The Higgs Boson and the Weak Force IVBs (Intermediate Vector Bosons): A General Systems Perspective (part I)

(A 4x3 (or 4x4) fractal pattern: a hypothetical scenario of force unification)

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"A man's reach should exceed his grasp..." (Browning)

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Abstract

There is a very good reason why the field vectors of the weak force involve the hugely massive Intermediate Vector Bosons (IVBs) and the associated Higgs boson (while the field vectors of the other forces, the photon, gluon, and graviton, are massless energy forms): the weak force is the only force that creates and/or transforms "singlet" elementary particles (single elementary particles without antimatter partners). Single elementary particles cannot be directly produced from the vacuum "zoo" of virtual (and symmetric) particle-antiparticle pairs, as in the case of electromagnetic or strong force particle-pair production (in collisions, for example). Hence some other mechanism for reproducing the original and invariant conserved parameters of single elementary particles must be employed.

Single elementary particles created today must be the same in all respects as those created eons ago during the "Big Bang", and the massive and elaborate mechanism of the weak force is the only way to accomplish this imperative of energy and symmetry conservation - the invariance of the mass of all elementary particles, wherever and whenever they may be created. It is also for this reason that the whole weak force transformation mechanism is quantized in terms of the invariant Higgs boson and IVB mass.

The large mass of the Higgs and IVBs actually recreates the energy-density of the primordial environment in which the elementary particles whose transformations they now mediate were originally created. A weak force transformation is in effect a "mimi-Big Bang", reproducing locally the conditions of the global "macro-Big Bang", so that the elementary particles produced by each are the same in every respect. This is the only way such a replication could be accomplished after eons of entropic evolution by the Cosmos (because the mass of the Higgs and IVBs (or of particles generally) is not enervated by the entropic expansion, spatial or historic, of the Cosmos. This is the fundamental reason why the weak force transformation mechanism employs massive bosons). The role of the Higgs is to select and gauge the appropriate unified-force symmetric energy-density state (usually the electroweak (EW) force-unification energy level) for the transformation at hand; IVBs appropriate for that particular symmetric energy state (the "W" family of IVBs in the electroweak case) then access (energize) the state and perform the requisite transformation. (See: "The 'W' IVB and the Weak Force Mechanism".)

Within a particular unified-force symmetric energy state (such as the electroweak), transformations appropriate to that state are but the natural course of events. At the electroweak energy level, all quark

"flavors" are equivalent (and hence readily swapped or transformed), and all lepton flavors are likewise equivalent, but the quark and lepton families do not intermingle. At the next higher "GUT" energy level, quark and lepton families also merge their separate identities and can exchange flavors. In addition to our electromagnetic "ground state", there may be three higher unified force energy-density levels: the electroweak ("EW"); the Grand Unified Theory ("GUT"); and the Theory of Everything ("TOE"); each with its own Higgs boson ("H1", "H2", "H3" (or) "Hw", "Hx", "Hy") and associated IVB "family" ("W", "X", "Y"). (See: "Table of the Higgs Cascade".)

The three levels of Higgs bosons gauge (fix the energy density of) three levels of unified-force symmetric energy states which the IVBs must access (energize) to perform their transformations. Hence the Higgs determines the IVB mass indirectly, by setting the energy level it must attain. It is within these unified-force symmetric energy states that the charge and mass parameters of the elementary particles are fixed. (This is not the same as the "standard model" Higgs boson action mechanism. See: "The Higgs Boson vs the Spacetime Metric".) The weak force "massive IVB" mechanism works because the unified-force symmetric energy states (the energy levels at which the forces join or separate from one another) are discreet, well defined, and invariant. They can therefore be accessed by a quantized high-energy particle (the IVB) whose mass reproduces exactly the necessary unified-force symmetric energy level for a specific transformation. As a typical example, the Higgs boson gauges the energy level for the EW unified-force symmetric energy state; by virtue of their quantized mass-energy, the "W"/"Z" IVBs recreate/access the EW energy level, transforming single elementary particles via a "local gauge symmetry current" of virtual particle-antiparticle pairs drawn from the Dirac/Heisenberg "vacuum". (See: "The 'W' IVB and the Weak Force Mechanism".)

CERN announced the discovery of a "Higgs-like" boson on 4 July, 2012, at approx. 125 GEV. (See: Science Vol. 337 13 July 2012 pp. 141-143) (see also www.sciencemag.org)

Introduction

Because it is responsible for the creation, destruction, and transformation of elementary particles and matter, the weak force is the most important - and the most mysterious - of the four forces of physics. In this paper I model the weak force (with associated Higgs bosons) in its full energy spectrum, which spans three symmetric energy states or force-unification domains. We are used to thinking of the weak force only in its lowest energy manifestation of "radioactive" nuclear decay, or element building in stars, reactions mediated by the "W" family of Intermediate Vector Bosons (IVBs) of the electroweak (EW) unified-force level. However, the weak force also has two (hypothetical) higher energy manifestations at the "Grand Unified Theory" (GUT) energy level (strong force unification level) and the "Theory of Everything" (TOE) energy level (gravitational unification or Planck scale energy level). These higher energy force-unification domains or symmetric energy states are mediated by the "X" and "Y" IVB weak force families, respectively. We therefore propose a three-level mass hierarchy in the weak force IVB families ("W", "X", "Y") that parallels the three-family mass hierarchies seen in the quarks, leptons, and neutrinos.

It should be easier to understand and appreciate the functional activity and role of the weak force (and its associated Higgs bosons) when seen in its full-spectrum array than when glimpsed, as usual, only in its partial, low energy, electroweak domain. At the electroweak energy level the "W" IVB creates/destroys/transforms single leptons and quarks (and transforms, but does not create or destroy, single baryons). The "X" IVB at the GUT energy level creates/destroys single baryons and transforms/destroys but does not create leptoquarks. The "Y" IVB at the TOE energy level creates/destroys leptoquarks (including the crucially important electrically neutral leptoquarks). Without the "X" and "Y" IVBs, we have no source for either single baryons or electrically neutral leptoquarks, so we need them both (or their analogs). The primordial heavy leptons or "Ylem" (Gamow's term) are evidently created by a group effort involving all four

forces, including gravity.

It should also be noted that not only does the weak force play an essential role in the devolution of our Universe from the Multiverse to its electromagnetic (EM) "ground state" (as driven by entropy and the intrinsic motion of light), but the weak force also figures prominently in the reverse process, the evolutionary "rebound" (as driven by symmetry conservation and the negentropic energy of gravity) toward our Universe's original symmetric energy state in the Multiverse (progressing upward through stars, black holes, and the "Big Crunch"). Thus the full range of weak force activity encompasses both the creation and destruction of matter, and the breaking as well as the conservation of symmetry. The weak force model presented below has the 4x3 and 4x4 form of other General Systems models presented on this website (see: "Introduction to General Systems").

The Weak Force Identity Charge

The weak force is associated with a charge known as "identity" or "number" charge. "Identity" charge is carried in explicit form by neutrinos and in implicit or "hidden" form by the massive leptons and (presumably) by baryons as well. All charges of matter are temporally conserved forms of light's (broken) symmetries: Noether's theorem. In the case of the weak force "identity" charge, that symmetry is the "anonymity" of massless photons, including their ability, as bosons, to pile up on top of each other (superimposing their identities and energies), and exist in many different energy states, depending only on their frequency ($E = h\nu$). Massive particles (fermions: leptons and baryons) break the "anonymous" symmetry state of the photon by assuming a single, distinct, massive, energy state that will not superimpose its energy or identity with others of its kind (the "Pauli Exclusion Principle"). The "identity" of a fermion is its most fundamental charge, distinguishing it as a specific form of bound energy, and allowing it (therefore) to be recognized by its antimatter partner (for purposes of annihilation and hence symmetry-keeping), and to be recreated in exactly the same form, energy, mass, charge, and spin at some later time and place. The electron created today must be the same in all respects as the electron created yesterday, tomorrow, or in the "Big Bang", and that conservation imperative of energy, symmetry and charge is made possible by the invariant "identity" charge of the weak force (and actually accomplished by the massive Higgs and IVBs). (See: "The Weak Force Identity charge".) The "identity" charge of an elementary particle is analogous to our common notion of a human "soul".

Rationale for the Higgs Boson

The Higgs boson is necessary to gauge the rest mass energy of the IVBs and the elementary leptons and quarks, so their masses will have a defined and invariant magnitude, reproducible everywhere and anywhere in time and space. This is the grand "local gauge symmetry" of the weak force and the *single* elementary particles it produces. An electron created today can be "swapped out" with any other in the Cosmos, no matter when or where it was produced, including in the "Big Bang". The large Higgs and IVB masses reproduce the force-unity energy levels in which these particles were first produced (the electroweak force-unity energy level in the case of the "W" IVBs). Hence every elementary particle is forged from the same original mold, and every weak force interaction is a mini "Creation Event". The Higgs acts through the IVBs to gauge the elementary particle masses. Regarding the inertial mass of particles as measured by resistance to acceleration ($F = MA$), see: "The Higgs Boson vs the Spacetime Metric". (See also: "The Mysteries of Mass" by Gordon Kane, Scientific American, July 2005, pp. 41-48.)

The anomalous parity violation of the weak force (surmised by Lee and Yang, 1956), is due to the absence of antimatter. Lacking other distinguishing charges, left vs right "handedness" is the only way neutrinos are differentiated from antineutrinos - all matter neutrinos have left-handed spin and all antimatter neutrinos have right-handed spin. In our matter-only universe, the weak force can only interact with left-handed electrons (for example), because the electron neutrinos which carry the electron's leptonic "number" or "identity"

charge (the alternative charge carrier) is perforce exclusively left-handed.

Like other charges, "handedness" must either be conserved as it is, or neutralized by its opposite. When an electron is created, its leptonic "number" or "identity" charge must be neutralized by an accompanying antineutrino, which however can only have right-handed spin, forcing the electron (which ordinarily can have either handedness) to have the opposite and balancing left-handed spin. When this electron is subsequently destroyed in some later weak force reaction, its number charge must be conserved (carried forward as is) by a (matter) neutrino, which of course can only have left-handed spin. Hence we see the parity charge "left-handedness" carried through the creation and destruction of (matter) electrons, first by the electron itself, and then by its neutrino. Thus arises the weak force violation of parity, coupling only to left-handed particles, an asymmetry which would be completely reversed if our world were made of antimatter.

There is another (but unrelated) famous asymmetry in the weak force, which produced our matter-only Cosmos - presumably via the asymmetric decay of electrically neutral leptoquark particle-antiparticle pairs during the "Big Bang". Other asymmetric weak force decays have been seen in certain neutral kaon decays (Cronin and Fitch 1964). Unlike the parity example, the reasons underlying these asymmetric particle decays are not understood - beyond "anthropic" principles. Indeed, the weak force remains full of mystery!

A Hierarchy of Force Unification

In our "ground" electromagnetic state, we do not find a Higgs boson or an IVB; they are characteristics of the higher energy levels of force unification (H1, H2, H3) (see: "Table of the Higgs Cascade"). However, we can suggest low-energy analogs. The photon is the ground state analog of the Higgs boson; the spacetime metric is the analog of the "particle metric" established by the Higgs boson. The photon establishes the EM spacetime metric, setting the dimensional scale at "velocity c"; similarly, the Higgs 1 boson establishes the EW "particle metric", setting the mass scale for the EW unified-force symmetric energy state and the elementary particles (leptons, quarks) the state contains, and the IVBs which must recreate/access the state. The two metrics are not strangers and continue to work together seamlessly in the EM ground state because they were once joined as part of the same regulatory metric at the EW energy level. In our ground state, the spacetime metric established by the photon determines a type of entropy-energy, an invariant and specific "intrinsic motion", gauged as "velocity c", which is also a symmetry condition of "non-locality". "Velocity c" regulates the entropic expansion of the global spacetime metric and the intrinsic (entropic), symmetric (non-local) motion of the photon within it. Similarly, at the H1 energy level, the Higgs 1 scalar boson gauges the mass/energy level of the EW symmetric energy state, including the IVBs associated with that state (gauged at about 81 proton masses for the "W" IVB). Among other conservation roles, "velocity c" and the spacetime metric function as symmetry gauges for massless free energy and inertial forces; similarly, the Higgs boson functions as a symmetry gauge for massive particles (within the several unified-force symmetric energy states). Like all particles, the quantized Higgs and IVBs are creations of the "energized" spacetime metric as it interacts with the four forces of physics.

In the electroweak unification scheme, the photon is the 4th member of the electroweak family of bosons (force-carriers), the other three being the "W+", "W-", and "Z" neutral IVBs. Both photon and the other Higgs 1 IVBs have access to the same vacuum "sea" of virtual particle-antiparticle pairs. The great difference between them is that:
A) the photon can have virtually any energy, whereas the "W" IVB is quantized to a single specific energy of (approximately) 81 GEV; (the Z neutral mass is about 91 GEV);
B) the photon can only create and destroy particle-antiparticle pairs, whereas the "W" IVB can create, destroy, and transform "singlet" (unpaired) elementary particles.

The spacetime metric acts as a regulatory and conservation mechanism, not only with respect to the entropy drive and "non-local" symmetric energy state of free energy (all photons travel only at "c"), but also with respect to the mass and charge of elementary particles created by photons in particle-antiparticle pairs (the "particle sea" of Heisenberg/Dirac virtual particles, and the creative products and potential of the "vacuum" particle "zoo"). No (single, elementary) virtual particle or particle-antiparticle pair can be materialized from the vacuum "sea" as a "real" particle unless it meets a universal and invariant standard for the mass and charge of that particle species (single elementary particles must materialize via the IVB weak force mechanism). The fact that both the electromagnetic and weak forces extract exactly the same electron, singly or in particle-antiparticle pairs, from the spacetime metric is compelling evidence for the electroweak unification, as well as for the universal regulatory role of the "vacuum" or spacetime metric. (See: "The 'W' IVB and the Weak Force Mechanism".) The spacetime metric (whose role is simply conservation) enters with the electromagnetic force and the photon at the "Creation Event". Like the spacetime metric, the Higgs (itself a part of the metric since we expect it can be materialized from it in collisions) also finds its rationale through symmetry, charge, and energy conservation. The gateway to 4-D temporal reality for single, unpaired particles is strictly regulated by the weak force and its quantized conservation mechanisms.

In a hierarchy of conservation invariants, all administered through the universal presence of the "vacuum" or "spacetime metric", we have as the most general examples the "life friendly" physical constants such as "c", "G", "h", the weak force asymmetry parameter gauging the creation of our matter-only Cosmos, etc. These constants evidently originate as "givens" from the Multiverse. Below these general physical and "life friendly" ("anthropic") parameters we have the force-unification energy levels of our own universe, gauged by the several Higgs, and from which the IVBs and elementary particles take their values. Finally we have the conserved charges of matter, which are all symmetry debts of light, and so take their values from the electromagnetic force and the electromagnetic nature of matter. Because the "four forces" of physics are produced by the symmetry-conserving activity of their charges and field vectors, *we find the ultimate unity of the forces in their common origin as symmetry debts of light*.

(For a discussion of CERN's Large Hadron Collider see: *Science*, 23 March 2007, page 1657-8.) (See also: *Science* 9 March 2012 Vol. 335 page 1159: tevatron data hints at Higgs mass of approx. 125 GEV.)

A 4x3 Pattern of Force Unification

The weak force IVBs (Intermediate Vector Bosons), plus their associated "Higgs" (H) bosons, form a 4x3 (or 4x4) "matrix" or pattern that complements the fractal description of the Cosmos at high energies, essentially describing the weak force creation of matter. The four-part IVB-plus-Higgs pattern occurs in three energy levels or unification regimes (4 "metric" weak force bosons in 3 symmetric energy states), above a fourth level electromagnetic (EM) "ground state". The "ground state" is the decay product of the "Electroweak (EW) Era". (See also: "Nature's Fractal Pathway".) Note in this regard that the quark and lepton "families" also occur in a hierarchy of three energy or mass levels above the ground state photon. The "metric" particles of the weak force (the IVBs and the Higgs boson) seem to be an analogous three-level energy or mass hierarchy. Given the absence of antimatter, the heavy quark and leptonic members of the fermion families (Hyperon Era) all decay to the "ground state" of our familiar spacetime metric and the photon, or charge-carrying electrons, neutrinos, neutrons, and protons (U, D quarks).

Perhaps a more familiar analogy from the hierarchy of biological classification will be helpful: species/genus/family/order. At the ground state electromagnetic level we find completely separate and stable elementary particle "species". At the electroweak level we find the several quark species joined together in

their own "genus" (hadrons), and likewise the several electron and neutrino species joined together in another genus (the leptons). At this electroweak energy level, transformations may occur within "genera" but not between genera, and single quarks, leptons, and mesons can be created and destroyed, but baryons can only be transformed. At the GUT level we find the hadron and lepton genera joined together in a "family" (the fermions), and the field vectors (except gravity) joined together in another family (the bosons). Now transformations may occur within the "family" level but not between families (creating and destroying single baryons and leptoquarks but not yet creating and transforming primordial leptoquark-antileptoquark particle pairs). At the final level of force unity, the TOE level, we find the fermion and boson families (including gravity) joined into an "order" (encompassing all free and bound forms of electromagnetic and gravitational energy - Gamow's "Ylem"), in which transformations between all types of particles are allowed, creating and destroying primordial massive leptonic particles including leptoquarks. This is the mysterious primordial creation of mass from light, or the conversion of free to bound electromagnetic energy. The role of the "Y" IVBs is perhaps to assist in the creation of leptoquarks, but certainly to transform primordial, electrically charged leptoquarks into primordial, electrically neutral leptoquarks (heavy analogs of neutrons). Leptons are the only true elementary particles (evidenced by the fact that only leptons have associated neutrinos - "identity" charges). The leptonic spectrum finds its natural upper limit in an overly heavy primordial particle which splits under its own mass and the self-repulsion of its electric charge into three parts (a more stable configuration or distribution of charge), producing a leptoquark, the "common ancestor" of all lighter leptons and hadrons. The leptoquark, as modeled here, is the key to the relationship between leptons and hadrons, the electromagnetic and strong forces, and the origin of color charge and the gluon field.

IVB "Family" Symmetric Energy Levels

Immediately above the Atomic Era or EM "ground state" of historic spacetime, photons, and cold, atomic matter, is the first IVB group at the "genus" level consisting of the W+, W-, and W neutral (or Z neutral), which is associated with the first-level Higgs boson, "H1" (Hyperon Era). This is the energy level of the electroweak (EW) unification, in which all transformations mediated by the "W" IVBs are continuously ongoing (quark-quark and lepton-lepton transformations). This level of unification is within the lepton and hadron "genera" separately, but not between them. In addition, the photon and the IVBs are indistinguishable at the EW unification level: at an energy density of 90 proton masses, photons and the "Z" IVB are effectively one and the same thing. When this H1 state decays to the EM ground state, light and the IVBs separate (the photon's wave form becomes dominant over its particle form), and the quarks, leptons, and neutrinos spill out as separate species like fruit from a cornucopia. (See: "The Particle Table".) The quark and lepton species are also grouped in three tiers of successively greater energy, each tier consisting of four particles, a basic example of a 4x3 and 4x4 resonant, repeating, fractal pattern found throughout the material phenomena of our Cosmos (including, most fundamentally, the 4 dimensions of the spacetime metric). (See: "Table 1: The Fractal Organization of Nature".)

Neither the photon of the electromagnetic force, nor the "EW" level IVBs of the weak force, carry the charge of their respective forces, electric charge and "identity" charge, even though they are the field vectors or force carriers of those forces. In the case of the photon, its electric field is neutralized by an exactly compensating magnetic field, and the action of the photon field vector is accomplished by a transfer of pure energy or momentum. The photon's electrical neutrality allows it to range freely through spacetime; if the photon itself carried charge, it would be as restricted in its activities as an electron. In the case of the "EW" family of IVBs, their charge neutrality (with respect to the "identity" charge) allows them to mediate the transformation of a variety of different charges - electric, identity, color, and spin - all via virtual particle-antiparticle pairs which "piggyback" on the massive IVBs. This "lack of agenda" with respect to identity charge allows the EW family IVBs to perform all the various transformations of the lepton and quark species, including those involving heavy leptons, neutrinos, quarks, mesons, and baryons (single baryons can be transformed but not created or destroyed at the EW level). (See: The "W" IVB and the Weak Force Mechanism.)

The second IVB "family" level (H2 or Leptoquark Era) is the unification level of the GUT (Grand Unified Theory), in which the strong force and electroweak force are unified. This second (hypothetical) IVB family consists of the X+, X-, X neutral heavy bosons, associated with a second-level Higgs boson, "H2". Whereas the E/W level IVBs transform one quark to another and one lepton to another (including the creation and destruction of leptons and quarks), the GUT level IVBs can also transform quarks to leptons (including the creation and destruction of single baryons and leptoquarks). This is the level of electrically neutral leptoquarks, the union of leptons and quarks. "Proton decay" is a GUT level process, which is why we never see it (the "X" IVB is prohibitively massive). Single hyperons and baryons originate from the "GUT" or "X" IVB energy level. Leptons, mesons, and other alternative charge carriers are characteristic of the "EW" IVB level. Only atomic and molecular (chemical - electron shell) combinations originate at the "EM" or "ground state" energy level. (See: Howard Georgi: "A Unified Theory of Elementary Particles and Forces," *Scientific American*, Vol. 242, No. 4, April, 1980, page 104+.)

The third "order" level of IVBs (also hypothetical) are at the TOE (Theory of Everything) level of unification, in which gravity is added to complete our 4x3 fractal scenario of force unification (Planck Era energy-level unification). We may designate these third-level IVBs as: Y+, Y-, Y neutral, associated in turn with a third-level Higgs boson, "H3". Massive particles, in the form of primordial electrically charged leptons and leptoquarks (in particle-antiparticle pairs), originate at the H3 energy level. Whereas level two (H2) may be seen today in proton decay (possibly a commonplace in the interiors of black holes), level three (H3) unification exists only at the very beginning or ending of the Cosmos (the "Big Bang" or "Big Crunch") (the conjoining or dissolution of gravity, spacetime, light, and particles, positive electromagnetic and negative gravitational energy). Black holes do not qualify for level 3 because of their partial and extended nature. The Universe does not begin as a black hole, but as an explosion of spacetime and energy, due to its initial matter-antimatter symmetry and consequent annihilation reactions; nor is there any spacetime external to its "horizon".

The entropy-driven (expansion and cooling) decay phase of level H3 to level H2, in which gravity and the spacetime metric separate from the primordial mass-carrying leptoquarks, may be described by the "inflationary" scenarios of Alan Guth and Andre Linde. Although I don't know what to think about this highly mathematical theory, it certainly describes a bizarre spacetime with which we have no familiarity (a supercooled "false vacuum" with "repulsive gravity"), and *if* it belongs anywhere in the "Higgs Cascade" model, it would either have to be here, or possibly at the even earlier stage of the separation between our Universe and the Multiverse. In my view, "inflation", if it exists at all, may simply represent the actual destruction of the spacetime metric by the too-violent explosion of the "Big Bang". Inflation ends (in this scenario) when the initial "over the top" energy input has expanded and cooled to the point where our familiar spacetime metric can accommodate and regulate it. There are, however, other ways to produce the observational effects which motivate Guth's theory of "inflation" (see: "A Spacetime Map of the Universe").

The "Higgs Cascade" is driven by entropy, which in its primordial forms consist of the intrinsic motions of light, gravity, and time, as "gauged" or regulated by c and G. (See: "Spatial vs Temporal Entropy".) The activity of the graviton, the field vector of gravity, is essentially the inverse of the photon, collapsing and heating space rather than the reverse. The intrinsic motion of the photon is the entropy drive of free energy, producing space and the expansion and cooling of space. The active principle of the gravitational "location" charge is time, which has its own intrinsic motion as the entropy drive of bound energy (at right angles to all three spatial dimensions), producing the expansion and aging of history. *A gravitational field is the spatial consequence of the intrinsic motion of time*. (See: "Entropy, Gravity, and Thermodynamics"; see also The Conversion of Space to Time".)

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