THE WEAK FORCE: "IDENTITY" OR NUMBER CHARGE

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Abstract

> "Noether's Theorem" states that in a multicomponent field such as the electromagnetic field (or the metric field of spacetime), where one finds a symmetry one will find an associated conservation law, and vice versa. In matter, light's symmetries are conserved by charge and spin; in spacetime, by inertial and gravitational forces. Neutrinos carry "identity" charge (aka "number" or "flavor" charge), the symmetry debt of light's "anonymity". *The charges of matter are the symmetry debts of light*.

Introduction

The charge associated with the weak force is usually known as "number" charge, although I prefer to call it "identity" charge, as the latter term better characterizes the function of this most important charge or symmetry debt. All elementary particles (the leptons) carry number (identity) charge, which occurs in two forms: 1) a "hidden" form carried by the massive leptons (the electron and its kin); 2) an "explicit" form carried by the (nearly) massless leptons, the neutrinos. A neutrino is simply the "bare", explicit form of number or identity charge. (The reader should refer to the "Particle Table" if the terminology in this article is unfamiliar.)

Number charge is strictly conserved as follows: every elementary particle - which means every lepton - carries a positive number charge, corresponding to its species or type, and every kind of elementary antiparticle carries an exactly equivalent but negative number charge. Together, the positive and negative number charges sum to zero. Number charge, like electric charge (and even the strong force color charge), must always exist in neutral combinations. For example, if an electron-positron particle-antiparticle pair is formed, their opposite number charges sum to zero. However, if a single electron is created (as in a weak force decay), its electric and number charge must still be neutralized, but because number charge occurs in two forms, this can be done by a positron neutrino instead of the positron itself. The advantage of this dual system of charge carriers is that it allows the creation of single particles whose charges do not have to be balanced by their antiparticles; by using a neutrino rather than an antiparticle, the otherwise inevitable annihilation reaction between matter and antimatter is avoided, and unpaired, isolated elementary particles of matter ("singlets") can be brought into existence. Matter can be isolated from antimatter only because the free neutrino can carry and balance matter's identity charge in alternate form.

Leptons as Alternative Charge Carriers

The role of identity or number charge is perhaps best explained and most readily appreciated by examining its role in actual weak force leptonic decays. A simplified form of 5 weak force decay reactions is given below, the simplicity allowing us to focus upon the conservation of two charges, the electric and identity charges. (More complete forms of these same reactions can be seen in the "Particle Table". See Also: "The "W" IVB and the Weak Force Mechanism").

Simplified examples of weak force leptonic decays (antiparticles underlined):
t = tau; *u* = muon; e = electron; *v* = neutrino; *lq* = leptoquark (hypothetical)
(decays 1-4 mediated by the "W" IVB; decay 5 mediated by the (hypothetical) "X" IVB)

1) *t*- -----> *u*- + *vt* + *vu*
(a tau decays to a muon, tau neutrino, and muon antineutrino)
2) *u*- -----> e- + *vu* + *v*e
(a muon decays to an electron, muon neutrino, and electron antineutrino)
3) (ud-) -----> *u*- + *vu*
(a negative pion decays to a muon and a muon antineutrino)
4) N -----> P+ + e- + *v*e
(a neutron decays to a proton, electron, and electron antineutrino)
5) P+ -----> *u*+ + *vlq* + *vu*
(hypothetical "proton decay", producing an antimuon, leptoquark neutrino, plus a muon neutrino)

Electric charges are usually represented by positive (+) and negative (-) signs, and it is easily seen by inspection that the electric charges on the left side of the reactions are equal to those on the right. The reader will also see that the same is true of identity charges. Recall that the massive leptons (electron, muon, and tau (e, *u*, *t*)) carry the charge in hidden form, while their neutrinos (*v*e, *vu*, *vt*) are the explicit form of the same charge; matter carries positive identity charge while antimatter carries negative identity charge. Using these rules, one can see that the total number of leptons is the same on the left as on the right side of the reactions (hypothetical reaction (5) is no exception because the proton is also assumed to carry a "hidden" number charge (*vlq*)). This arithmetic method of summation is why this charge is usually called "lepton number" charge. However, this charge is more specific than simple "number", as it is furthermore true that the identity of the "parent" lepton is conserved from one side of the reaction to the other, being carried on the right by neutrinos. Let us examine these reactions one at a time.

In reaction (1) a massive tau (*t*-) decays to a less massive muon (*u*-). The electric charge of the tau is conserved by passing it to the muon. However, a single elementary particle has disappeared (the tau), and another has been created (the muon). Both carry hidden identity charges which must be conserved (in the case of the tau) or balanced (in the case of the muon) by their respective neutrinos or antineutrinos. Hence we must find a tau neutrino and a muon antineutrino on the product (right) side of the reaction. (The reader may wish to consult the more complete form of all these reactions to see how they are very simply accomplished by the "W" IVB and virtual particle-antiparticle pairs: see "The Particle Table" or "The 'W' Particle and the Weak Force Mechanism").

In reaction (2) a massive muon (*u*-) decays to the ground state electron (e-), the lowest mass possible for an electrically charged particle. An electron is just a "bare" electric charge plus a "hidden" identity charge. Reaction (2) is exactly like reaction (1), except the muon decays rather than the tau, producing an electron rather than a muon. (All particles in these reactions also carry spin, which although not shown, is also strictly conserved from one side of the reaction to the other.)

In reaction (3) a negatively charged meson (ud-) decays to a muon and a muon antineutrino. Mesons are always composed of quark-antiquark pairs, which will annihilate each other provided their electric charges can be conserved. What is different about this reaction is that we see no neutrinos are necessary to conserve quark identity, even though two different quark "flavors" (u, d) are involved. Whatever partial identity or "flavor" charge a sub-elementary quark may carry is evidently neutralized by its antimatter partner. The same is true for color charges (and spin) carried by quark-antiquark pairs in mesons. The separate "flavors" or partial identity charges of quarks are not strictly conserved. In other respects, charged meson decay is like a heavy lepton decay; electric charge is conserved by a muon; in turn, the muon's identity charge (and spin) is balanced by a muon antineutrino.

Reaction (4) involves the decay of a neutron to a proton, known as "beta" decay because it produces "beta" particles, or electrons. A neutron (or proton) is composed of 3 quarks: the quark composition of a neutron is (ddu); that of the proton is (uud+). The proton is slightly lighter than the neutron, so the proton is the "ground state" or lowest energy state of the baryons (the class of all particles containing 3 quarks).

What is new in reaction (4) is that one baryon replaces another: the neutron decays to the proton, but baryons as a class never simply disappear (or appear) in any reaction - unlike the leptons and mesons, which come and go, so long as their charges are balanced. This suggests that the baryon carries an additional charge which cannot be balanced, neutralized, canceled, or otherwise carried by the leptonic field of alternative charge carriers; this is indeed so, and the charge is known as "color". All quarks carry color charges; the quarks of mesons, however, do not carry net color because their quark-antiquark pairs always carry color charge in neutral combinations - red-antired, for example. The weak force leptonic decay pathway is therefore open to mesons but closed to baryons. The three quarks of baryons, however, carry color in a composite, "white" combination which can self-annihilate when sufficiently compressed (the physical limit of the phenomenon of "asymptotic freedom" (Gross, Politzer, and Wilczek 1973) - see discussion in "The Formation of Matter and the Origin of Information"). However, when quarks and their color charges are expanded and explicit (the normal state), baryons can only be neutralized by "antiwhite" (that is, antimatter baryons). Given the absence of antimatter, normal baryons cannot completely decay because there is no alternative charge carrier for whole-baryon ("white") color. The special circumstances under which baryons *can* completely decay ("proton decay", reaction 5), are discussed under the color charge section in "Symmetry Principles of the Unified Field Theory".

Proton Decay and Leptoquark Antineutrinos

While baryons (or any other particles) can be readily created as particle-antiparticle pairs given sufficient energy, the production of any single, unpaired particle ("singlet") is difficult; indeed the asymmetric process of creating unpaired, single particles constitutes the "secret of matter" of the weak force and the material world. The mysterious and asymmetric weak force can create unpaired leptons, but the creation of a single, unpaired baryon (or its destruction) has never been seen, and has perhaps never even occurred since the primordial creation of matter in the "Big Bang". (See: "The 'W' IVB as a Bridge Between Virtual and Real Particles".)

There is no known weak force decay of a proton which is the equivalent of reaction (3), the leptonic decay of a meson. The absence of (the much sought for) "proton decay" has led to the notion of "baryon number" conservation, the equivalent of lepton number conservation. However, as we have seen, there are no separate neutrinos associated with the various (six in all) quark flavors, so if baryon number conservation is the equivalent of lepton number conservation, it must be associated with baryons as a class, not with the individual flavors of the sub-elementary quarks. In other words, there must be one single neutrino species which carries the identity charge of all baryons, regardless of their internal quark composition. If we ever observe "proton decay", we should also observe the production of this type of neutrino (the leptoquark neutrino - *vlq*). See: "The Particle Table".)

Reaction (5) shows just such a hypothetical "proton decay", with the production of a leptoquark neutrino (*vlq*), which carries baryon number or identity charge. This is the equivalent of the leptonic decay of a charged meson (reaction 3). The reason this reaction is so rare (in fact, unknown) is that the (hypothetical) "X" IVB required to compress the quarks to "leptonic" size and hence color neutrality is extremely massive. Once the color charge is sufficiently compressed to achieve complete "asymptotic freedom" and color neutrality, however, this reaction is no different from other weak force leptonic decays - except for the presence of the leptoquark antineutrino. (See: "The Half-Life of Proton Decay and the 'Heat Death' of the Cosmos".)

The major point here is that once a baryon (any baryon) has attained the (colorless) internal configuration of a leptoquark, it becomes the 4th and heaviest member of the leptonic spectrum, the primordial ancestral particle which unites the quark and leptonic elementary particle series. (See "The Formation of Matter and the Origin of Information" for a more complete discussion of the leptoquarks.) (See also: "The Leptoquark Diagram".)

Note especially in the 5 reactions above the role of the leptons as alternative charge carriers both for each other and for the mesons and baryons. Charges in these reactions are not balanced, neutralized, or canceled by antimatter partners, which would result in annihilation reactions, but by the leptonic field of alternative charge carriers. The massive leptons (electron, muon, tau) function as alternative carriers of electric charge, while their neutrinos function as alternative carriers of identity charge. (Mesons perform a similar function as alternative carriers of quark flavor and color charges in the transformations and decays of baryons.) Without the services of these alternative charge carriers, the world of matter would not exist, as all charges would have to be balanced by antimatter, resulting in annihilation. The leptonic charge field of elementary particles, or alternative charge carriers, functions to reveal the information content of the quark mass field. Nevertheless, while alternative charge carriers are a necessary condition for the creation of matter, by themselves they are not a sufficient condition; there still must be an additional asymmetry in the rate of weak force decays in matter as compared to antimatter (Cronin, 1981). Presumably, this asymmetry involves the rate of decay of electrically neutral leptoquarks vs electrically neutral anti-leptoquarks. (For a further discussion of the weak force in its full energy spectrum, see: "The Higgs Boson and the Weak Force IVBs".)

The "Anonymity" Symmetry Debt of Light: "Identity" Charge

While everyone is aware of electric charge, few people outside physics are familiar with number charge (although most have heard of neutrinos), yet it is perhaps the most important of all charges, the one most responsible for the phenomenon of manifestation and the creation of matter. *The charges of matter are the symmetry debts of light:* the symmetry associated with number or identity charge is the "anonymity" or sameness of all photons. All photons are alike - one cannot be distinguished from another; those that are more energetic are simply composed of greater numbers of superimposed identical photons, or quanta of light. This is the "symmetry of anonymity" which is characteristic of this type of particle (the "bosons"), and allows quanta of light to pile up one on top of another.

The photon is said to be its own antiparticle and carries no charges of any kind. Hence any particle-antiparticle pair a photon creates must necessarily bear charges which sum to zero, since the photon has none to begin with. All charges of any particle-antiparticle pair exist to facilitate an annihilation reaction between matter and antimatter, recreating the parent photon and thus preserving its symmetry, which includes (among other characteristics) light's lack of charge, lack of a gravitational field and time dimension, light's intrinsic motion, and light's metric and "non-local" distributional symmetry. This is why we say the charges of matter represent the symmetry debts of light, since the original function of charge in the particle-antiparticle pair is to motivate, facilitate, and produce an annihilation reaction, returning the particle-antiparticle system to the symmetric energy state of the light which created it, fulfilling "Noether's theorem" (see above) regarding the conservation of symmetry. When matter is isolated from antimatter, its charges retain (conserve) their original function and potency, but must find a new reaction pathway back to the original symmetry state of the light which created them. (See also: "Symmetry Principles of the Unified Field Theory".

Unlike light, the massive particles which light produces ("fermions") are not all the same - as "singlets" they do not carry the symmetry of light's "anonymity", they are distinct, different, and distinguishable, at least between the various elementary types. Therefore they break the photon's symmetry of "anonymity" and acquire the symmetry debt of "identity". One symmetry conservation function of the identity charge is evidently to facilitate timely annihilations (within the Heisenberg limit for virtual reality) by the identification of appropriate reaction partners for matter-antimatter pairs.

The simple view of neutrino function presented above is correct so far as leptonic decays are concerned. However, this picture has recently become more complicated by the discovery of neutrino mass states and the oscillation of neutrino flavors in flight after the decay. Here symmetry conservation is observed at the generic level of flavor, rather than the specific level - see the discussion below.

Neutrino Mass and Oscillations

See: *Scientific American,* May 2010 pages 38-45: "Through Neutrino Eyes" by Gelmini, Kusenko, and Weiler for an authoritative discussion of neutrino oscillation and mass.

According to Gelmini et al., neutrino mass is the basis upon which one neutrino is distinguished from another. Neutrinos oscillate not only between their 3 leptonic flavors, but between 3 mass states, and it is the relative proportion of these mass states that determines flavor. Because any neutrino flavor can can exhibit any mass state, neutrinos can evidently code for flavor identity at both the generic level of all lepton flavors, and at the specific level of a single leptonic flavor. This solves the "mystery of the missing solar neutrinos". (See: A. McDonald, J. Klein, and D. Wark: "Solving the Solar Neutrino Problem". *Scientific American,* April, 2003.) (See also: *Science*: Vol. 313, 21 July 2006, page 291, regarding neutrino oscillations). The situation is complex in that while an electron neutrino can only react with an electron (or positron), it may nevertheless change into a muon or tau neutrino during flight, and while in this new configuration, react only with a muon or tau (or their antiparticles). Hence while a specific neutrino flavor does code for and react with a single leptonic flavor, you can't be sure which neutrino flavor you are going to end up with, no matter what flavor you began with.

The fluid mix of neutrino identities (in flight) reflects the fluid state of identity in the electroweak symmetric energy state generally, in which all leptonic identities are merged at their generic level, and likewise all quark identities are merged at their generic level. In the electroweak symmetric energy state (or during the electroweak era of the "Big Bang"), transformations of one leptonic flavor into another, or one quark flavor into another, were simply the normal course of events. This is the generic level of symmetry which the "W" family of IVBs recreates (and is how the "W" effects identity transformations), not the specific level of lesser symmetry (individual identity) we experience today. Specific leptonic and quark identities "freeze out" or "crystalize" only in the cold ground state of our present electromagnetic era. In flight, the neutrino seems to at least partially return to this fluid state of electroweak generic identity. Oscillations or superpositions of identity occur between other closely related particles as well, including the quarks of the "K0 long" and "K0 short" mesons, and even the proton-neutron "nucleons".

It is interesting to note the unexpected but crucial role of mass in both the IVBs (field vector) and the neutrino (alternative charge carrier) of the weak force. This mass is the basis of similarity allowing their interaction, and it is of course the weak force that brings mass-matter into existence. The three oscillating mass states associated with a neutrino flavor bring to mind the three oscillating (but massless) color charges which are likewise necessary to differentiate the quarks of a baryon. Just as any quark can have any color, so any neutrino can have any mass state. We cannot push this analogy too far, however; we are trying to use it to understand why neutrinos are distinguished by mass rather than by some massless attribute (such as color).

The mass of a neutrino provides a basis of similarity allowing interaction with other massive particles, beginning with the massive IVBs. Because neutrinos lack electric charge, there must be some other (non-gravitational) principle which allows interactions with other massive particles. A charge carrier must not only be able to accept and carry a symmetry debt, it must also be able to pay and discharge the debt through a final interaction.

The role of deBroglie mass waves is fundamental to the phenomenon of neutrino oscillation. The oscillating neutrino spectrum is a consequence of the 3-member family structure of the elementary leptonic mass series - electron, muon, tau. If the leptonic spectrum had only a single member, then we would have only a single neutrino and no oscillations. Since this hypothetical single neutrino would still have to interact occasionally - to receive and discharge its symmetry debt - we may assume it would still have to be massive to provide a functional basis for interaction with the IVBs.

The IVBs recreate an invariant, primordial state of force unification symmetry (the electroweak era) by virtue of their huge and quantized mass. In this state the three members of the leptonic elementary particle spectrum are all equivalent (a generic level of identity rather than a specific level of identity), and transformations of one leptonic species into another are accomplished as a matter of course. Now it is most curious to note that the observed oscillations of the neutrinos apparently preserve a "memory" of this same primordial symmetry state, and in this reflection we catch a glimpse of why both the IVBs and the neutrinos must share a massive parameter. The neutrino cannot interact unless the "memory" of the "generic" electroweak symmetric energy state it carries within itself can be recreated, matched, or decoded by the IVB field - a "lock and key" mechanism. Hence we arrive at the curious phenomenon of a particle which carries its charge in the form of mass, and yet can travel through light years of lead without interacting.

It has been suggested that the three-family structure of the particle spectrum (including the quarks) is necessary to produce the weak force asymmetry which allows the primordial creation of matter during the "Big Bang". If this is true, the "harmonic" 3-part family structure of the elementary particles may have its ultimate explanation as "anthropic" necessity. Because "cosmological" neutrinos can carry, without interaction, significant amounts of energy (due to the phenomenon of relativistic mass?), they may have been instrumental in the dispersal of energy during the initial expansion of the Big Bang, preventing the collapse of the entire system into a cosmic-scale black hole.

The hypothetical leptoquark neutrino is a candidate for "dark matter". This neutrino could be quite massive (and possibly relatively slow moving?), and because it is sufficiently different from the other leptonic neutrinos, it may not participate in their "harmonic" spectrum and oscillations. It is "sterile" to the extent that it can only be seen during proton decay or proton creation - via the "X" IVB.

Hiding the Neutrino's Identity Charge

We can think of neutrinos as traveling (existing) from one IVB "event" to another - almost as an airplane travels only between airports. Typically, the neutrino is "born" or initiated in an IVB event (for example, during the decay of a muon to an electron, in which both a muon neutrino and an electron antineutrino are produced (in all reactions below, antiparticles are underlined; the electroweak transformation matrix of the "W" IVB is represented by square brackets; virtual particle-antiparticle pairs of mesons and leptons are enclosed in parentheses)):

Muon Decay:
u-[(e+ x e-)]W- ---> νu + νe + e-

In such an initiating decay, neutrinos pick up their symmetry debt of "identity" and perform their function as alternative charge carriers (and conservers) of the muon's and electron's identity charges. Subsequently, the neutrinos carry their charges through spacetime at nearly the speed of light until they engage in another IVB interaction in which their services as alternative charge carriers are required, or they are annihilated/neutralized by corresponding anticharges. Neutrino oscillations during flight mean that weak force charge conservation may by observed at the generic level of lepton number rather than the specific level of lepton identity: what began as an electron neutrino may end up as a muon neutrino, etc. Once within the transformation matrix of the "W" IVB, however, oscillations cease and weak force charge is conserved at the specific level of lepton identity: electron neutrinos only react with electrons, etc. Below I give examples of baryon transformations occurring in the sun and in the neutrino detector:

Solar fusion: proton ---> neutron
uud+[(du- x du+)(e- x e+)]W+ ---> udd + νe + e+

Detector: neutron ---> proton
(path 1)
udd[(du+ x du-)(e+ x e-)]W- ---> udu+ + νe + e-
(path 2)
udd[(du+ x du-)(νe x νe)]W- ---> udu+ + νe + e-

In the dector reaction (path 1), the energy of the incoming neutrino creates both a positively and negatively charged meson pair, and an electron and positron pair (all virtual). The positive meson reacts with the neutron, annihilating a "d" quark and replacing it with an "u" quark, transforming the neutron to a proton; the negative pion cancels the electric charge of the positron, and then self-annihilates, releasing also the positron's hidden identity charge as the product antineutrino. Meanwhile, the electron picks up the identity charge of the incoming solar neutrino and becomes "real", balancing the electric charge of the product proton. I think this is the most probable pathway for this reaction. However, there is another possibility involving the creation of a neutrino-antineutrino pair rather than the electron-positron pair.

I show this second case (path 2) with the incoming solar electron neutrino in brackets within the transforming grip of the "W", where it is paired with a positron neutrino. The "W" transforms and "hides" the electron neutrino in the product electron, which also picks up and conserves the electric charge of the negative virtual pion; the pion, stripped of its electric charge, then self-annihilates. All charges of the positive pion go to the product proton, while the positron neutrino remains to balance the lepton number of the reaction.

For a more detailed explanation of these reactions and symbols see either "The Particle Table" or "The 'W' IVB and the Weak Force IVBs".

See also: Sverker Johansson's website for an authoritative discussion of neutrinos and the "Soar Neutrino Problem":
http://www.talkorigins.org/faqs/faq-solar.html
"The Solar FAQ"

Summary

All this leads us to the conclusion not only that a leptoquark neutrino species must exist (serving to identify the whole class of the baryons through their ancestral elementary leptonic form, the leptoquark), but that "identity" is the fundamental charge to be associated with the weak force, taking its place as one of the four fundamental charges of nature (electric, location, color, identity). Just as the "location" charge of gravitation represents the fundamental information "bit" of the dimensional realm, so "identity" represents the fundamental information "bit" of the particle realm. It is a remarkable fact that between the dimensional charge of gravitation and the information charge of the neutrino, spacetime records the location, mass, and identity of every elementary particle within its cosmic domain (as symmetry debts). Finally, every action or event is stored indefinitely in historic spacetime (as causality debts - "Karma"). This exhaustive record is part of the function of spacetime as a true "conservation domain" - extending beyond simple raw energy conservation to include symmetry conservation (as charge, spin, inertia, and gravity), entropy (as time and - again - gravity), and causality (as information stored in historic spacetime ("karma")). (See: "The Tetrahedron Model".)

The universe of matter only exists due to a basic asymmetry in weak force reactions with matter vs antimatter (manifesting most probably in the asymmetric decays of electrically neutral leptoquarks vs antileptoquarks during the "Big Bang"), and because the meson and leptonic fields of alternative charge carriers provide a charge-conserving decay pathway in lieu of antimatter charge partners. The mesons and leptons exist to provide alternative charge carriers for the mass-carrying quarks; this is the natural role and function of the mesons and leptons. The massive leptons (such as the electron) provide alternative carriers for electric charge; the (almost) massless leptons (neutrinos) provide alternative carriers for number or identity charge; the mesons provide alternative carriers for quark partial charges, including quark color and flavor. It is due to the services of the meson and leptonic fields of alternative charge carriers that the information content and potential of the primary mass-carrying quark field can actually manifest as "singlet" baryons.

Postscript: Why the "Identity" Charge is Hidden

Unlike electric charge, "identity" charge (AKA lepton "number" charge) is "hidden" or implicit in the massive leptonic charge carriers, the electron, muon, and tau (and probably the "leptoquark" as well). Neutrinos are the explicit form of identity charge; there is no hidden form of electric charge among the elementary leptons, although the neutron is an inexact analog among the composite baryons. It is instructive to consider why this difference should exist, and its significance for these two types of charge.

The charge conservation reason for hiding identity charge is simple. Since identity charge is a "handed" charge, as we know from the explicit example of the neutrino, massive leptons (such as the electron) cannot conserve this charge in its explicit form, since any massive particle can be either left- or right-handed in its spin orientation. "Hiding" the handed identity charge as an implicit lepton number charge renders this conservation dilemma moot, since in this hidden condition the charge exhibits no handed preference. Only during a weak force transformation involving the IVBs must the lepton "awaken" to its true identity and left-handed spin orientation.

The symmetry between matter and antimatter lies at the root of the difference between any charge and its anti-charge. It is probably easiest for us to intuit this fundamental natural division as analogous to that between positive and negative numbers, or in financial terms, as between a debt and the equivalent positive balance. In the case of electric charge, we know that an electrically neutral photon (quantum unit of light) of sufficient energy can momentarily divide into two halves, one with positive electric charge and the other with negative electric charge (electron vs positron). Since opposite electric charges attract each other but similar charges repel, it is apparent that the purpose of these charges is to cause the annihilation of the particle pair, restoring (conserving) the former symmetric energy state of the photon that created them. It is possible to give these opposite charges a dimensional interpretation: Feynman thought positrons might be electrons traveling backward in time (in such a case, anti-charges represent the presence of an antiuniverse). In "virtual" pair creation, where there is not enough energy in the original photon to create a "real-time" electron-positron pair, in addition to the positive and negative electric charge, we attribute negative energy to one partner and positive energy to the other, with the consequence that the annihilation must occur within the "Heisenberg time limit" for virtual reality. Hence virtual pair creation requires no net energy.

While it is not completely clear what "negative energy" might be, other than a bookkeeping device for purposes of conservation, we seem to have an actual example in gravitation. Taking this hint, even though gravitational energy is not typically involved in virtual pair production (except near black holes), we surmise that "negative energy" is a type of binding energy which exists in response to threats to some conserved parameter, just as negative electric charge exists in response to threats to symmetry conservation. Negative charge and energy make common cause in virtual pair creation and annihilation.

In the case of the neutrino, rather than positive and negative electrical charges (however they may be physically interpreted), we find another type of symmetry conservation protected by a completely different kind of charge, the left- vs right-handed spin of the partners: all neutrinos have left-handed spin, all antineutrinos have right-handed spin (this is part of the "identity" symmetry charge of neutrinos, in this case distinguishing the broad category of matter from antimatter). Consequently it is said we live in a left-handed universe. (In the strong force we find yet another charge system protecting symmetry (through protecting whole quantum units of charge), the color vs anti-color charges of the quarks and gluons.) There is something puzzling about this weak force "handed" symmetry charge: if a virtual neutrino-antineutrino particle pair is created, what force acts to bring them together again and cause their mutual annihilation? It would seem that simple geometry, or their mutual "entanglement" within the spacetime metric, must ensure the annihilation of such a pair, perhaps even preventing its formation to begin with. "Bare" neutrino matter-antimatter particle pairs can only be created by the neutral weak force field vector, the "Z" IVB. The mysteries of the weak force and its strange short-range massive field vectors, the "Intermediate Vector Bosons" (which regulate symmetry and energy conservation and the transmission of the weak force "identity" charge), can only be understood within the context of its natural role: the creation, transformation, and annihilation of *single* elementary particles. Elementary particles created today must be exactly the same in all respects as those created eons ago during the "Big Bang"; it is surmounting this challenge that makes the weak force so strange. (See: "The Higgs Boson and the Weak Force IVBs".)

Consider now the difficulty of separating a neutrino-antineutrino particle pair, mutually "entangled" within the spacetime metric. Electrons and positrons can be separated because they have a long-range field vector (photons) which can be brought to bear from external sources (electric/magnetic fields), but neutrinos lack any such "handles" by which we might manipulate them. Nevertheless, nature must separate these neutrino pairs if symmetry is to be broken and matter is to be created without its antimatter complement. The method nature uses is to "hide" one member of the pair in a massive particle, such as the electron. The hidden identity charge can then be manipulated via the electric charge of the electron which carries it. The other (explicit) member of the identity charge pair is then free to roam about the universe, although it will forever retain its ability to annihilate the charge of its imprisoned partner. The electron is therefore an alternative charge carrier for both electric and identity charge. The electric charge is explicit and typically functions to balance the proton's positive electric charge, while the identity charge is hidden, functioning nevertheless to balance the explicit identity charge of the electron anti-neutrino.

Because electron-positron pairs are readily produced by photons alone, it is obvious that the "hiding" of identity charges within these massive leptons does not require the action of the weak force IVBs, as does the creation of a "singlet" neutrino (via the "W" IVB), or the creation of a "bare" neutrino-antineutrino pair (via the "Z" IVB). Rather, we see that however such massive leptonic particle pairs are produced, they always carry both explicit electric and implicit "identity" (lepton number) charges. We surmise, therefore, that the ability of Nature to create identity charges which can be hidden in implicit form predetermines what massive leptons can be materialized - apparently only 3 or 4 types, if we include the leptoquark.

Except for matter-antimatter annihilation reactions, neutrinos originate in and return to the symmetric force-unity environment of the weak force IVBs, and they evidently retain a "memory" of the generic identity state of their origin which facilitates their return. In weak force transformations mediated by the "W" family of IVBs, the Higgs boson sets the energy scale for a unified force symmetric energy state (the electroweak force-unity state), and the "W" IVBs perform the actual transformations. (See: "The 'W' IVB and the Weak Force Mechanism".) As a consequence of the hidden quality of its weak force identity charge, the electron is not constrained in its other activities by identity charge, whereas the explicit electric charge completely controls its behavior. Only during transformations or annihilations must the electron acknowledge and be constrained by the presence of its "hidden" left-handed identity charge.

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Further Reading:

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