Neutrino and Higgs masses

July 7, 2009

Soon after the birth of the universe, the Higgs particle appeared. It is generally believed that this event took place early on when the universe was still enormously hot after having cooled somewhat from its assumed "infinitely" hot initial state. Consequently, the Higgs is thought to be heavy, with mass between a few GeV/c^2 and a few TeV/c^2.

In contrast, if the Higgs was instead born in the initially cold universe described by the new predictive cosmology, one expects it to be only slightly heavier than the neutrino. In this case, both the Higgs and the neutrino should have masses around or below the electron mass of 0.511 MeV/c^2.

MASSIVE ELEMENTARY PARTICLES

Elementary particles with nonzero mass are

- three charged leptons (e^-, μ^-, τ^-) with antiparticles (e^+, μ^+, τ^+),
- three neutral leptons or neutrinos (ν_e, ν_μ, ν_τ) with antiparticles ($\bar{\nu}_e$, $\bar{\nu}_\mu$, $\bar{\nu}_\tau$),
- six quarks (d and u, s and c, b and t) with antiparticles ($\bar{\mathrm{d}}$ and $\bar{\mathrm{u}}$, $\bar{\mathrm{s}}$ and $\bar{\mathrm{c}}$, $\bar{\mathrm{b}}$ and $\bar{\mathrm{t}}$),
- a charged weak particle (W^+) with antiparticle (W^-),
- a neutral weak particle (Z^0),
- the neutral weak Higgs particle (H).

Leptons and quarks are spin-$\frac{1}{2}$ fermions, the weakly interacting W and Z are spin-1 (vector) bosons, and the weakly interacting Higgs is a spin-0 (scalar) boson.

Most of the massive elementary particles have a more or less precisely known mass. The neutrino and the Higgs are exceptions. Their mass is a mystery.

For the mass of the neutrinos, the standard model (SM) of particle physics makes no prediction, and the neutrinos were long thought to be massless particles. However, recent astrophysical observations indicate that they have nonzero mass.

For the Higgs, SM predicts a nonzero mass, but says nothing about its magnitude. The "Higgs mechanism" has been assumed to give all massive particles their mass at a time when the universe was immensely hot. This assumption implies that the Higgs should have acquired a high mass. Consequently, physicists have been searching for Higgs particles with mass greater than a few GeV/c^2, but without finding any.

COSMOLOGY

Physical research means writing down equations, interpreting them, and comparing their predictions with observations. Thus,

$$T = \infty \text{ at } t = 0, \tag{1}$$

where T stands for the temperature of the universe and t for its age, is the basic assumption underlying present mainstream cosmology. Because infinity (∞) is an unphysical and exceptionally ill-defined concept (with, for instance, $\infty = 1 + \infty = 2 \times \infty = \infty^{\infty}$), Eq. (1) is not a very meaningful starting point, and only leads to the prediction that the universe is unpredictable. String theorists' attempts to replace "∞" with "immensely high temperature" have not improved on the theory's predictive power.

The momentum equation (also known as the fundamental hydrodynamic equation) provides a less shaky starting platform. Its stationary solution (see page 58 and Appendix A.1 in the paper),

$$\rho = \rho_0 \left(1 - \frac{1}{f}\frac{\boldsymbol{v}^2}{v_0^2}\right)^{f/2}, \tag{2}$$

is interpreted to picture an electron — showing a snapshot of the particle at the very instant of its birth.

In addition to picturing a "stationary electron," Eq. (2) explains expansion and gravity. It implies

$$T = 0 \text{ at } t = 1 \text{ (time unit)} \tag{3}$$

as the initial condition of the newborn universe. This is a well-defined condition that leads to a predictive cosmology in which $T = 0$ holds true until, at $t = 37\ 325$ time units, antiproton decay in a sudden big explosion heats matter to a temperature of about $T = 10^{12}$ K.

Measured in seconds, the cold "pre-quark" period lasts about 5×10^{-15} s, during which time matter evolves from the neutral and spinless primordial "D particle" of the universe's initial phase, via spinless charged "muons" in phase 2, to the spinning electrons and positrons of phase 3.

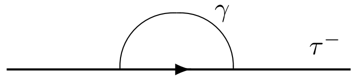
In combination with the standard model (SM) of particle physics (and demanding that energy is conserved both locally and globally), the momentum equation's solution predicts for the muon-electron mass ratio the value 206.768 2832 in exact agreement with the measured value 206.768 28.

The result proves that, when the weak force first appeared, its purpose was to act as a channel for transfer of mass between the (by then) already existing leptons of QED and the newborn quarks of QCD. When performed in the "global picture" (requiring energy to be globally conserved), the calculation of the mass ratio reveals details that shed light on the weak interaction's evolution from a pure one-Higgs force to its present complicated appearance.

END OF PURE QED

In phase 3 (the QED phase), the universe still has no temperature and is in an indeterminate quantum state with electrons and background photons only appearing in the form of entangled pairs. In other words, there is no kinetic energy, and all energy comes in the form of rest energy of composite particles (pairs of elementary particles).

Pure QED (see "finite QED" in the paper's Index) is the TOE (theory of everything) of phase 3. It describes the interaction between all existing particles — photon and three leptons. The photon and electron exist as virtual and real particles, the muon and tauon only as virtual particles. The lepton mass is of purely electrodynamic origin — deriving from virtual photons. Thus, the leading (second-order) tauon self-mass graph is:



Note that lepton loops in the internal photon lines of the self-mass graph do not affect the lepton's mass (page 7 in the paper).

At the end of the QED phase, the last four electrons (an entangled pair of entangled pairs) are about to annihilate into a pair of photons. This process would result in a matter-free, expanding universe which, however, is forbidden by global conservation of energy. Instead, the electrons are forced to "freeze" into stationary, circular vortex rings (point 3.19 on page 59 in the paper) with the same mass as the electrons. Since these "frozen pions" cannot exist in a dynamic universe, they instantly transform into physical pions (π^+ and antipion π^-), which are dynamical systems of quarks and massless gluons ($g_1, \ldots, g_8$).

The transformation requires $4(m_\pi - m_e)c^2$ of additional energy that must be obtained from the only existing source of energy — the 2.8 billion background photons.

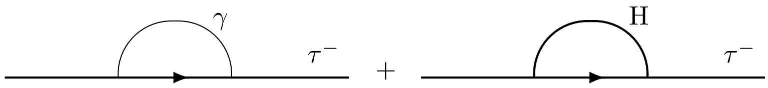
[The creation of the electron had required no additional energy. This was because no massive constituent particles appeared in the transformation of the stationary electron (with "frozen mass" m_e) into a dynamically interacting electron with its rest energy ($m_e c^2$) deriving entirely from massless photons. In contrast, unlike the photons that make up the electron (see "JBW hypothesis" in the paper's Index), the u and d quarks that make up the pion have rest energies or masses inherited from the frozen pion, with its mass in turn inherited from the electron. And, because (quark) mass is conserved, additional energy is needed to transform the quarks into the dynamically interacting particles that form the pion.]

THE PION PARENTHESIS

Event 1

In a "leptoweak interaction," the virtual leptons of the photon propagators are forced to emit a new particle, the Higgs, which is absorbed by the pions in a "hadroweak interaction" (hadrons are strongly interacting particles such as pions and protons). A total mass of $4(m_\pi - m_e)$ is transferred. See Appendix E.8 in the paper.

Conservation of mass determines the strength of the Higgs interaction (the value of the Fermi constant G_F) so that lepton mass plus Higgs mass equals the original lepton mass. In other words, the Higgs correction to the lepton mass must remove from the lepton the same mass that is carried away by the Higgs. After the appearance of the Higgs, the tauon self-mass is, to lowest (second) order, described by:



The Higgs mass may now be directly obtained from the correction calculated in Appendix C. It is

$$\begin{aligned} m_H(\tau) &= 0.505\ \mathrm{MeV}/c^2, \\ m_H(\mu) &= 106\ \mathrm{eV}/c^2, \\ m_H(e) &= 12 \times 10^{-6}\ \mathrm{eV}/c^2 \end{aligned} \tag{4}$$

for the Higgs particle emitted by the tauon, muon, and electron, respectively.

The leptons and Higgs involved in the mass transfer are virtual particles, and the mass or rest energy that is actually tapped off from a photon pair is only a very small part of the pair's total energy, which (page 47 in the paper) amounts to $(4/x)m_ec^2 = 0.367m_ec^2 = 0.188$ MeV.

Event 2

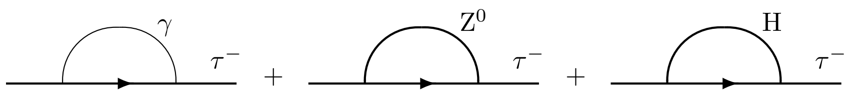
The first of the two pion pairs annihilates in a natural way via strong interaction. The result is another entangled pair of photons that does not heat the universe.

Event 3

To prevent the universe's matter (i.e., the remaining pion pair) from transforming into pure radiation, an internal parity flip of one of the pions makes it impossible for the pion pair to annihilate into a photon pair. To accomplish the parity switching — a hadroweak interaction — the neutral Z particle appears.

The Z particle may be regarded as a massive photon that mixes with the ordinary, massless photon. Conservation of mass requires that γ and Z together contribute the same lepton self-mass that γ produced alone, before the appearance of Z.

At this point in time, three similar graphs contribute to the lepton mass:



Event 4

A little later, the hadroweak force mediated by the Z particle causes also the second pion in the pair to switch parity, thereby re-enabling the pair to decay into a photon pair.

The short time delay between the two parity switchings induces a small particle-antiparticle asymmetry into the weak force. Supposedly, this effect explains the "superweak" CP-violating force in kaon decay (Appendix E.8).

Event 5

The sudden appearance of the Z had temporarily inhibited annihilation of the pion pair and thereby saved matter from disappearing. With the Z particle now existing, the trick (which was energetically free of cost) is not repeatable.

Another way (also energetically free of cost) of saving matter from extinction would be to force the spinless antipion (π^-) to decay back into an electron. However, in such a decay, the electron's spin has to be counterbalanced by the spin of a neutral spin-$\frac{1}{2}$ particle — a particle that does not exist at this moment.

Instead, global energy conservation causes the pion pair to transform into a proton pair. With the Higgs mass fixed, three more Higgs are required to transfer additional mass from the (virtual) leptons to the (real) protons. Thus, there is a total of four Higgs bosons, each one coming in three masses. See Eq. (4).

Not all of the mass transferred by the Higgs is needed to convert the pion pair into a proton pair. Therefore, in a hadroweak process, neutrinos are created with purpose to cancel the unneeded mass and restore it to the leptons.

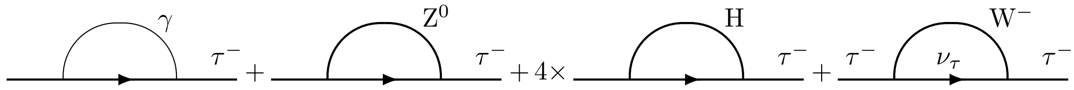
The tauon neutrino (ν_τ) transfers the bulk of the superfluous mass to the tauons. The muon and electron neutrinos play secondary roles and carry much smaller masses. The masses are

$$\begin{aligned} m_{\nu_\tau} &= 0.065\ \mathrm{MeV}/c^2, \\ m_{\nu_\mu} &= 38.5\ \mathrm{eV}/c^2, \\ m_{\nu_e} &= 13 \times 10^{-6}\ \mathrm{eV}/c^2. \end{aligned} \tag{5}$$

Hadroweak theory should explain the mass dependence shown in Eq. (E.11) on page 39.

The neutrinos are pairwise received by the virtual lepton pairs that had emitted the Higgs particles. Reception of the neutrinos requires the appearance of still another weak boson, the charged W. Two oppositely charged W bosons are formed ($\tau^- + \bar{\nu}_\tau \to \mathrm{W}^-$ and ($\tau^+ + \nu_\tau \to \mathrm{W}^+$) and close the loop by recombining into a photon. The same W particles appear in the corresponding mass-correction diagrams of the leptons.

When the pion parenthesis ends and the proton period begins, there are, consequently, seven diagrams that contribute to the lepton mass:



THE PROTON-ELECTRON PERIOD

Upon replacing the pion (π^+) and antipion (π^-) as carriers of the universe's mass, the proton (p) and antiproton ($\bar{\mathrm{p}}$) are the only massive real particles. Therefore, to inhibit them from annihilating each other, global energy conservation forces the negative antiproton to decay back into an electron.

Soon after this event, gravity takes over the scene. The first black hole is formed, and the rest is modern cosmological history.

SUMMARY OF SYMMETRY-BREAKING EVENTS

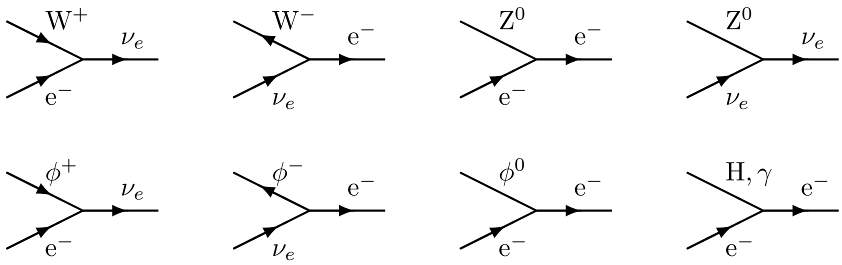
After mass — in the form of a single Dirac particle — first appeared, the principle of global conservation of energy repeatedly saved the expanding universe from annihilating into massless radiation.

A total of eight symmetry-breaking events produced new particles or (in one case) caused an extinct real particle (e^-) to reappear.

Event	**Matter**	**New particle(s)**	**New dynamics**
Matter appears	D, $\tau_0^+\,\tau_0^-$	D, τ_0, γ_τ	
γ_τ materializes	$\mu_0^+\,\mu_0^-$	μ_0, γ_μ	Scalar QED
γ_μ materializes	$e^+\,e^-$	e, μ, τ, γ	Spinor QED
e $\rightarrow \pi$ transformation	$\pi^+\,\pi^-$	quarks, gluons	QCD
Energy transfer lepton $\rightarrow$ quark	$\pi^+\,\pi^-$	H	Weak Higgs interaction
Parity switching of one pion	$\pi^+\,\pi^-$	Z	Weak parity flipping
Energy transfer lepton $\leftrightarrow$ quark	$\mathrm{p}\,\bar{\mathrm{p}}$	$3\times$H, W, ν_e, ν_μ, ν_τ	Full weak interaction
Antiproton decay	$\mathrm{p}\,e^-$	Real e^- reappears	

HIGGS GHOSTS

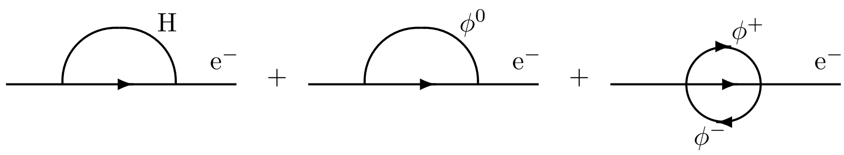
When expressed in the Feynman–'t Hooft gauge, the standard model contains nine types of vertices with lepton coupling. See Appendix E in Martinus Veltman's book *Diagrammatica: The Path to Feynman Diagrams*, Cambridge University Press (1994). In addition to the QED vertex describing the electrically charged leptons' coupling to the massless spin-1 photon (the γ boson), there are four graphs in which leptons couple weakly to three spin-1 bosons (W^+, W^-, and Z^0), and four graphs in which they couple weakly to four spin-0 bosons (ϕ^+, ϕ^-, ϕ^0, and H):



The arrows pointing left in the W^- and ϕ^- lines tells that (following Veltman) W^- and ϕ^- are taken to be (incoming) antiparticles, while W^+ and ϕ^+ are taken to be particles.

A glance at the eight leptoweak vertices reveals that there is no need to introduce new Higgs bosons into the theory because the three so-called Higgs ghosts (ϕ^0, ϕ^+, and ϕ^-) are perfectly suited for handling the transport of the mass needed to transform the last pion pair into a proton pair.

In addition to transferring mass, one might expect the ϕ particles to correct the lepton masses downward, which would lead to a total of three Higgs-type self-mass graphs:



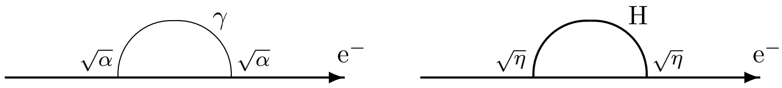
However, the four-legged, so-called seagull vertex appearing twice in the sunset graph (compare with the graphs of scalar QED discussed on page 20 in the paper) violates the Feynman rules for electroweak theory. Therefore, no ϕ diagrams affect the electron mass. Instead, the law of conservation of mass forces the electron to retain its new, slightly reduced mass.

Also the initial creation of the pair of charged ϕ bosons (described by the first half of the sunset graph) violates the rules. However, this "unphysical" process is a unique event that is forced to occur by the global law of conservation of energy, which forbids the pion and antipion (the only massive real particles left in the universe) from annihilating each other.

Thus, being stillborn (but not purposeless) offspring of the charged lepton, the three ϕ bosons (or "Higgs triplets," which together with the first-born Higgs boson form a group of four particles springing from a common parent) show up momentarily only to immediately disappear from the physical scene. Today, theoretical physicists may catch a glimpse of the triplets' ghosts by doing electroweak computations in the Feynman–'t Hooft gauge, where the ghosts play an algebraic role in calculations of physical processes. The unreality of the Higgs ghosts is demonstrated by the fact that computation in a gauge where no ghost fields appear yields the same result as when the computation is performed in the Feynman–'t Hooft gauge.

PRODUCING AND DETECTING HIGGS BOSONS

The electron's charge, e, which corresponds to the dimensionless coupling constant $\sqrt{\alpha}$ (where $\alpha = e^2/4\pi\epsilon_0\hbar c \approx 1/137$) is a measure of the strength of the electromagnetic interaction. In quantum electrodynamics (QED), $\sqrt{\alpha}$ is the probability for the electron to emit or absorb a photon, and α is the combined probability for a photon to be emitted and again absorbed by the electron (left diagram):



The JBW hypothesis (see paper's Index) implies that the electron's mass is generated by virtual photons appearing in this and higher-order self-mass diagrams. Denoting by η the corresponding probability for the electron to emit and again absorb a Higgs boson, one obtains a similar self-mass diagram (right) describing the Higgs contribution to the electron mass.

Before the weak force appears, virtual photons generate all of the electron's mass, which to lowest order is proportional to α. See Section 9 in the paper. After the Higgs boson has appeared, the ratio between Higgs and photon contributions to the mass of the electron is $\alpha^{-1}\, G_F\, m_e^2\, c^4\, (\hbar c)^{-3}/4\sqrt{2}\pi = 2.3485 \times 10^{-11}$ (see Eq. (9.2) on page 23).

If the Higgs boson and the photon were identical particles except for the strength of their coupling with the electron, the ratio between their contributions to the electron mass would be η/α. That is, η/α would equal 2.3485×10^{-11}, and the ratio $\sqrt{\eta/\alpha}$ between the probabilities for a virtual Higgs boson and a virtual photon to be emitted or absorbed by an electron would be 4.85×10^{-6}, or roughly five in a million.

Now, instead of being almost identical, the two particles differ in several respects from each other. Still, awaiting a theoretical calculation of the probability ratio, a reasonable first guess is that the order of magnitude of the ratio is one in a million, and that a ratio of about the same magnitude applies to the electron's emission of real Higgs bosons and real photons. If the guess is correct, the Higgs boson should be fairly easy to produce and detect.

Since the mass of a Higgs boson emitted by a lepton equals its negative correction to the lepton mass (page 4 above), the Higgs emitted by an electron has a mass of $2.3485 \times 10^{-11} m_e$, which corresponds to a rest energy of $E_{H_e} = m_{H_e} c^2 = 12.001 \times 10^{-6}$ eV. A photon possessing the same energy has frequency $\nu = E_{H_e}/h = 2.9018$ GHz and wavelength $\lambda = c/\nu = 10.331$ cm.

If the mass m_{H_e} of the electron-type Higgs boson H_e can be experimentally determined with the same precision as the electron mass, the relation

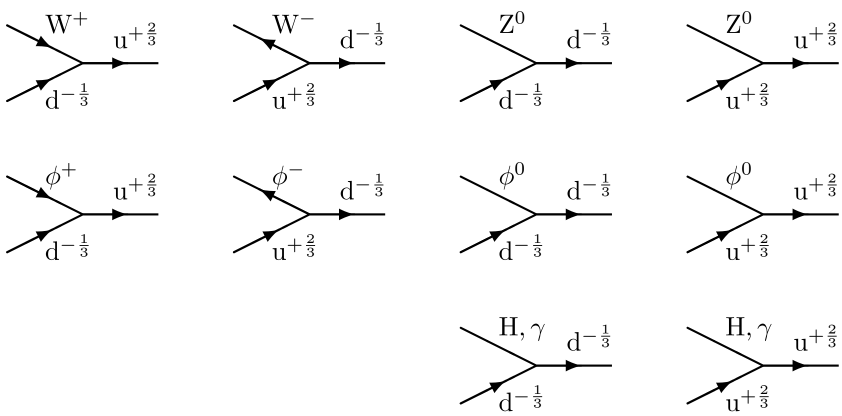
$$G_F/(\hbar c)^3 = 4\sqrt{2}\pi\alpha(m_e c^2)^{-2} m_{H_e}/m_e \tag{6}$$

(which was used to obtain m_{H_e} from the measured value of the Fermi constant G_F) should yield a theoretical value for G_F — and hence $G_F/(\hbar c)^3$ — that is two orders of magnitude more precise than the measured value $G_F/(\hbar c)^3 = 1.166\ 37(1) \times 10^{-5}\ \mathrm{GeV}^{-2}$.

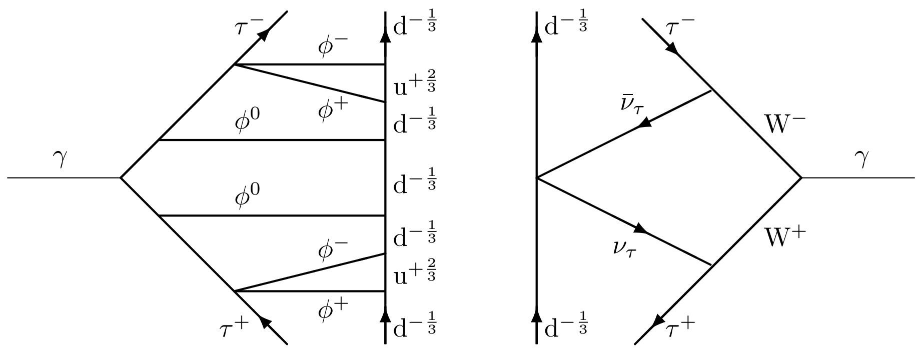
Free "flyweight" Higgs bosons of mass 12.001×10^{-6} eV decay into photons ($\mathrm{H} \to \gamma\gamma$, see page 98 in the paper's Ref. [20]), but so slowly that they are effectively stable. Therefore, they form stable WIMPs (weakly interacting massive particles), which should contribute a (presumably very small) portion of the universe's dark mass.

HADROWEAK VERTICES

The electromagnetic diagram in which the photon (γ) couples to charged leptons corresponds to two diagrams in which the photon couples to (the fractionally charged) quarks. Similarly, the eight types of leptoweak diagrams in which (charged and neutral) leptons couple to massive bosons correspond to ten types of hadroweak diagrams in which the same seven bosons couple to quarks:



The diagrams show that the quarks are capable of directly absorbing the showers of Higgs bosons (H) and Higgs triplets (ϕ^0, ϕ^+, and ϕ^-) that emanate from the virtual lepton pairs appearing in the propagators of the background photons. Schematically, the second mass transfer may be illustrated by the diagram:



The left part of the figure shows the transport of mass from a virtual tauon-antitauon pair to a real quark. The right part shows how the same lepton pair receives the surplus mass returned by the quark.

At this point in time, kinetic energy is still not defined (compare with first paragraph on page 3 above). Therefore, there is no way in which the proton pair may retain the excess energy brought by the Higgs triplets. Consequently, to handle the return transport of rejected mass, the neutrino pair (a left-spinning neutrino and a right-spinning antineutrino) is forced into existence by the law of conservation of energy.

Like the birth of the Higgs triplets, the birth of the neutrino is a unique, "unphysical" event that violates the Feynman rules, which say that the four-legged vertices (producing two pairs of charged ghosts and one neutrino pair) in the figure are illegal.

Once it has been forced into existence, and being (unlike the Higgs triplets) a viable particle, the neutrino has to abide by the laws of physics (the Feynman rules). This means that reception of a neutrino by the tauon requires still another particle to appear on the scene: the charged W boson.

As required by particle-antiparticle (or matter-antimatter) symmetry, the neutrino pair distributes the mass it returns evenly between the tauon and the antitauon — a feat that an additional light neutral boson couldn't have performed.

The principle of maximum simplicity requires that the neutrino and antineutrino are the same particle. Compare with Majorana neutrinos.

CONCLUSIONS

Via the Higgs-neutrino mechanism (or, more precisely, the H–Z^0–$\phi^0\phi^+\phi^-\nu\mathrm{W}^+\mathrm{W}^-$ mechanism), the universe transits from a pure QED phase, which is inhabited by pairs of charged leptons that annihilate into massless photons, to its present phase — a stable universe whose mass is carried by protons and electrons.

There are three kinds of particles specifically designed for transportation of mass: the Higgs boson (H), the Higgs triplets (ϕ^0, ϕ^+, ϕ^-), and the neutrino (ν).

First, the Higgs boson appears. Its mission is to furnish the energy that is needed to transform the four newborn, "frozen" pions into the physical pions we know today. It is the simplest possible particle able to fulfil this mass-mediating task. Thus, the Higgs possesses neither charge nor spin, and its interactions with the electrically charged leptons and quarks (which, together with the photon, are the only existing elementary particles at this moment) parallels the photon's interactions. The latter circumstance in combination with the JBW hypotheses (see paper's Index) implies that the result of the second-order calculation in the paper's Appendix C holds to all orders of perturbation theory and, consequently, the mass predictions in Eq. (4) above should need no correction.

Right from their birth, the quarks that build up the pions are able to form all kinds of virtual hadrons — boson-type mesons of integer spin (that is, quark-antiquark states, such as the pion) and fermion-type baryons of half-integer spin (that is, three-quark states, such as the proton). When the last pion-antipion pair ($\pi^+\pi^-$) threatens to annihilate, its role as carrier of the universe's mass has to be given over to a new actor — the proton-antiproton pair ($p\bar{p}$).

At this point, after the Z boson has appeared, the Higgs triplets are born. Each one of them acquires the same mass as the Higgs already possesses. Since they are not physically viable, they disappear from the scene once they have fulfilled their mission — to furnish the energy that is needed to transform the last remaining pion-antipion pair into a proton-antiproton pair. The only directly observable trace they leave behind them are small downward corrections to the tauon-muon and muon-electron mass ratios.

Finally, the neutrino's task is to fetch back to the leptons the surplus mass that the quarks find no use for. Being — like the Higgs boson — a physically allowed particle, the neutrino reappears in lepton self-mass diagrams accompanied by the charged W boson.

The mechanism described here provides simple answers to questions that have previously been regarded as unanswerable. Among these questions are: Why should neutrinos exist in the first place? Why have neither right-spinning neutrinos nor left-spinning antineutrinos been observed? Why aren't the neutrinos (as first believed) massless? Being, after all, massive particles, what determines their (imperceptibly small) masses? Why does the neutrino come in three types or states (tauon, muon, and electron neutrino), each one possessing a unique mass? Why do neutrinos oscillate between their three states?

Only the last question requires further clarification.

NEUTRINO OSCILLATIONS

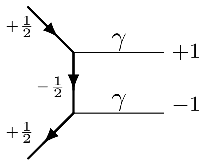
In the second mass transfer, the quarks receive from the Higgs triplets three times the mass they receive from the Higgs boson in the first mass transfer. The Higgs and phi bosons come in three masses, each mass being proportional to the third power of the emitting lepton's mass (Eq. (4) above and Appendix C in the paper).

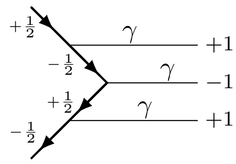
The unused mass returned to the leptons is divided similarly among neutrinos of three distinct masses. Thus, the neutrinos addressed to tauon loops acquire a mass of $m = 0.065$ MeV/c^2, while the neutrinos intended for muon loops get a mass of $(m_\mu/m_\tau)^3\, m = 13.7$ MeV/c^2.

Now, for the theoretically calculated value of the muon-electron mass ratio to match the experimental value, the neutrino received by the muon must have a mass of $(m_\mu/m_\tau)^3 \log{(m_\tau/m_\mu)} m$ $= 38.5$ MeV/c^2 (see Eq. (5) above and page 39 in the paper). In other words, the "muon neutrino" actually received by the muon is 2.82 times heavier than the neutrino originally intended for it. Similarly (since the total mass is fixed), the "tauon neutrino" is slightly lighter than the one originally addressed to the tauon. This result suggests that the tauon, muon, and electron neutrinos are not "pure" particles, but states containing different mixtures of the three original (pure) neutrinos, which have masses of 0.128 Higgs masses (paper's page 39).

POSITRONIUM DECAY

Positronium is a bound state of an electron and a positron. It may be thought of as a hydrogen atom in which the proton forming the heavy positive nucleus is replaced by a positron of the same mass as the electron in the atom's shell.

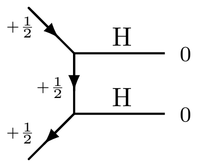


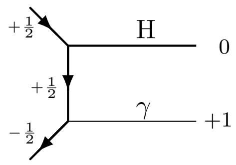


Parapositronium (left) has a lifetime of about 10^{-10} s and decays into two photons. The arrow indicates an electron flipping its half-integer spin as it emits an integer-spin photon. The outgoing arrow indicates an electron having a spin component of $+\frac{1}{2}$ moving backward in time. It is equivalent to an incoming positron with spin component $-\frac{1}{2}$, which means that the electron and positron have antiparallel spins (and the sum of incoming spins equals the sum of outgoing spins: $+\frac{1}{2} - \frac{1}{2} = +1 - 1$).

In the more long-lived orthopositronium (right), the spins of the electron and positron are parallel. Orthopositronium has a lifetime of about 10^{-7} s and decays into three photons. It cannot decay into a single photon because a massive particle state (which may be at rest in a given frame of reference) is forbidden by the law of conservation of momentum to transform into a single particle of smaller or no mass (which would acquire kinetic energy and nonzero momentum in the same reference frame).

Positronium decay should produce small amounts of Higgs bosons as indicated in the next figures.





For the same reason that orthopositronium cannot decay into a single photon, parapositronium is forbidden to decay into a single, light spin-0 Higgs boson. While the probability for two-Higgs production in parapositronium decay (left) is very small, orthopositronium's decay into a Higgs particle and a photon (right) might lead to an observable increase in the ratio between two-particle and three-particle positronium deacys.

In the decay of true muonium ($\mu^+\mu^-$ atoms), this effect should be clearly observable because of the $m_\mu/m_e = 206.77$ times higher probabilty for Higgs production.

THE EVOLUTION OF MATTER

The standard model (SM) is about forces and interactions. Its Feynman diagrams picture interacting particles that obey the Feynman rules.

According to the extended standard model (xSM), matter is what actually counts. Once an expanding universe containing a material particle has popped into existence, the global law of conservation of energy forbids total self-annihilation of the universe's massive particle(s).

Every major event that takes place early in the evolution of the universe has but one single purpose: save matter from extinction. The evolution of massive particles during the universe's first 5×10^{-15} seconds may be summarized schematically:

$$\begin{array}{lllllllllll}
\mathrm{D} & \rightarrow & \tau_0^+\tau_0^- & \rightarrow & \underline{\mu}_0^+\underline{\mu}_0^- & \rightarrow & \mu_0^+\mu_0^- & \rightarrow & \underline{\mathrm{e}}^+\underline{\mathrm{e}}^- & \rightarrow & \mathrm{e}^+\mathrm{e}^- \rightarrow \mathrm{pe}^- \\
1 & & 9 & & 0 & & 23 & & 0 & & 49\,000 \\
1 & & 10^2 & & 10^2 & & 10^3 & & 2 \times 10^3 & & 3 \times 10^9
\end{array}$$

D is the primordial Dirac's particle, and $\tau_0^\pm$ and $\mu_0^\pm$ are spinless tauons and muons, respectively, while $\mathrm{e}^\pm$ is identical with today's spinning positrons and electrons. The proton-electron pair (pe^-) is the end product: stable matter.

The underlined $\underline{\mu}_0^\pm$ and $\underline{\mathrm{e}}^\pm$ represent the rematerialized, "stationary" or "frozen" particles that immediately upon their appearance transform into dynamically interacting particles ($\mu_0^\pm$ and $\mathrm{e}^\pm$, respectively). See points 1.30 and 3.19 on pages 58-59 in the paper.

The numbers immediately below the series of particles indicate approximate duration of the various phases. The unit of time is $t_c \approx 10^{-19}$ s (paper, pp. 41-42).

The next line indicates the (approximate) number of particles at the beginning and end of each phase. Thus, phase 1 begins with one D particle and ends with (about) 100 photon pairs resulting from tauon-pair annihilation. Phase 2 begins with 100 muon pairs and ends with (about) 1000 photon pairs, while phase 3 begins with 2000 electron pairs (rematerialized pairwise from pairs of photons, $\gamma\gamma \rightarrow \mathrm{e}^+\mathrm{e}^-\ \mathrm{e}^+\mathrm{e}^-$) and ends with about 3 billion photons.

The final transformation in phase 4 of electronic matter into stable matter (proton plus electron) proceeds via pionic matter. With pion subscript suggesting intrinsic parity (pp. 41-42):

$$\begin{array}{ccccccccccccc}
\mathrm{e}^+\mathrm{e}^-\ \mathrm{e}^+\mathrm{e}^- & \rightarrow & \underline{\pi}^+\underline{\pi}^-\ \underline{\pi}^+\underline{\pi}^- & \xrightarrow{\mathrm{H}} & \pi_-^+\pi_-^-\ \pi_-^+\pi_-^- & \rightarrow & \pi_-^+\pi_-^- & \xrightarrow{\mathrm{Z}} & \pi_+^+\pi_-^- & \rightarrow & \pi_+^+\pi_+^- & \xrightarrow{\phi\nu\mathrm{W}} & \mathrm{p\bar{p}} \rightarrow \mathrm{pe}^- \\
 & & 0 & & 10^{-5} & & 10^{-5} & & 10^3 & & 10^{-5} & & 10^{-5}
\end{array}$$

Again, the numbers indicate approximate lifetimes of the particle states in the t_c time unit.

The symbols above the arrows stand for auxiliary particles without which the transformation of an electron pair into a 1837 times heavier proton pair wouldn't be possible. Primary, mass-carrying actors are the Higgs boson (H), the Higgs triplets (ϕ bosons of the same mass as H), and the neutrino (ν).

ELEMENTARY PARTICLE RELATIONS

The tauon, muon, and electron represent three generations of the lepton family. This circumstance isn't altered by the fact that the initially spinless tauon and muon were reborn as spinning particles at the same time as the electron was born.

The quarks are fractionally charged spin-$\frac{1}{2}$ particles with relationships between each other that correspond to the relationships between the charged leptons (which are spin-$\frac{1}{2}$ particles possessing integer charge). Even though all six quarks were born at the same instant, the fact that the relations between them mimic the family structure of the charged leptons suggests that the quarks, too, should be classified as particles of three generations belonging to a common family:

Generation	Charged leptons		Quarks	
1	τ^-	τ^+	$\mathrm{b}^{-\frac{1}{3}}$	$\mathrm{t}^{+\frac{2}{3}}$
2	μ^-	μ^+	$\mathrm{s}^{-\frac{1}{3}}$	$\mathrm{c}^{+\frac{2}{3}}$
3	e^-	e^+	$\mathrm{d}^{-\frac{1}{3}}$	$\mathrm{u}^{+\frac{2}{3}}$

There only exists one kind of Higgs particle. However, it comes in three weights or masses. Its weight (or mass content) depends on which particle emits it. Therefore, one may still talk about, say, an electron-type Higgs particle (alternatively electron Higgs, e-Higgs, or H_e) if it is understood that "type" solely refers to the particle's mass content, and not to properties that in some other way distinguish various kinds of particles from each other.

Compare with the three kinds of charged spin-$\frac{1}{2}$ elementary particles (e, μ, and τ). Although they, too, are primarily distinguished by their different mass content, they also differ in other respects. Thus, through the interplay between mass, spin, and charge, they acquire a magnetic moment that differs slightly between the three generations (the measured so-called anomalous magnetic moments are 0.001 159 652 18 and 0.001 165 92 for the electron and muon, respectively, while no precise value has been obtained for the tauon).

After the charged leptons had given birth to the spinless Higgs boson, they a little later gave birth to the spinless ϕ^0, ϕ^+, and ϕ^- bosons. Thus, the Higgs boson and the "Higgs triplets" (which today only show up in the form of "Higgs ghosts") actually belong to the same family as the charged leptons — their parents. Also, one may justifiably declare that the electron, muon, and tauon Higgs (H_e, H_μ, and H_τ) represent the electron, muon, and tauon generation, respectively.

While the Higgs boson — born of a lepton — is a natural member of the lepton family, the status of the neutrino is less obvious: born of a quark, but immediately adopted by the lepton family, it may be looked upon as a kind of foster child that the family received in return for their lost Higgs triplets.

The photon, gluons, and Z and W bosons belong to a different category of particles. They are so-called gauge bosons that mediate the electromagnetic, strong, and weak force, respectively.

A way of summarizing the elementary particles described by xSM is to say that they form two families and a team of servants.

To the first family — the lepton family — belong the ordinary electron, a heavy electron (or muon), and a superheavy electron (or tauon) representing three generations, each one with its own set of five weak offspring: the Higgs boson, the no longer existing Higgs triplets, and the neutrino. Each of the five weak offspring appeared in three different weights, just like their parents. So for instance, the Higgs boson is one of the five weak offspring, and it comes in three distinct weights.

To the second family — the quark family — belong the d-u quark pair, a heavy quark pair (s-c), and a superheavy quark pair (b-t). The d-u quark pair had a weak offspring — the neutrino — that appeared in three well-specified birth weights but, after being adopted by the lepton family, today shows up in mixtures of its birth weights.

The servants are force-mediating spin-1 bosons. Four of them (the photon, neutral Z^0, and charged W^+ and W^- particles) serve both families, while the remaining eight (the gluons, $g_1, \ldots, g_8$) only serve the quark family.

For clarity, it should be emphasized that, only when it appears for the first time, does the Higgs boson deprive its parent particle (the lepton) of part of its mass. In subsequent emissions of Higgs bosons, the mass of the emitting particle is conserved.

The same holds for the neutrino, which originally drew mass from the d and u quarks who gave birth to it.

For further discussions about the original "extended standard model" (xSM) theory and its later developments, please refer to a series of articles published on the website iTWire.com. The articles are:

Original Article
1. "Predictive Cosmology: Creation's secret revealed in muon-electron mass ratio = 206.768 283," published on August 10, 2009 (http://www.itwire.com/content/view/26822/1066)

Series of Three Interview Articles
2. "Predictive Cosmology and Standard Model revisited," published on December 21, 2009 (http://www.itwire.com/content/view/30199/1066)

3. "Q&A Interview, Part 2: Predictive Cosmology and Standard Model revisited," published on January 9, 2010 (http://www.itwire.com/content/view/30398/1066)

4. "Q&A Interview, Part 3: Predictive Cosmology and Standard Model revisited," published on March 3, 2010 (http://www.itwire.com/science-news/energy/37280-xsm3)

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