The Higgs Boson vs the Spacetime Metric

(Revised Dec., 2010)

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(See also: "The Mysteries of Mass" by Gordon Kane, *Scientific American,* July 2005, pp. 41-48; and: "When Fields Collide" by David Kaiser, *Scientific American,* June 2007, pages 63 - 69.)

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Abstract

Currently, there seems to be (at least) two interpretations of the activity of the Higgs boson: 1) the older, original interpretation of the Higgs as the scalar or gauge boson which determines the *rest masses* of the IVBs and elementary particles (which I can understand and endorse); 2) a newer (additional? alternative?) interpretation consisting of a "Higgs ether" which acts as the source of particle mass in the sense of *inertial resistance* to acceleration. In this latter interpretation, all massive particles interact with a universal Higgs field in proportion to their bound energy content, and it is this interaction or "Higgs ether drag" which causes the inertial resistance to acceleration we characterize as mass. It is this latter interpretation which I cannot understand or endorse, as it seems to force a distinction between rest mass and inertial mass, and has no power at all to explain Einstein's relativistic mass. However, replacing the "Higgs ether drag" hypothesis (but retaining the Higgs scalar hypothesis) with a "gravitational field drag" hypothesis does allow us to understand the mechanism of relativistic variability in the metric and energetic parameters of mass, and crucially preserves the necessary equivalence between inertial and rest mass.

Introduction

In terms of Newtonian or low-velocity mechanics, the inertial resistance to acceleration by mass is simply explained by the conservation of energy. Energy is obviously required to accomplish an acceleration, in direct proportion to an object's mass (F = ma). There is nothing particularly mysterious about mass or inertial resistance at low velocity. Classically, mass was at least no more mysterious than energy or spacetime; the equivalence between gravitational "weight" and inertial mass was its greatest mystery. Einstein explained that puzzle but introduced new ones: according to the high-velocity mechanics of Special Relativity, inertial mass increases with increasing velocity, clocks slow and meter sticks shrink with increasing velocity, destroying the classical simplicity of metric symmetry and energy conservation. Energy conservation and causality nevertheless prevail, of course, but it requires a changed (or "warped") metric to do so, and a new understanding of the relation between free and bound electromagnetic energy (E = mcc), and between gravitation and spacetime.

More recently still, a new question regarding the scalar origin of the mass of the elementary particles has been raised, a question answered by positing the "Higgs" mechanism (as originally suggested by Peter Higgs). The Higgs boson acts as a mass scalar which determines the masses of the weak force IVBs

(Intermediate Vector Bosons), and subsequently, acting through the IVBs, "gauges" the specific masses of the elementary particles (formalized in the mathematics of the electroweak unification of the "standard model").

The Higgs Field vs the Spacetime Metric

In his book "Nothingness: The Science of Empty Space" by Henning Genz (English Translation 1999, Perseus Books Pub. L.L.C.), on pages 228-237, Genz provides an illuminating explanation of the "Higgs" field and particle, currently the "Holy Grail" of particle physics. As I read and reread this section, I was struck with the similarity between Genz's description of the interaction of the Higgs field with a particle, and my own notion of the interaction of the spacetime metric with a particle's gravitational field. In Genz's description of the Higgs mechanism, the interaction of a particle with the Higgs field provides the particle's attribute of inertial mass (resistance to acceleration); in my conception, a particle's inertial mass or resistance to acceleration is the consequence of the interaction of the particle's gravitational field with the metric field of spacetime.

I am considering the distinction here between the "rest mass" energy content (E = mcc) of an elementary particle (quarks, leptons), which is evidently scaled by the Higgs boson, and the inertial mass due to acceleration (or the gravitational mass or "weight" of the same particle). M is the same quantity in all three cases, and must be, for energy conservation reasons, which is the rationale for this discussion. However, to attribute the inertial mass of acceleration to an interaction between the Higgs scalar and elementary particles (as a sort of modern-day "ether drag") is to lose the identity between rest mass and inertial mass in non-elementary particles, since the binding energy component of rest mass (which is considerable in composite particles such as baryons) cannot be attributed to the Higgs interaction. We preserve this identity (necessary for energy conservation) by attributing a particle's inertial mass of acceleration to the interaction between the spacetime metric and a particle's gravitational field, as we know the gravitational field is an exact measure of the total bound energy content of a particle (Gm), whatever the source of that bound energy may be (elementary particle "rest" mass, composite particle binding energy, etc.). (See also: "A Description of Gravitation"). Crucially, this formulation also preserves the identity between gravitational "weight" and inertial mass, as well as Einstein's "Equivalence Principle".

The gravitational field of a massive particle is produced by the intrinsic (entropic) motion of the particle's time dimension, exiting space at right angles to all three spatial dimensions, and dragging space along behind it (see: "The Conversion of Space to Time"). The spatial dimensions self-annihilate at the gravitational center of mass, leaving behind an uncanceled, metrically equivalent temporal residue, which in turn moves on down the time line into history, pulling more space behind it, repeating the self-feeding entropic cycle forever. *A gravitational field is the spatial consequence of the intrinsic motion of time*. Time is the primordial entropy drive of bound energy, produced by the gravitational annihilation of a metrically equivalent quantity of space. (see: "Entropy, Gravitation, and Thermodynamics").

Gravity

The interaction of a massive particle's gravitational field with the spacetime metric is an interaction with the same spacetime metric that originally established the weak force IVBs and the particle "zoo" through its interaction with high-energy light during the "Big Bang". Even though the Higgs may be an attribute of the spacetime metric (as a weak force mass scalar), setting the energy scale for the IVBs and by extension for the rest masses of the elementary particles they produce, this is a one-time high-energy interaction; the Higgs field does not continue to interact with particles (as a sort of "ether drag") to produce their inertial resistance to acceleration. Instead, this role is played by the spacetime metric, interacting with a particle's gravitational field, an interaction which produces a particle's inertial resistance to acceleration, and precisely in proportion to its mass. It also seems highly unsatisfactory to attribute part of a composite particle's *inertial* mass of acceleration to the interaction of its elementary components with the Higgs boson, and another part (binding energy, for example) to some other, non-Higgs type of inertial interaction: "inertial mass" should arise from a single source to retain its identity with "rest mass" and "gravitational weight". The "Higgs field" may be necessary to gauge the energy scale and regulate the specific *rest mass* or quantized bound energy content of the weak force IVBs and the various elementary particle species (quarks and leptons) the IVBs create, but has nothing further to do with their mass as observed in inertial resistance to acceleration (or gravitational "weight"). The quantization of the Higgs and IVBs is necessary to ensure the invariance of the single elementary particles they produce. (See: "The Higgs Boson and the Weak Force IVBs".) Even though the Higgs may be viewed as a scaling property arising from the metric itself (a "metric" particle), and as establishing through the IVBs the rest masses of particles, this is not the specific attribute of the metric which creates inertial mass as defined by resistance to acceleration. Energy conservation, as well as Einstein's "Equivalence Principle", requires that the "m" in "rest mass" ($E = mcc$), inertial mass (resistance to acceleration: $F = ma$), and gravitational "weight" ("gm" in an equivalent local field), are all identical.

Mass, Energy, Time

Let us take note at this juncture of the relationship between mass, energy, and time, which we find not only in the non-obvious notion that gravitation, which is exactly proportional to and produced by mass (Gm), creates time and the entropy drive of bound energy (through the annihilation of space and the extraction of a metrically equivalent temporal residue); but also in the famous set of equations relating "frequency" and energy: $E = h\nu$ (Einstein-Planck); $E = mcc$ (Einstein); $h\nu = mcc$ (de Broglie) (the time component is implicit in *frequency)*. This subtle relationship emerges again in the notion of the increase of a particle's mass with relativistic motion in Einstein's Special Relativity, a puzzling result which is explained through the concept that a particle's inertial mass is entirely due to the interaction of its gravitational field with the metric field of spacetime.

The "mass" or inertial resistance to acceleration offered by a particle is due to the interaction and interference of the particle's gravitational field with the metric field of spacetime. The interaction of these two fields also produces the anomalous results of relativistic motion in the spatial, temporal, and mass parameters of the moving or accelerated system, as discovered by Einstein (slowing of clocks, shrinking of meter sticks, increasing particle mass). Because (in this view) the inertial mass of the system is from the outset attributed to the interaction of its gravitational field with the metric field of spacetime, the relativistic increase of mass with accelerated motion is seen as a natural outcome of the interaction, interference, and especially the feedback between the temporal (or "frequency") components of these two metric fields, and the connection (mentioned above) between frequency, time, energy, and mass (including the covariance of space with time).

Recall that although the gravitational field of a particle may seem to be weak, it extends throughout the Universe, and the negative gravitational energy of a particle is equal in magnitude to its positive rest mass energy - a notion attributed to Pascual Jordan and demonstrated by black hole theory (through the complete conversion of the black hole's gravitational field energy to light via Hawking's "quantum radiance").

Lorentz Invariance

A particle's inertial resistance to acceleration might also be explained as the energy required to distort a particle's metric parameters in the service of "Lorentz Invariance" - maintaining the invariance of velocity c, Einstein's "Interval", causality, charge, etc. (the slowing of clocks and the shrinking of meter sticks in Einstein's Special Relativity theory, due to the relative motion of massive objects). However, this perfectly plausible explanation (in terms of ultimate principles) cannot be distinguished from the gravitational argument, and lacks the latter's proximate mechanism - in which the graviton or the temporal component of spacetime acts as a "local gauge symmetry current" protecting "velocity c".

The equivalence of gravitational and inertial mass ("weight" vs resistance to acceleration - leading to Einstein's "Equivalence Principle") is due not only to the reciprocal character of the spacetime accelerations of gravity vs (for example) rocket engines, but to the interaction in both cases of a particle's gravitational field with the metric component of (identically but reciprocally) accelerating spacetime. Likewise, the vanishing of "g" forces in orbit or free-fall is the vanishing of the forced interaction between the two fields. Time is the common feature of gravity, acceleration, and even mass (as we saw above, through "frequency": h*v* = mcc). In contrast to immobile, massive matter, note in this connection that light, whose "inertial" state is "intrinsic" motion in space with "velocity c", has neither mass, a time dimension, nor a gravitational field, and consequently and significantly, has *no inertial resistance to acceleration*. (See: "Does Light Produce a Gravitational Field?")

Postscript

The Higgs Boson and the Higgs Particle Metric

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We must use analogy to gain some level of understanding concerning the unfamiliar concepts of the Higgs field and the Higgs boson (the latter is the quantum unit of the field). We are familiar with the spacetime metric and the photon. The spacetime metric is the low-energy analog of the Higgs field and the photon is the analog of the Higgs boson. The spacetime (or electromagnetic) metric regulates the common features of our dimensionality - the symmetric relations between the dimensions as well as the various particles it contains, as manifest through the very limited varieties of virtual and real particles spacetime will produce and maintain (the leptonic and hadronic families of elementary particles). The electromagnetic metric is "gauged" or regulated by "velocity c", the electromagnetic constant, which determines the "velocity" of light (actually "c" is the gauge of the entropy drive of free electromagnetic energy, as well as the gauge of light's non-local distributional symmetry: simultaneously everywhere). The gauge constant c also determines the magnitude of electric charge, the inertial properties of spacetime, the invariance of causality and Einstein's "Interval", and the energetic equivalence between free and bound forms of electromagnetic energy: E = mcc. We are composed of electromagnetic energy and live within its conservation domain. We must obey the conservation rules laid down by the gauge constant c and the spacetime metric which it establishes, regulates, and maintains. The "tyranny of velocity c" is how we usually experience the limitations of this metric, but is is also limited in terms of its dimensionality and the paucity of its elementary particle spectrum.

The special feature of our spacetime or electromagnetic metric is that it will produce a (limited) spectrum of elementary particles (in particle-antiparticle pairs) when it is supplied with sufficient energy. This phenomenon tells us that electromagnetic energy exists in two forms - free (light) and bound (particles). There is no explanation for this fact anymore than there is an explanation for the existence of light or free energy. But the universe of our experience obviously depends upon it - we live in a compound conservation domain of free and bound electromagnetic energy. (The only explanation on offer is that the negative energy of the gravitational field of bound energy is required to balance the positive energy of the "Big Bang", and so allow the creation of the universe from no net energy. Similarly, the primordial presence of antimatter was required to balance the charges of matter, allowing the creation of the cosmos from a condition of no net charge.) When our familiar spacetime metric is sufficiently compressed, its particle nature, rather than its wave nature, is expressed. This is the principle which links all the Higgs energy levels with our own. The Higgs metric is a particle metric rather than a dimensional metric, and its symmetries are between particles and forces rather than between dimensions.

Now imagine our entire electromagnetic metric raised to a (much) higher energy level in which the spacetime metric is replaced by the Higgs (or "particle") metric, the photon is replaced by the Higgs boson, and the gauge (regulatory) role of the electromagnetic constant ("velocity c") is replaced by the Higgs gauge constant which we will designate as Higgs1 (since there are several higher energy Higgs conservation domains). Such a high energy conservation domain existed in the very early universe, and actually exists today in the extremely ephemeral and limited form of the weak force "Intermediate Vector Bosons" (IVBs), the W+, W- and Z (neutral). A defining feature of this energy level is that it is the energy level at which the electromagnetic and weak forces are unified - the domain of the so-called electroweak force. The union of these forces comprises an energy state of higher symmetry than that of our familiar ground state, the electromagnetic state; we can designate the latter (for convenience) as H0. We envision a cascading series of force-unity symmetric energy states beginning with H3 at the moment of the "Creation Event", in which all 4 forces were united, including gravity: the TOE or "Theory of Everything" state in which leptoquarks are created and destroyed (the era of "Ylem").

The particles of the initial state (H3) were designated as "Ylem" by George Gamow, and apparently consisted of a "quark soup" which the "Y" IVBs of the weak force organized into electrically neutral leptoquarks. These latter persist as the main constituents of H2, the "Leptoquark Era", where they decay asymmetrically to produce matter and hyperons (heavy baryons) of the H1 energy level. Mass is created in H3 by the interaction of gravity with the other forces, including light and the spacetime metric, or (equivalently) gravity and the H3 Higgs field. An "inflationary" era may have occurred between H3 and H2, causing a huge expansion of the early universe, but this theory remains controversial. (See: "Inflation".)

As the universe expanded and cooled, it stepped down to H2, the force-unity symmetry state in which the strong and electroweak forces are unified (the GUT or "Grand Unified Theory" symmetric energy state in which baryons are created and destroyed - the leptoquark era resulting in the creation of matter). With further expansion and cooling the universe steps down to the H1 or electroweak force-unity symmetry state (the hyperon era under consideration here), in which individual leptons and quarks are created, transformed, and/or destroyed. The final stable ground state of the universe is that of our daily experience, H0 or the electromagnetic ground state in which only information states (electron shell chemical combinations) are created and destroyed. (All nuclear reactions/transformations belong to the H1 energy level or above.)

The symmetries of these force-unity or Higgs states are manifest in the union of particle identities as well as of forces. In the H0 ground state, all particle identities are separately conserved; in the H1 state all leptonic particle identities are joined and all quark identities are joined; in the H2 state the leptonic identities are merged with the quark identities; and at the H3 state, boson and fermion identities are unified - all forms of energy, bound or free (including gravity), are united in H3. The biological taxonomic scheme in which species identities are progressively subsumed at the genus, family, and order levels of relationship presents a familiar analogy from the H0 information domain.

Each of these force-unity states must be distinguished by its own Higgs boson or scalar particle, not only to unambiguously distinguish one Higgs state from another, but crucially to maintain the conservation parameters of mass, charge, identity, energy, etc., of the various particles as they fall through the cascade of manifestation to the ground state. Hence the need for quantized scalar particles or distinct Higgs bosons at every level, to ensure conservation and exact replication of the conserved parameters of elementary particles. Elementary particles created today must be the same in every respect as those created eons ago in the "Big Bang" - for obvious reasons of energy, symmetry, and charge conservation.

The Earth is the domain of chemical transformations, information, and the H0 ground state, but the Sun is a domain of nuclear transformations where the H1 or electroweak state is commonplace (in the interior), as leptons are created and destroyed and quarks are transformed during the conversion of protons to neutrons and hydrogen to helium. These transformations are accomplished by the weak force IVBs, representatives of the H1 symmetry state, in which all leptonic identities are equivalent and all quark identities are equivalent (H1 is the "generic" state for both leptonic and quark "species"), and hence transformations (or "swapping") of specific identities within the leptonic "genus" or within the quark "genus" are simply the normal course of events.

At the high temperatures of H1, all particles are moving so fast they are essentially the same as photons moving at velocity c. At the H1 energy level, there are no large, empty dimensions: instead, the metric is densely occupied with particles (quarks and leptons); photons cannot move freely under these conditions in any case. Symmetry is expressed through a "particle metric" rather than a dimensional metric. Symmetry-breaking occurs as these particles are released into the large spacetime dimensions of H0, where their differential "rest mass" shows up as inertial and gravitational mass differences. The Higgs boson does indeed replace the photon in H1.

The necessity for the Higgs mechanism is due entirely to the necessity for mass as carried by *single* particles of matter (not particle-antiparticle pairs). Mass in necessary because of its gravitational field, which provides negative energy to balance the positive energy of the Creation Event, allowing the universe to be born as a quantum fluctuation of no net energy. Hence mass is required for the universe to exist - it is not an accidental, incidental, or trivial component of the cosmos. (Nor are we: we are required so that the universe may know itself and enlarge its creative capacity.)

Summary

The spacetime metric is the common thread that links the 4 levels of the "Higgs Cascade". The metric is compressed more and more severely at each higher level of the cascade (at each earlier era of expansion) and the Higgs bosons (H1, H2, H3) gauge or identify each stage of compression. Each stage represents a merging of forces and particle identities, and at each stage a specific type of particle can be produced: at H1 leptons and individual quarks (alternative charge carriers) can be created, transformed, and destroyed (and baryons can be transformed but not created); at H2 barons can be created and destroyed (and matter is asymmetrically created without antimatter); at H3 leptoquarks are created and destroyed (and mass - bound electromagnetic energy - is created). The quantization of these various stages by the several Higgs bosons ensures that the elementary particles created in them will be the same whenever and wherever they are produced and reproduced - an obvious requirement of energy, symmetry, and charge conservation.

The Higgs bosons regulate, gauge, or identify the higher symmetric energy states of the particles and forces in the same sense as the electromagnetic constant c regulates the symmetric aspects of our more familiar (and much expanded) spacetime metric. The spacetime metric can and will produce (and annihilate) elementary particles in symmetric particle-antiparticle pairs, either as virtual particles or as real particles whenever sufficient energy is available. It is a conservation function of the metric and the electromagnetic constant c to ensure the invariance of such particle pairs as well as their immediate or eventual annihilation. However, if single elementary particles are to be produced, without a corresponding annihilation partner, then the elaborate weak force mechanism must be engaged to recreate the original environmental conditions (heat, energy, density, etc.) in which these particles were first created to ensure their absolute invariance throughout space and time.

Mass or bound electromagnetic energy is created in H3 by the complete merger of gravity with the spacetime metric, free energy, and the other forces. The result is Gamow's "Ylem", the primordial substance, consisting of a "quark soup" in which the quarks are the mass carriers. These primordial quarks are either annihilated by antiquarks or organized into electrically neutral triplets by the "Y" IVBs, in which case they may live long enough to persist into the H2 era of expansion where their asymmetric decay as electrically neutral leptoquarks (via the "X" IVBs) produces the hyperon era and the matter content of our universe. Hyperons decay via the "W" IVBs of the H1 level to produce the protons and neutrons of the H0 ground state, along with their alternative charge carriers, the leptons, neutrinos, and mesons, which serve to balance charges in the absence of antimatter.

We can think of the IVBs as the particles of the Higgs metric. The IVBs are simply compressed, quantized examples of the early dense spacetime metric as it existed (in the case of the "W" IVB family) during the electroweak era of the "Big Bang", the time in the early universe when the electromagnetic and weak forces were unified. The compressed metric of the IVBs contains all the usual suspects of our ordinary spacetime metric - that is, the complete spectrum of elementary particles, both lepton and quark, that can be produced as virtual particles in our own universe, the H0 ground state. The big difference between a metric gauged by c (the ground state) and a metric gauged by the H1 Higgs boson (the electroweak state) seems to be that the IVB's virtual particles are so close together in the compressed metric that they can freely exchange identities without threatening or violating any conservation laws - which they cannot do in the expanded metric of the ground state.

Given the presence of a pre-existing "parent particle" ripe for a transformation (note that this is a pre-existing condition of asymmetry, due to the universal absence of antimatter) the IVBs will use their store of (access to) virtual particles to effect any transformation which is energetically possible and obeys the conservation laws regarding charge, spin, mass, momentum, etc. (See: The "W" IVB and the Weak Force Mechanism.) We can think of the "W" IVBs as the form of a "genus" or Higgs metric lepton or quark composite particle. Similarly, the "Z" neutral IVB would represent the generic or Higgs metric form of a composite neutrino particle. In any case, we see that the weak force asymmetry may often (not always) be imposed from the pre-existing environmental conditions (such as a single pre-existing matter particle), while the weak force IVB acts from its symmetric reservoir of virtual particle-antiparticle pairs. The original asymmetric production of matter baryons is, or course, traceable to the asymmetric weak force decay of electrically neutral leptoquarks in the H2 or GUT Leptoquark Era.

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