INTRODUCTION TO THE HIGGS BOSON PAPERS: PART I

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Abstract

Although I had heard about, read about, and wondered about the "Higgs boson" for years, I simply couldn't get a "feel" for this particle, mostly because I was unable to place it within any overall, coherent scheme of physical phenomena. I didn't want to believe in its reality, but I hadn't wanted to believe in the reality of the "W" and "Z" IVBs, either. Having eaten a large serving of humble pie with the discovery of these particles in the early 1980s at CERN, I was not eager for second helpings from the Higgs, so I kept searching for its conservation role. What finally broke the impasse for me was the article by Gordon Kane in *Scientific American* (and there is much else in this article I don't agree with), which mentioned there could be more than one Higgs boson. (See: "The Mysteries of Mass" by Gordon Kane, *Scientific American* , July 2005, pp. 41-48.) That idea allowed me almost immediately to "do my thing", which is the construction of General Systems hierarchies, using the "phase transition" energy levels, or force- unification symmetric energy states, as benchmarks for the four sequential steps of a weak force decay "cascade" from the "Multiverse" to "ground state" atomic matter in our universe, with one step allotted to each of the four forces as they joined (or separated from) the unification hierarchy, and one Higgs

boson identifying each unified-force energy plateau. (See: "Table of the Higgs Cascade".) (On July 4, 2012, CERN announced the tentative discovery of a massive, Higgs-like boson, at 126 GEV on the LHC at Geneva, Switzerland.)

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Introduction

I had been blocked from understanding the Higgs role and mechanism through thinking there was only one Higgs boson; the dam burst when I realized there could be more than one Higgs. Suddenly I saw how the various Higgs bosons could serve as a selection mechanism to define, organize, and "gauge" the energy levels or symmetric energy states of several other processes I had known about for some time, such as the compression of the quarks by the "X" IVBs to produce "proton decay", and the creation of leptoquarks by an even higher energy process involving the splitting of primordial charged leptons by "Y" IVBs to produce both electrically charged and neutral leptoquarks. It all fell into place once my mind was opened to the possibility of multiple Higgs bosons, one each to "gauge" or scale the stages of the decay sequences of the cascade. Here was the natural conservation role for the Higgs I was seeking. The quantization of the Higgs and IVBs is necessary to ensure the invariance of the *single* elementary particles they produce. No matter if this was not the exact same role posited for the Higgs in other sources; given the ambiguity in the technical jargon and explanations I had encountered, it was close enough to satisfy.

A common interpretation (in the popular literature) of the Higgs boson's role is that it is responsible for the inertial mass (mass measured as resistance to acceleration, as distinct from Einstein's "rest mass") of elementary particles - see Kane's article, above. This interpretation and distinction I have never understood and still do not agree with. I do agree that the Higgs is responsible for the Einstein "rest mass" of a particle (E = mcc), in that the Higgs scales, regulates, or "gauges" the mass-energy of the unified-force symmetric energy level (the electroweak (EW) for example) at which these particles exist in a "generic" state of shared identity. But this is not how most authors seem to interpret the action of the Higgs. Instead, they argue that the Higgs acts like a spacetime field (something like the old "ether") which resists the motion of (accelerating) elementary particles (and only elementary particles, not compound particles such as baryons, whose mass consists mostly of binding energy). The objectionable feature of this idea is that it gives us several different kinds of inertial mass, and therefore compromises (it seems to me) a fundamental principle of Einstein's, the "Equivalence Principle" between rest mass, inertial mass, and gravitational mass ("weight"). Furthermore, in this interpretation, the Higgs is being thrust into a role which is already filled by the spacetime metric.

In my view, the inertial mass of a particle (the mass due to a particle's resistance to acceleration) is a consequence of the interference between the particle's gravitational field (which exactly measures its rest mass or bound energy content - Gm) and the spacetime metric. This latter interpretation satisfies Einstein's Equivalence Principle, the identity between inertial mass, rest mass, and gravitational "weight", and also explains why the accelerated motion of particles affects their dimensional and mass parameters (because of feedback between the metric fields of spacetime and gravitation). It also frees the Higgs boson for a more satisfactory role in the conservation economy of Nature as simply the scalar of elementary particle mass in unified-force symmetric energy states during the creation of "singlets" by the weak force. In this conception, the Higgs acts through the weak force IVBs to gauge the masses of elementary particles. I explain all this in greater detail in the paper: "The Higgs Boson vs the Spacetime Metric". (See also: "Extending Einstein's

Equivalence Principle.) This also explains why light, which has no mass and produces no gravitational field, has no inertial resistance to acceleration. (See: "Does Light Produce a Gravitational Field?")

Charge Invariance

The unified field theory, as developed in various papers on this website (see especially: "Symmetry Principles of the Unified Field Theory"), rests upon 4 fundamental conservation principles of physical law: 1) the Conservation of Energy (1st law of thermodynamics); 2) Entropy (2nd law of thermodynamics); 3) the Conservation of Symmetry (Noether's Theorem); 4) Causality (law of cause and effect). (See: "The Tetrahedron Model" (diagram) (text))

In writing the "Higgs Boson" series of papers referred to in the title (and also the "Global vs Local Gauge Symmetry" papers), I have found it necessary to invoke a corollary, a natural adjunct of the symmetry conservation principle: *charge invariance* (including the invariance of other associated energetic and quantum-mechanical physical parameters of elementary charge-carrying particles, such as "rest mass" and spin). The magnitude of charge/mass/spin must remain invariant over time, despite the effects of entropy, the expansion of the Universe, the effects of relative motion, or any other factor which might either inflate or deflate the original value/magnitude of charge and other conserved physical parameters. Obviously, symmetry conservation over time and space depends upon charge invariance, which is implied in any notion of charge conservation. Charge conservation and charge invariance in the "particle" forces (including rest mass and spin), the invariance of "velocity c", Einstein's "Interval", "Lorentz Invariance", causality, and inertia in the "spacetime" forces, are the heart and soul of Noether's Theorem regarding symmetry conservation: "*the charges of matter are the symmetry debts of light*". Because of the firm connection between energy and symmetry conservation (as formalized in "Noether's Theorem"), physical parameters are typically conserved by both principles, if they are conserved by either.

While the principle of charge invariance has major consequences for charged particles in relative motion (magnetism for example), it also has major consequences for the creation, destruction, and transformation of "singlet" or unpaired elementary particles over the course of history (the elaborate weak force transformation mechanism, including the massive weak force Higgs boson and IVBs for example).

The central fact of our Universe is that it is "asymmetric", composed of matter only, not a symmetric mix of matter and antimatter. Nevertheless, the Cosmos apparently was born in a state of massless, chargeless symmetry, originally composed of equal parts matter and antimatter, and subsequently devolved to its current "ground state" of asymmetry (involving mass, charge, gravitation, and time - the asymmetric "gang of four"). Getting from the symmetric "Big Bang" origin of our Universe to its present asymmetric "ground state" is an evolutionary journey that imposes many constraints upon any intuitive mythology or rational hypothesis that attempts to reconstruct it. Among these constraints are the "global vs local gauge symmetry" dualities in the structure of spacetime and the field vectors of the forces (such as the electro/magnetic force), necessary to accommodate the relative motion of matter and charged particles vs the (much simpler) absolute motion of light. The massive Higgs boson and the weak force IVBs are likewise necessary for the creation, transformation, and decay of "singlet" or isolated elementary particles of matter, vs the (much simpler) electromagnetic creation and annihilation of particle-antiparticle pairs.

If the central fact of our Universe is its asymmetric content of matter, then the central force of the Universe must be the weak force, whose role is the creation/destruction/transformation of "singlet" elementary particles, isolated elementary particles of matter rather than particle-antiparticle pairs (as produced by the electromagnetic force). (See: "The Particle Table".)

Not only does the weak force create isolated particles of matter during the Big Bang (by virtue of its asymmetric reactions with matter vs antimatter), the weak force also creates and transforms isolated particles of matter (and sometimes antimatter) at later times, including today (radioactive decay, astrophysical processes, etc.). The weak force provides a "lawful" pathway of decay ("lawful" in that the decay pathway, driven by entropy, obeys the conservation laws) from the high energy, high mass particles created during the earliest moments of the "Big Bang" (leptoquarks, hyperons), to the low energy, low mass particles of "ground state" atomic matter (protons, neutrons, electrons, neutrinos). The mechanism of particle creation, transformation, and decay involves both the massive Higgs boson and the weak force field vectors, or "Intermediate Vector Bosons" (IVBs) (so-called because in contrast to most massless bosons - photons, gravitons, gluons - IVBs are very massive). The decay cascade is driven by positive entropy, regulated by the weak force, with an evolutionary "rebound" driven by symmetry conservation, time, and the negative entropy of gravitation. (See: "Nature's Fractal Pathway".)

The Higgs Cascade

The Higgs boson is a quantized scalar particle, reflecting and identifying the energy density or energy scale at which the "phase transitions" of force unification or symmetric energy states occur, also "gauging", "scaling", or regulating the mass of the elementary particles which exist - and the IVBs which perform elementary particle transformations - within those energy boundaries and symmetry states. These are very specific energy levels determined by the "phase transition" boundaries or unified symmetric energy states of the four forces - the energy density or temperature at which the four forces merge into (or separate from) one another. These phase transitions are symmetry stages, levels, or steps in a hierarchy of energetic unification regimes beginning with the lowest electromagnetic (EM) "ground state" (cold atomic matter), and ending with the highest (the "Creation Event", "Big Bang", or separation of our universe from the "Multiverse"). (See: "The Higgs Boson and the Weak Force IVBs" (table and text)) (table only).

The quantization of the (several) Higgs scalar bosons reflects the fact that these phase transitions are distinct and definite, always taking place at the same energy level, and therefore the IVBs gauged and selected by the Higgs always access the same energy level, producing elementary particles of the same charge, mass, and energy, no matter when or where in the Cosmos such weak force transitions happen to occur. The quantized Higgs boson is an obvious concession to charge and mass invariance in the service of energy, symmetry, and charge conservation. The quantized Higgs ensures that the IVB it gauges is in the correct symmetry state, unification regime, or energy level to perform the desired transformation, which will occur as a natural matter of course if the energy level and symmetric energy state is properly gauged or selected.

We can think of the Higgs boson as a scalar property necessary to distinguish between several force-unification energy levels or symmetric energy states, a property that also gauges IVB masses associated with each specific force-unity state. The scalar is necessary to ensure the invariance of the IVB's mass, energy, and consequently its product, regardless of its relative motion, entropy, when or where it operates, or any other factor that could affect the invariance of the elementary particles the IVB produces. The IVB itself is necessary to provide a "lawful" pathway or mechanism of decay for the "singlet" bound energy forms of one symmetry state to the "singlet" bound energy forms of another state with greater (total system) entropy and less bound energy. (See: "The 'W' IVB and the Weak Force Mechanism".) Note that the mass of the Higgs, the IVBs, or the elementary particles they produce is not affected by the entropic expansion of the universe - a fact which allows quantized bound energy rest-mass to be used as a time-invariant scalar or gauge.

The enormous mass of the "W" IVB family - about 80-90 proton masses - which would seem to be much more massive than necessary to effect the transformations it produces (such as the creation of a single electron) - is due to the great energy density of the force-unification symmetric energy state which the IVB represents (the electroweak (EW) force-unification symmetric energy state in the case of the "W" IVB "family"). The IVBs work their transformations indirectly, by occupying the original force-unification symmetry state in which these transformations first occurred during the exceedingly high temperatures and energy densities of the "Big Bang". Once the IVB is in this original energy-density state, the transformations which are the natural consequences of the symmetries native to that state occur as a matter of course. (For example, the lepton and quark "species" of our ground state EM level, exist in a unified "generic" state at the EW energy level - the lepton "genus" and the hadron "genus". Transformations between species within their own genus occur effortlessly due to their merged identities.) This strategy is necessary to ensure that the *single* elementary particles the IVBs create will always be the same, whether they were created during the "Big Bang" or billions of years later, in very different environments, times, and circumstances. Energy and charge conservation obviously demand that the elementary particles created today be exactly the same as those created yesterday, tomorrow, or in the "Big Bang". This is why the creation of "singlet" elementary particles of matter (particles that are unpaired with antimatter annihilation partners), is fraught with so much difficulty, and requires the extremely elaborate and conservative weak force Higgs and IVB mechanism which reprises the original mode and "Big Bang" environment of particle creation. The mass of the Higgs boson is the universal weak force constant which scales or "gauges" the unified-force symmetric energy states, the weak force IVBs, and the latter-day creation of single and invariant elementary particles. The invariant Higgs mass is the analog of the invariant "velocity c": the latter scales the relations among the dimensions of spacetime and the intrinsic motion of the photon, in the low-energy domain of our electromagnetic ground state; the Higgs scales the several symmetric energy states, the mass of their associated IVBs, and the elementary particles they produce. The "W" family of IVBs belong to the EW realm, not to our EM realm, which is why they appear so massive, ephemeral, and strange to us.

Three Energy Levels of Higgs Bosons and Weak Force IVBs

The transformation mechanism of the IVBs is relatively simple. (See:

"The 'W' IVBs and the Weak Force Mechanism".) The IVBs are "metric" particles, quantized examples of the energy-dense metric at which a particular force-unification symmetric phase transition, or joining of forces, takes place. There are (presumably) three separate and discreet unified-force symmetric phase transition energy levels, with a distinct and separate Higgs scalar boson and cohort of IVBs associated with (and definitively distinguishing) each level. The first (lowest) Higgs level is the "W" IVB "genus" level, consisting of the W+, W-, and W neutral (or Z neutral) IVBs. This (Hyperon Era) energy level (about 80 proton masses or 80 GEVs for the W+ and W-, and about 91 GEVs for the Z neutral) corresponds to the energy density at which the electric and weak forces join (the photon becomes part of the "W" IVB group). The symmetry of this phase transition consists not only in the merger of the photon with the "W" IVBs, but also in the joining of the three quark family members with each other, and likewise, the joining of the three lepton family members with each other (but quarks remain distinct from leptons). This is a more symmetric state because the lepton species are not distinguished among themselves, nor are the quark species distinguished among themselves, nor are photons distinguished from the "W" IVBs, nor, indeed, are the electric and weak forces distinguished from one another. Consequently, transitions among the six quark species and transitions among the six lepton species take place with significantly enhanced facility at this energy level. (See: "The Particle Table".) In the (perhaps) more familiar terms of a biological taxonomic hierarchy, this is a symmetry realized at the "generic" (EW) level, unifying quark or lepton "species" collected from the EM level within their own separate "genera".

Because the "W" IVBs are essentially examples of (quantized portions of) the H1 energy density or electroweak unified-force symmetric energy state (which is why they are so massive), they can perform any transformation that normally characterizes this symmetric level of force unification (see table). This level is experimentally verified with regard to the "W" family of IVBs, but the race continues to discover the level 1 (H1) Higgs boson (discovery announced at CERN on 4 July, 2012). On this H1 level we find the production of alternative charge carriers (leptons, neutrinos, and mesons), the transformations of hyperons and baryons, and the creation and destruction of mesons, quarks, and unpaired lepton "singlets". (The creation and destruction of baryon "singlets" is a higher (H2) energy level process.) H1 is the familiar energy level of weak-force nuclear transformations, including radioactivity, fission, and element-building in stars, accessible only through the "W" IVBs if "singlet", isolated, elementary particles are created, destroyed, or transformed (such as electrons, neutrinos, or changes in quark "flavors" involving electric charge).

"Alternative charge carriers" (leptons, neutrinos, mesons) balance the charges of other particles (notably baryons) in the absence of antimatter charge partners. Importantly, alternative charge carriers avoid annihilation reactions and are therefore crucial for the creation of "singlets" or isolated particles of matter. The electron-proton pair is our most familiar example, but the electron-electron antineutrino pair is equally important - as is the (hypothetical) proton - leptoquark antineutrino pair.

In a similar mode, the next higher step in the force-unification hierarchy is that between the strong force and the electroweak force, the so-called GUT unified force level or Grand Unified Theory. (This second energy level (Leptoquark Era) of IVBs and Higgs (H2) remains hypothetical, having not been experimentally verified.) Here the quark "genera" and lepton "genera" are unified into a fermion "family", manifesting as hybrid particles called "leptoquarks". The IVBs of this "H2" level are designated "X" IVBs (X+, X-, X neutral), and are simply heavier versions of the "W" IVBs. Matter is created at this level (during the Big Bang) through the asymmetric weak force decay of electrically neutral leptoquarks vs antileptoquarks, with the (net) emission of leptoquark antineutrinos. The H2 level hosts the creation and destruction of baryons as "singlets" or unpaired, isolated particles (including "proton decay"). It is here that the asymmetric creation of matter occurs during the "Big Bang", with the "X" IVBs destroying more (electrically neutral) antileptoquarks than leptoquarks. The (net) leptoquark antineutrinos produced in these reactions are "dark matter" candidates. It is possible that this energy level occurs today inside black holes, where "proton decay" may be commonplace. (See: "The Origin of Matter and Information".)

The final IVB level (also hypothetical) is the H3 energy state (Planck Era), designated the TOE (Theory of Everything) or quantum gravity energy level (this is the level of Gamow's primordial electromagnetic substance or "Ylem"). We will name the IVBs of this level the "Y" IVB family, presumably also a triplet of Y+, Y-, and Y neutral "metric" particles. ("Metric" particles are composed of a bound form of compacted, possibly convoluted, energy-dense spacetime metric. Their mass is composed not of quark or leptonic matter, but simply of the energy required to bind and maintain the spacetime metric into their particular form, density, and configuration.) The symmetric "phase transition" of the H3 energy level is the final joining of forces, the joining of gravity with the strong and electroweak forces. This is the level of "quantum gravity" and the creation of mass or bound electromagnetic energy in the form of primordial massive leptons and leptoquarks, produced by the "Y" IVBs, probably by splitting the primordial charged leptons into three roughly equal parts. Like the "X", the "Y" IVB is also a super-heavy version of the "W" IVB. Unlike the "X", the "Y" is special in that it gets some extra help in its role from gravity (although the "X" may also get some help from gravity, as when it (presumably) produces proton decay in black holes). The "Y" IVBs of the "Ylem" create both electrically charged and neutral leptoquarks, but only the neutrals survive long enough to enter the H2 energy level, where they may undergo weak force decays via the "X" IVBs. (Electrically charged leptoquarks are immediately annihilated by their anti-mates in the H3 level.)

Leptoquarks are conceived as the most massive members of the leptonic spectrum; in fact, they may be so massive that they are unstable under the repulsive forces of their own electric charge, and undergo a sort of "decay" or reorganization (orchestrated by the "Y" IVBs) to a more stable three-part subdivision of both their mass and electric charge (quarks) - hence setting a natural upper mass limit to the leptonic spectrum, and establishing an ancestral relationship between the leptons and quarks. Leptoquarks are created by the combined efforts of all the forces at the H3 energy level. Leptoquarks are composed of a highly compressed portion of the spacetime metric, and this metric contains (at least potentially) both quarks and leptons - the quarks representing subdivisions of leptonic elementary charges, which latter represent temporal forms of symmetry debts. We know this because today's metric still retains the ability to produce both quarks (mesons) and leptons as virtual particle-antiparticle pairs when appropriately energized. Symmetry conservation as applied to leptonic unit charges creates the confining strong force "color" charge, mediated by an eight-part "gluon" field, which prevents these fractional quark charges from ever leading an independent existence, in which they could not be canceled, neutralized, balanced, or annihilated by ordinary whole-value leptonic elementary charges. The great significance of quarks is that some combinations of their partial leptonic charges are electrically neutral, and it is these long-lived combinations which are susceptible to the asymmetric decays of the "X" IVBs of level H2 - creating the matter-only universe we inhabit. The "leptoquark" concept provides the missing link between the hadrons and leptons, and clarifies the relationship between the electromagnetic and strong forces - including the origin of the latter as the symmetry debt of whole-unit quantum charge.

The three levels of Higgs bosons gauge (fix the energy 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 to which it must rise. 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".)

At the highest (TOE) force unification level with the Higgs 3 boson, we have the "Y" IVBs and the primordial charged leptons and charged and neutral leptoquarks (Planck Era, fermion and boson "families" joined into an electromagnetic "order" - Gamow's "Ylem"); the intermediate (GUT) force-unification level with the Higgs 2 boson, the "X" IVBs, and (electrically neutral) leptoquarks and leptoquark neutrinos (Leptoquark Era, quark and lepton "genera" combined into a fermion "family", but not with bosons); the next lower (EW) force unification level with the Higgs 1 boson, the "W" IVBs (Hyperon Era), with leptons and quarks combined within themselves as separate "genera"; still below all these we find the final ground state electromagnetic (EM) realm of light (Atomic-Chemical Era), expanded and cold spacetime dimensions, gravity, ground state quark and lepton species (separate and distinct), and atomic matter. Once this ground state is reached, the material system immediately "rebounds" toward its original symmetric state via the gravitational creation of planets, stars, galaxies, and perhaps culminating in the "Big Crunch".

One way to understand the Higgs and its associated IVBs is by analogy with the "ground state" electromagnetic force and its associated photon. "Velocity c", the electromagnetic force constant, is the "gauge" or scalar of the spacetime metric, and the photon is its force carrier ("field vector"). "Velocity c" gauges a symmetric energy state of the spacetime metric in which the photon is non-local, and time and distance (x, t) are banished. Leptons and quarks are stable at this ground state energy level, and can only be transformed, created, or destroyed at the next higher energy level or symmetric energy state

(H1, the EW force-unity state). (Neutrinos, however, can apparently oscillate among their several flavors even in the EM ground state.)

In an analogous fashion, the mass of the Higgs boson is the weak force gauge constant, scaling a "particle metric", and the "W" IVB family is its force carrier. The massive Higgs boson "gauges" a symmetric energy state of force-unity and generic particle identity (the electroweak unified-force particle "metric" or regime), in which the IVB is "non-local" in the sense that it has no specific identity. Instead, the "W" IVB has many potential quark and lepton identities (the alternative charge carriers it produces - leptons, neutrinos, quarks, mesons), while the independent existence of the elementary leptonic and quark species is banished. Baryons may be transformed but not created or destroyed at the H1 energy level (due to the conserved color charge of their quarks). The creation and destruction of baryons becomes possible only with the merger of the quark and lepton "genera" into the "family" of fermions and leptoquarks at the next higher GUT or H2 energy level.

Most curiously, we see astrophysical, gravitationally bound states tracking or reprising (approximately) the four stages of the "Higgs Cascade" and force unity states. The planets in stage 1, the electromagnetic ground state; stars in stage 2, the electroweak state of lepton and quark transformations; black holes in stage 3, the GUT state (where proton decay is thought to be commonplace); and finally the Big Crunch in stage 4, where gravity, spacetime, light, and particles are all fused together in the ultimate mixture of matter and antimatter, positive and negative energy.

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