The Weak Force: Identity or Number Charge; Neutrinos

(revised Jan., 2009)

John A. Gowan
home page

Table of Contents:

Abstract
Introduction
Leptons as Alternative Charge Carriers
Proton Decay and Leptoquark Antineutrinos
The "Anonymity" Symmetry Debt of Light: "Identity" Charge
Summary
Links

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 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 and is observed 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.

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 $\underline{\text{underlined}}$):
t = tau; *u* = muon; e = electron; *v* = neutrino; *lq* = leptoquark (hypothetical)

1) *t*- -----> *u*- + *vt* + $\underline{vu}$
(a tau decays to a muon, tau neutrino, and muon antineutrino)
2) *u*- -----> e- + *vu* + $\underline{v\text{e}}$
(a muon decays to an electron, muon neutrino, and electron antineutrino)
3) ($\underline{\text{u}}$d-) -----> *u*- + $\underline{vu}$
(a negative pion decays to a muon and a muon antineutrino)
4) N -----> P+ + e- + $\underline{v\text{e}}$
(a neutron decays to a proton, electron, and electron antineutrino)
5) P+ -----> $\underline{u}$+ + *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 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 (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 leptons involved does not change from one side of the reaction to the other, being carried either as a neutrino, as the massive lepton itself, or in neutral combinations. 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 (the case of the tau) or balanced (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 the reaction to see how this transformation is very simply accomplished by the "W" IVB and a virtual particle-antiparticle pair of muons: 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 ($\underline{\text{u}}$d-) decays to a muon and a muon antineutrino. Mesons are always composed of quark-antiquark pairs, which will annihilate each other once their electric charges are 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, or green-antigreen, 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"), but when expanded and explicit (the normal state), can only be neutralized by "antiwhite" (that is, antimatter baryons). 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 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 than 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". The symmetry conservation function of the identity charge is evidently to facilitate timely annihilations by the identification of appropriate reaction partners for matter-antimatter pairs.

The three neutrinos (*ve*, *vu*, *vt*) are not just general "number charges" for the entire class of leptons, as each is distinctive and specific to its own type or species of lepton (recently there is some evidence suggesting neutrinos can transform into one another via "oscillations") (*Science*: Vol. 313, 21 July 2006, page 291). In addition to distinguishing between the leptonic species of matter, neutrinos also distinguish matter from antimatter: all matter neutrinos have left-handed spin, all antimatter neutrinos have right-handed spin. It is this specificity of function that alerts us to the notion that neutrinos represent more than a generalized leptonic number charge, and are in fact an "identity" charge. (For example, compare the many different carriers of the generalized electric charge in the above reactions with the single, specific carriers of the several types of identity charge). In turn, this knowledge allows us to discover the symmetry debt these charges represent (the "anonymity" of photons) as well as to identify their probable function (the identification of suitable partners in the annihilation reactions of matter-antimatter pairs) - neither of which follows from the notion of a generalized "number" charge.

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 metric warpage 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 color and flavor. It is due to the services of the meson and leptonic fields of alternative charge carriers that the information content of the primary mass-carrying quark field can actually manifest as baryons.

Links:

Information

- Section VI: Introduction to Information
- The Information Pathway (text)
- Chardin: Prophet of the Information Age
- The Formation of Matter and the Origin of Information
- Causality vs Information
- Nature's Fractal Pathway

Weak Force, Intermediate Vector Bosons ("IVBs")

- Section IV: Introduction to the Weak Force
- The "W" Intermediate Vector Boson and the Weak Force Mechanism (pdf file)
- The "W" IVB and the Weak Force Mechanism (html file)
- Global-Local Gauge Symmetries of the Weak Force
- The Weak Force: Identity or Number Charge
- The Weak Force "W" Particle as the Bridge Between Symmetric (2-D) and Asymmetric (4-D) Reality
- The Strong and Weak Short-Range Particle Forces
- Section XVI: Introduction to the Higgs Boson
- The "Higgs" Boson and the Spacetime Metric
- The "Higgs" Boson and the Weak Force IVBs: Part I
- The "Higgs" Boson and the Weak Force IVBs: Parts II, III, IV
- "Dark Matter" and the Weak Force
- Section XVIII: The Strong Force: Two Expressions
- The Particle Table

Literature cited:

D. J. Gross and F. Wilczek. 1973. Ultraviolet Behavior of Non-Abelian Gauge Theories. Phys. Rev. Lett. 30: 1343.

H. D. Politzer. 1973. Phys. Rev. Lett. 30: 1346.

Cronin, J. W. 1981. CP Symmetry Violation - the Search for its Origin. Science 212: 1221.

Noether, E. *Emmy Noether: A Tribute to her Life and Work*. Brewer, J. W. and M. K. Smith, eds. M. Dekker, New York, 1981, 180 + x pp. + 10 plates.

home page

identity.html