proton, including its charge. No neutrinos are associated with mesons, which as quark-antiquark combinations, are not elementary particles. Presumably the only direct interaction between quarks and weak force neutrinos is at the much higher energy level of the "leptoquark" neutrinos and the "X" IVBs.

I think this new proposal for the mechanism of beta decay is much better than my old one. The new mechanism features a true electroweak mechanism, an actual marriage of the electric and weak forces, while the old is purely an electromagnetic model, involving only the usual particle-antiparticle pairs. The old "beta decay" model also has two problems: 1) Where does the product neutrino come from? and 2) What happens to the negatively charged meson that cancels electric charges with the positron? Neither problem arises in the new mechanism, and no new problems are introduced. (Problem 2) persists in charged meson decay, but at least the (more intractable) origin of the neutrino is solved. We assume, as before, that the quark-antiquark composition of the meson results in self-annihilation between the (non-conserved) quark flavors, once the electric charge is transferred to/conserved by other carriers.

1) "Beta Decay" of neutron to proton: (antiparticles underlined, neutrinos in italics)
Old: udd [(du+ x du-)(e+ x e-)]W- ----> udu+ + *ve* + e-

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

2) Decay of muon to electron:
Old: u-[e+ x e-]W- ----> *v*u + *ve* + e-

New: u-[(u- x *vu*)(e- x *ve*)]W- ----> *vu* + e- + *ve*

3) Decay of charged meson to muon:
Old: ud-[u+ x u-]W- ----> *vu* + u-

New: ud-[*vu* + u-]W- ----> *vu* + u-

In all the decays above, what had been essentially electromagnetic decays mediated by typical particle-antiparticle pairs drawn from the Heisenberg-Dirac spacetime "vacuum", are replaced by electroweak lepton pairs (neutrino - massive lepton pairs) drawn directly from the high-energy, "generic" electroweak unified-force energetic symmetry state represented by the "W" IVBs. These are typically simpler, direct, less problematic pathways. The electroweak pathways furthermore illustrate the massive leptons' acquisition of "hidden" identity charges via exchanges with neutrinos.

The question now is whether or not I should throw out all the earlier reaction equations of the weak force IVB mechanism - the ones utilizing strictly electromagnetic particle-antiparticle pairs? Unfortunately, to do so would simply be replacing one speculation by another, for the actual mechanism "inside" the weak force IVBs will probably forever remain something of a "black box", due to constraints upon our detailed knowledge imposed by the rules of quantum mechanics. But both pathway representations have utility, and I propose to retain both.

The "electromagnetic" pathway illustrates the parameters of charge conservation that any reaction pathway must observe, and demonstrates that these parameters can be filled by virtual particle-antiparticle pairs readily available from the "vacuum". The "electroweak" pathway may give a (relatively) more accurate picture of reality and the marriage between the electromagnetic and weak forces (as represented by the huge mass-energy of the IVBs). This marriage also gives us some understanding of how the massive leptons acquire the "hidden" identity charges from their associated neutrinos (via continuous identity exchange in the "generic" union created by the mass-energy of the IVBs). It also helps us understand why the leptonic mass spectrum is so limited - it represents the "harmonic" convergence of the electromagnetic and weak forces at just those few energetic frequencies where electromagnetic massive particles and weak force neutrinos can be paired, and "hidden" charges can be acquired by the massive leptons, charges which are the exact equivalent of the "explicit" identity charges carried by neutrinos.

Links
Weak Force, Intermediate Vector Bosons ("IVBs")

The "W" Intermediate Vector Boson and the Weak Force Mechanism (pdf file)
The "W" IVB and the Weak Force Mechanism (html file)
Global-Local Gauge Symmetries of the Weak Force
The Weak Force: Identity or Number Charge
The Weak Force "W" Particle as the Bridge Between Symmetric (2-D) and Asymmetric (4-D) Reality
The Strong and Weak Short-Range Particle Forces
The Strong Force: Two Expressions
"Dark Matter" and the Weak Force

See also:

Introduction to the Higgs Boson Papers
The Higgs Boson and the Spacetime Metric
The "Higgs" Boson and the Weak Force IVBs: Part I
The "Higgs" Boson and the Weak Force IVBs: Part 2
The "Higgs" Boson and the Weak Force IVBs: Part 3
The "Higgs" Boson and the Weak Force IVBs: Part 4
The "Higgs" Boson and the Weak Force IVBs: Part V

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