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The Short-Range or "Particle" Forces: Part II

(revised March, 2012)

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Abstract

The strong force is responsible for the binding of compound atomic nuclei and the binding of quarks in the class of heavy composite particles, the hadrons. Hadrons consist of baryons (containing 3 quarks) and mesons (containing quark-antiquark pairs). The weak force is responsible for the creation, destruction, and transformation of single, unpaired elementary particles (quarks and leptons). Both forces are to be understood in terms of energy, charge, and especially symmetry conservation. The strong force conserves whole quantum units of charge and achieves "least bound energy" nuclear configurations; the weak force ensures the invariance of all conserved parameters in elementary particles during the creation, destruction, or transformation of single, unpaired particles.

The Intermediate Vector Bosons (IVBs) (weak force)

The IVBs are unusual in that unlike all other field vectors of the "standard model", they are massive. It is the great mass of the IVBs that makes the weak force "weak", that is, slow to act. This is because the energy to produce these massive bosons must be borrowed, and the more energy required, the more difficult it is to borrow it. The "W" and "Z" are about 81 and 91 times heavier than the proton, respectively, and the hypothetical "X" is presumed to be very much more massive still.

The IVBs are probably metric particles, that is, particles composed entirely of the dimensional metric bound into a dense and specific configuration. Their mass is derived entirely from the binding energy required to deform and hold the metric in their own particular way. The IVBs apparently act by engulfing particles within their unique geometry, which brings reactants very close together so they can interact in ways they could not in ordinary, extended space. In this regard the IVBs are like metric catalysts, and resemble the "strings" of string theory. The IVBs are evidently derived from the dense metric of the early Universe, when the reactions they now rarely produce would have been a commonplace of that primordial energy-dense environment. The mass of the IVBs recreates a primordial force unification symmetric energy state, as gauged by the Higgs boson (in the case of the "W" IVBs, the "electroweak" force unification era as it existed during the "Big Bang"). All transformations originating with the electroweak force unification symmetry state or era can therefore be reproduced by the "W" IVB. (See: "The Higgs Boson and the Weak Force

IVBs".)

A basic function of the IVBs is to form a bridge between real particles and the virtual particle "sea" of the vacuum; the IVBs thus make available all the electric, number, color, and flavor charges of the virtual particle "sea", so that "real" particles can use them to accomplish transformations and decays, and to materialize and dematerialize as necessary. The IVB is essentially acting like a human "spirit medium" or priest, bridging the gap between the manifest and unmanifest worlds. It is the "magical" ability of the IVBs to contact, catalyze, and materialize the virtual particle "sea" that is their distinguishing characteristic and that requires their unique structure and mass.

The role of the (hypothetical) "X" IVB is to compress the quarks of a baryon so tightly within its dense metric that the color charge self-annihilates, producing a leptoquark. The "X" IVB reproduces the primordial force unification symmetric energy state of the "GUT" era, as it existed during the "Big Bang", as gauged by an appropriate Higgs boson ("Grand Unified Theory" or strong force plus electroweak force unification era). (See: "Table of the Higgs Cascade".) With no color charge, the leptoquark can decay like any other heavy lepton. Proton decay is rare because the mass of the X is so great; the great mass of the X is due to the great energy required to compress the quarks sufficiently to vanish their color charges (the principle of "asymptotic freedom"). The role of the IVBs is to bring real particles and virtual particle-antiparticle pairs into a sufficient proximity, enabling real particles to exchange their conserved charges and energy with the alternative charge carriers of the virtual leptonic and/or meson field, thus manifesting aspects of the virtual field, and so facilitating the decay of the "real" particles to lower bound energy states. (See: "The 'W' IVB and the Weak Force Mechanism".)

The Weak Force Creation of Singlets

The weak force only creates particle "singlets" - isolated particles of matter without antimatter partners. Charge and symmetry conservation require charge invariance over time - elementary particles created today must be the same in all respects as those created in the "Big Bang". The weak force mechanism satisfies this criterion by recreating the original energy-dense environmental conditions (via the huge mass of the IVBs) in which the elementary particles in question were first created.

The most significant feature of the massive IVBs is that they recreate the original conditions of the energy-dense primordial metric in which particles were first created and transformed during the early micro-moments of the "Big Bang". This recapitulation ensures that the original and invariant values of charge, mass, and energy are handed on to the next generation. The IVB mass not only provides a "safe house" where charge and energy transfers can take place, it simultaneously ensures that the appropriate alternative charge carriers are present.

There is a crucial difference between the electromagnetic creation of particles via particle-antiparticle formation, and the weak force transformation of existing particles to other elementary forms. In the case of particle-antiparticle pair creation, there can be no question of the suitability of the partner for a subsequent annihilation reaction which will conserve symmetry. However, in the case of the transformation of an existing elementary particle to another form, alternative charge carriers must be used, since actual antiparticles can only produce annihilations. But how is the weak force to guarantee that the alternative charge carrier - which may be a meson, a neutrino, or a massive lepton - will have the correct charge in kind and magnitude to conserve symmetry at some future date in some future reaction, with an unknown partner which is not its antiparticle? Furthermore, the quark charges are both partial and hidden (because they are "confined"), and the number charges of the massive leptons and baryons are also hidden (because they are "implicit") - they have no long-range projection (such as the magnetic field of electric charge) to indicate to a potential reaction partner the relative condition of their energy state.

These problems are all solved by a return to the original conditions in which these particles and transformations were first created, much as we return and refer to the Bureau of Standards when we need to recalibrate our instruments. The necessity for charge and mass invariance in the service of symmetry, charge, and energy conservation therefore offers a plausible explanation for the otherwise enigmatic large mass of the weak force IVBs. The IVB mass serves to recreate the original energy-dense environmental conditions in which the reactions they now mediate took place, ensuring charge and mass invariance and hence symmetry, charge, and energy conservation regardless of the type of alternative charge carrier that may be required, or when or where the new elementary particles may be created. (See: Global-Local Gauge Symmetries of the Weak Force.)

A Particle Metric

In the dimensional realm we have seen that space, created by the intrinsic motion of light, is also the entropic conservation domain of light, establishing (via the inertial forces of the metric) the rate of propagation of electromagnetic waves, the symmetry of the dimensional metric, and conserving free energy within a defined dimensional framework. Space also accommodates the additional energy conservation requirements of bound energy through the addition of a 4th dimension, time (an alternative, primordial entropy drive for matter, creating history). The forces of gravitation and inertia, the intrinsic motions of light and time, demonstrate these dimensional conservation properties to our physical senses. (See: "Spatial vs Temporal Entropy".)

But spacetime is also the conservation domain of particles. The fact that a dimensional framework exists (time and historic spacetime) to conserve the energy accounts of matter implies that a corresponding particle framework, a particle "metric", must also exist embedded in the structure of spacetime. The inherent capacity of space and light to accommodate and conserve the dimensional aspects of mass (via time and gravitation) implies also that space and light have an inherent capacity to produce massive particles, and vice versa. Each capacity implies the latent presence of the other: why otherwise should either exist?

For a further discussion of the weak force in its full energy spectrum, see: "The Higgs Boson and the Weak Force IVBs".

Virtual Particles

The manifest world of particles is but the 4-dimensional, explicit, "real" expression of this 2-dimensional, implicit, "virtual" potential of space to produce matter (the elementary particle analog of Plato's realm of "ideal forms"). It is like the metric of spacetime, inherent in the structure and conservation function of light, but expressed in terms of particles rather than waves. This is the particle spectrum of spacetime (the virtual particle "sea" or "zoo"), a spectrum whose full extent we are still exploring with our accelerators.

Ordinarily, this spectrum is expressed only virtually, in the production of particle-antiparticle pairs of different types; if we could identify all the allowed types of virtual particle-antiparticle pairs, we would know what the full particle spectrum is that spacetime is prepared to produce and conserve. Of course, we only see the ones that become real, including those we succeed in producing in our accelerators. But the "vacuum" (spacetime) is at all times full of these virtual pairs, in greater or lesser abundance and duration depending upon the energy required to produce them. It is this background of virtual particles which I refer to as the embedded particle "metric", "sea", or "zoo" of spacetime (the Heisenberg-Dirac "vacuum sea" of virtual particle-antiparticle pairs).

As far as we can tell from the "real" particles which come from the virtual "sea" of spacetime, only a very few particle types are allowed and produced - the particle spectrum is quantized and quite limited, as we have seen in the preceding section. We have identified this particle spectrum as the leptonic spectrum (or series) of elementary particles. This embedded particle spectrum is simply a "given condition" of our spacetime - we can no more explain its form or energy parameters than we can explain the magnitude of c or Planck's constant of energy. But we can learn something about its range and characteristics, depending upon how complete our theories are, how powerful and/or sensitive our instruments are, and what instruments and theories we choose to use. It is only in this century that we have become aware of the virtual particle spectrum embedded in the vacuum, or made much progress in identifying its range in terms of "real" particles; the "top" quark has been found only recently (Fermilab 1994), although long suspected; the "X" IVB particle, the leptoquark (and its neutrino), still exist in theory only. A host of other hypothetical particles may also be present, like fish deep in the vacuum "sea" waiting to be discovered: among others, the particles of supersymmetry and string theory; the "Higgs" boson; and the particles comprising the notorious "dark matter" and "dark energy" of cosmology - if any of these actually exist. The high-energy vacuum of spacetime is like the Earth's ocean depths - we still don't know what is in there. (The leptoquark neutrino (which may be quite heavy) is my choice as a likely candidate for "dark matter".)

Virtual Particles and the Spacetime Metric

We are usually unaware of the virtual particle-antiparticle background of space, just as we are usually unaware of the dimensional metric. We become aware of the dimensional metric through gravitation, time, velocity c, and the inertial forces associated with accelerated motion, and we become aware of the particle "metric" through high-energy physics experiments, radioactivity and "cosmic rays", and because we and the world are made from a materialized portion of it. Of course, one awareness is dependent upon the other - we are aware of the dimensional metric because it affects the massive particles we are made of. What we are usually not aware of is that the universal system is a conserved and integrated whole - particle and dimensions alike. Particles are as much a part of spacetime as light; indeed, particles are made from light (a long-standing hypothesis also proved experimentally only recently - at SLAC). Matter is an asymmetric form of light, 1/2 of a symmetric particle-antiparticle pair, the energy of light brought to rest in the conserved form of an elementary particle.

So long as particles remain as particle-antiparticle pairs, they simply continuously annihilate one another and never intrude into the "real" world of 4-dimensions (we are 4-dimensional chauvinists - the 2-dimensional world is quite real, but it is so symmetric and quantized at such an energy level that we cannot experience it. Light is as close as we get to it, but we only see light when it, too, becomes bound and part of our 4-D world. Our thoughts and dreams are perhaps the only 2-dimensional "virtual" reality we physically experience). Note the grand analogy (awaiting exposition) between the manifestation of 2-D virtual particles via the massive weak force IVBs and the manifestation of 2-D thoughts via our hard-won social comprehension and implementation of natural law. In this we compare the "hard" mathematical structure of natural law plus a formal social structure, to the massive quantum-mechanical mechanism of the weak force and IVBs. (See: "A General Systems Analysis of the Creative Process in Nature".)

Particle Creation (weak force)

The difficult problem is how to bring a single particle of matter (rather than a particle-antiparticle pair) out of the virtual world of 2-dimensions and into the "real" world of 4-dimensions. The problem is one of conservation: the raw energy, the symmetry, and the entropy of free energy must all be conserved in such a transformation. The raw energy of light is conserved as the mass and momentum of particles. Symmetry conservation takes the form of conserved charges (and spin); unless the particle is electrically neutral to begin with, there will have to be electric charge conservation; a gravitational location charge will inevitably be engendered, ushering in the time dimension (conserving entropy and causality); if quarks are involved, there must be a color charge; and finally there must be an "identity" charge (carried by a neutrino), informing spacetime as to the particular type of particle created. (See: "The Origin of Matter and Information".)

An especially difficult problem is that all elementary particles, whether created today or eons ago in the "Big

Bang", must be exactly the same in mass, charge, and all other respects - for obvious reasons of energy, symmetry, and charge conservation. It is this problem of charge and mass invariance in the creation and transformation of elementary particles that requires the hugely massive IVBs of the weak force (as scaled by the Higgs boson) to recreate the primordial energy-dense environmental conditions in which these elementary particles originated. Only in this way can they be exactly reproduced, anytime, anywhere, regardless of entropy, the passage of time, the expansion of the Cosmos, etc.

During the Big Bang, the weak force "X" IVB brings (electrically neutral) leptoquarks into the 4th dimension of real time. As these particles cascade downward via the "W" IVB to their ground state (the proton), they bring other single leptons (alternative charge carriers) into existence as required to balance electric charge. The ordinary leptonic field (below the mass energy level of the leptoquarks) functions as an alternative charge carrier for the massive quark field, which in its absence could not manifest, as quarks could, in that case, only balance their charges with antiquarks, resulting in "mutually assured annihilation". The identity of every elementary particle is conserved as an antineutrino (or neutrino) as it is created. All elementary matter particles in the Universe today have a conserved identity in spacetime in the form of an antineutrino. For baryons, this is the antineutrino of the antileptoquark whose decay forced matter leptoquarks to become "real" (the proportion of these asymmetric decays to symmetric particle-antiparticle annihilations is thought to be roughly one in ten billion). I suggest a possible reaction pathway in "The Particle Table"; (or see: "The Origin of Matter and Information"). Since all particles are elementary in their origin (including baryons because of their derivation from leptoquarks), all particles have a conserved identity (and through gravitation, a known location and mass) in spacetime. Finally, through historic spacetime, all events are permanently recorded so long as the Universe does not collapse in a "Big Crunch". (See: "A Spacetime Map of the Universe".)

The philosophers, the poets, and the shamans have known for a long time about the "virtual sea" in its most generalized spiritual and ideal context and meaning (the "Akashic Record" for one example); the scientists of today are investigating its narrowest, most literal, and most specialized aspect. Before we put too much emphasis on the machinery of particle physics, it is well for us to remember that neither "Truth" nor "Beauty" comes out of a particle accelerator, but only out of the abstracting, synthetic, and emergent communicative power of the minds, hearts, and souls of human beings.

Particle Decays (weak force)

The leptonic series of elementary particles - electron, muon, tau, and leptoquark, represent quantum steps or "rungs" in the particle spectrum or "ladder" of spacetime. Elementary particles can be created in these discreet energies but no others (analogously to the discreet quantum energy levels of electron orbital shells in atoms). Each step is distinguished by a corresponding neutrino, which is the (explicit) identity charge and hallmark of an elementary particle: there are no neutrinos associated with the sub-elementary quarks. The hypothetical leptoquark neutrino carries a single identity charge for all baryons; baryons must all return to the leptoquark configuration to decay (the color charge must self-annihilate - "in the limit" of "asymptotic freedom").

An analogous quantum spectrum or series characterizes the quarks; the quark series is of lesser significance than the leptonic one, for just as quarks are sub-elementary, so the quark spectrum is sub-elementary, and has no associated neutrinos. Because quarks can exist only as quark-antiquark pairs (the mesons), or triplets wholly confined within the baryons, they either annihilate each other (the mesons) or their transformations occur within the confines of the baryon. If their transformations require electric charge conservation, then a lepton or a charged meson must be extracted from the virtual particle "sea" by the weak force "W"; flavor transformations among the quarks of a baryon likewise require the services of the "W" IVBs to produce the necessary flavor charges from the mesons of the virtual sea. (See: "The Role of the "W" IVB in Weak Force Transformations".)

The decays of leptons are the simplest to understand (see reactions in "The Particle Table"). Suppose a tau decays into a muon, a favorable symmetry-conserving reaction since the muon is much lighter and the tau can convert a lot of bound energy to free energy in the process. One might think that this reaction would be fast and easy: the tau simply jumps to a lower quantum slot and becomes a muon, shedding excess energy in a flash of light.

But leptons are true elementary particles and their identities must be conserved, both for the tau, which must be destroyed, and for the muon, which must be created. The "W" repackages the tau mass energy into the muon, and produces a tau neutrino to conserve its identity charge. Likewise, a muon antineutrino must be produced to conserve (balance) the muon's identity charge (when the muon decays, the neutrino it releases will cancel this antineutrino). Apparently the "W" "bear hugs" both the tau and a muon-antimuon virtual particle pair so tightly that the tau's mass energy can flow to and materialize the muon at the same time it is annihilating with the antimuon, liberating both the tau's neutrino identity charge and the antimuon's neutrino identity charge in the process. The reaction takes a (relatively) long time because the "W" is so massive and therefore very difficult to produce.

Baryon Decays

A more complex weak force interaction occurs when a baryon decays from a neutron to a proton ("beta" decay); here an electron must be produced to carry the electrical charge difference. The "W" produces the electron and its antineutrino. The decay of a neutron to a proton is incredibly slow by the standards of particle physics (a half-life of 15 minutes - a trillion times slower than many other weak force decays), because there is barely enough energy difference between the neutron and proton to allow it, and the pathway is very complex, involving a virtual alternative charge carrier meson for the quark flavor transformation as well as the virtual electron-positron pair.

If no elementary particle is involved in a decay or transformation, if there is no leptonic identity to be conserved and no quark flavor to be supplied from the virtual "sea", then the IVBs are not involved in the interaction. There is one apparent exception: the "Z" (neutral) mediates weak force transformations in which two particles swap identities, or simply scatter (bounce) off each other - an electron and its neutrino, for example. In the case of the simple swap, a weak force interaction is nevertheless required because an elementary particle has both disappeared and been produced. This is a dangerous transaction from a conservation point of view, and so requires the safeguard of the structural confines of the IVB. In the case of simple scattering, the point is that the neutrino simply has no other way of interacting with matter except through the mediation of a weak force IVB - which is why it hardly ever does. What other types of particles are "out there" that interact even less frequently or perhaps not at all? These are among the "dark matter" candidates, known only by their gravitational influences, and the leptoquark neutrino may be one of them.

Summary

The derivation of quarks from the leptonic series via the "fractured lepton" model helps us to understand a number of important concepts: 1) the relationship of baryons to leptons - baryons are fractured, expanded leptons, which is why they carry exactly the same electrical charges as, and interact so freely with, leptons; 2) the origin of color charge, a virtual field of quantum-mechanically modified photons which acts to keep this "elementary" particle from coming apart, hence preventing a quantum-mechanical and symmetry conservation disaster; 3) the nature of the leptoquark, a fractured elementary lepton whose quarks have not yet expanded due to high external pressure, and consequently has no explicit color charge; 4) the nature of "leptoquark decay" - having no explicit color charge, electrically neutral leptoquarks can undergo leptonic decay via the "X" IVB, emitting a leptoquark neutrino; 5) the nature of proton decay, again via the "X" IVB, which must follow the leptoquark model, its quarks compressed to "leptonic size" until the color charge vanishes ("in the limit" of "asymptotic freedom"), then decaying with the emission of a leptoquark neutrino -

a process that probably can occur routinely only in black holes in the present Universe; 6) why no neutrinos are associated with quarks - quarks are sub-elementary particles which have only a collective identity realized in the leptoquark and conserved as the leptoquark neutrino; 7) the triangular relationship between the strong force, weak force, and the leptoquark. Color and identity charge converge in the formation of the fractured leptonic particle that is the leptoquark and the ancestor of both the baryons and the leptons (strong and electroweak force unification at the GUT energy level).

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- The Particle Table

The Tetrahedron Diagrams (Text)
The "Tetrahedron Model" Diagram
The Hourglass or "Grail" Diagrams

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