Chapter 12

Bonds, Quarks, Gluons and Neutrinos

Introduction: This chapter lumps together several difficult subjects not previously covered. These include bonds, the ψ function, quarks, gluons, the weak force and neutrinos. Most of these are not clearly understood in mainstream physics. This vagueness prevents plausibility calculations to test the spacetime model involving these subjects. For example, quarks do not exist in isolation, so their properties are always partly hidden. Even their mass/energy is a mystery. Perhaps the most shocking conclusion is that the spacetime based model in its current state of development does not need gluons. As previously explained, there is only one truly fundamental force (the relativistic force) and this force is always repulsive. This single force appears to be capable of generating a force with the strength and bonding characteristics of the strong force. With this bonding accomplished by an interaction with the spacetime field, are gluons required? Color charge is another property currently assigned to gluons, but the properties requiring color charge can probably be explained as an interaction between quarks (rotars) and the spacetime field. The elimination of gluons is a preliminary conclusion that needs to be refined and perhaps modified upon further analysis. This is the last chapter that deals with particles and forces before switching to cosmology. The subjects with the greatest unknowns are lumped into this chapter.

Virtual Photons Examined: The standard model considers the electromagnetic force to be transferred between point particles by the exchange of virtual photons. This raises interesting questions. Where does the loss of energy occur when an electron is bound to a proton? It is not sufficient to say that there is a reduction in the electric field. The virtual photons ARE the electric field. Do the virtual photons that supposedly bond oppositely charged particles possess negative energy? (no such thing – only the absence of positive energy) Does a proton bound in a hydrogen atom have more or less virtual photons surrounding it compared to the same proton in isolation? What is the wavelength of a virtual photon? These questions are introduced to raise some doubts about virtual photons and the generally accepted explanations.

The spacetime model of the universe proposes that there are no virtual photon messenger particles. These are replaced by fluctuations of the spacetime field which exert pressure. All rotars possess an "external volume" of standing waves and non-oscillating strain in spacetime previously discussed. The external volumes of interacting rotars overlap. Two oppositely charged rotars interact in a way that decreases the Compton rotational frequency of each rotar (ω_c is reduced). The location of the lost energy is easy to identify. Also the overlapping external volumes affect the pressure exerted on opposite sides of a rotar by vacuum energy. This pressure difference distributed over the rotar's area causes a net force. If a rotar is free to move, there is a net migration of the rotational path of each rotar towards the oppositely charged rotar with each rotation. We consider this force and migration to be electromagnetic attraction.

Electrons Bound in Atoms: In the Bohr model of a hydrogen atom, the electron's 1s orbital (the lowest energy level) is described as having a radius of $a_o = \hbar c/E_e\alpha \approx 5.3 \times 10^{-11}$ m. Also the orbital angular momentum of the electron's 1s orbital is $\hbar$ according to the Bohr model. The combination of this radius size and this angular momentum corresponds to the electron having velocity of $v = \alpha c$ (about 137 times slower than the speed of light). The de Broglie wavelength for an electron at this velocity is $\lambda_d = 2\pi a_o$. This means that the de Broglie wavelength equals the circumference of this Bohr orbit. This is an appealing picture, but according to quantum mechanics, the Bohr atom model is an oversimplification.

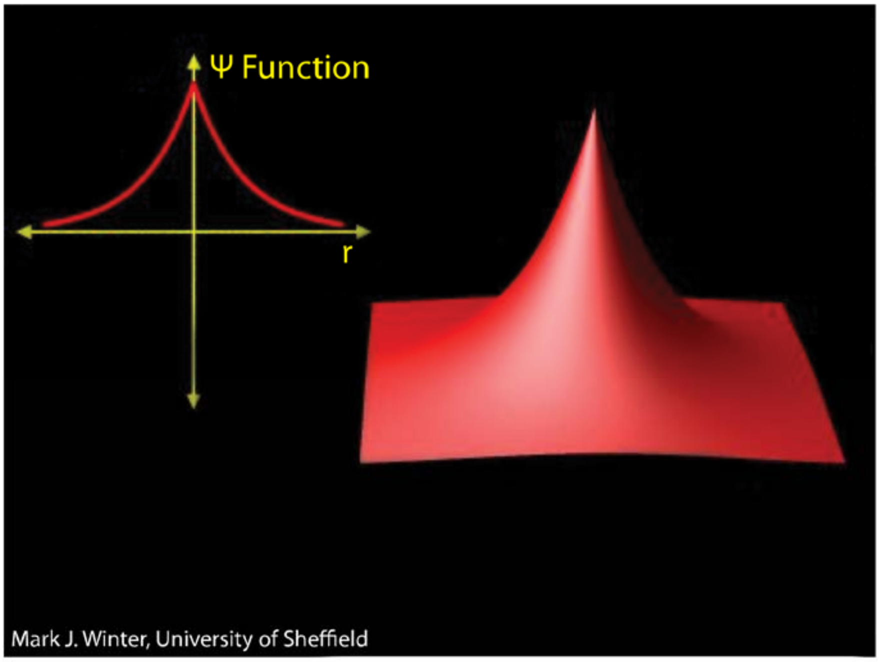

FIGURE 12-1 Plot of the 1s wave function of an Atomic Orbital

Figure 12-1[1] shows the graph and the 3 dimensional plot representing the ψ function of the 1s orbital of an electron in a hydrogen atom. Squaring this ψ function gives the probability of finding the electron. For the 1s atomic orbital, the peak corresponds to the location of the proton in the hydrogen atom. The closer we probe to the proton, the higher the probability of locating the electron. This plot, obtained from the Schrodinger equation, looks nothing like what might be expected from the Bohr model. There is no exclusive orbit with radius a_o. There is no net orbital

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[1] Mark J. Winter http://winter.group.shef.ac.uk/orbitron/

angular momentum. The only angular momentum of this orbital is the ½$\hbar$ angular momentum of the electron.

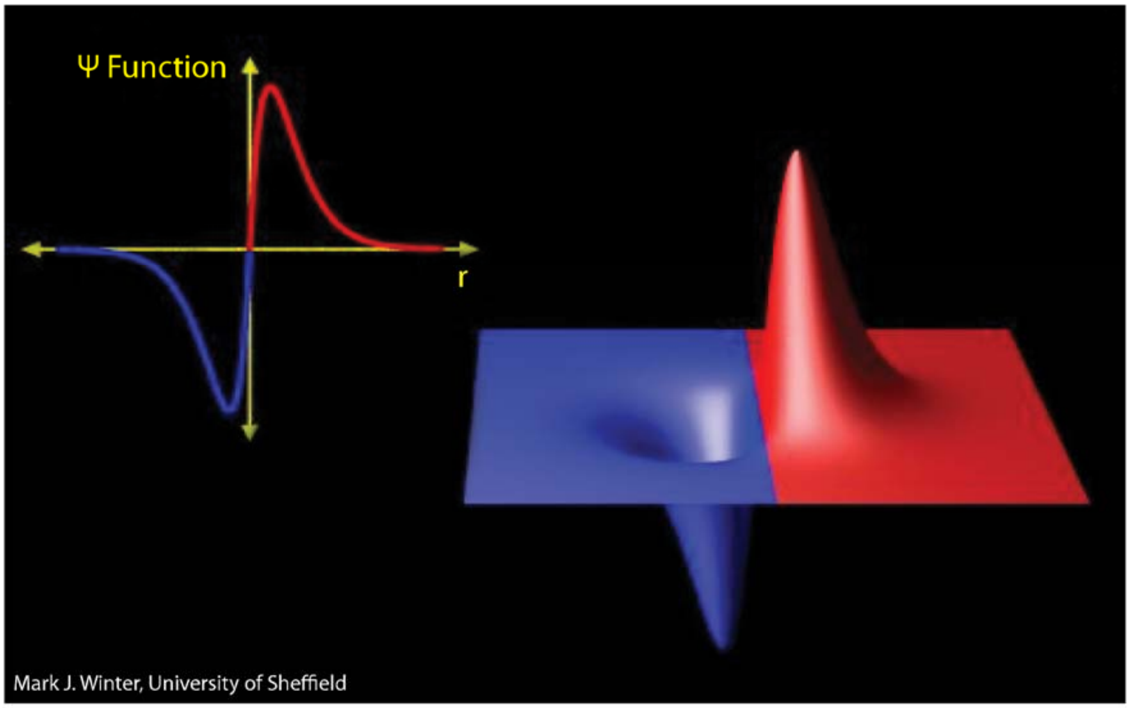

FIGURE 12-2 Plot of the $2p_x$ wave function of an Atomic Orbital

Figure 12-2 is similar to figure 12-1 except figure 12-2 shows the Ψ function and probability of finding an electron that is in the 2p orbital of a hydrogen atom. To understand these figures in terms of the spacetime wave model of rotars, it is necessary to examine the Ψ function.

Ψ Function: It is an axiom of quantum mechanics that the ψ function has no physical significance; only the square of the ψ function can be physically interpreted as representing the probability of finding a particle. It is proposed here that the spacetime wave model of rotars does give a physical meaning to the Ψ function. This physical meaning is easiest to explain by returning to the hypothetical example of a "particle in a box". In this exercise, students calculate what would happen if a particle was placed in a small cavity surrounded by impenetrable walls (an infinite energy well). There are no such cavities, but if there were the particle's quantum mechanical properties would be exhibited. The particle can only possess a few specific positive energies corresponding to a few specific kinetic energies which produce wave nulls at the walls. Furthermore, the particle can never be stationary within the cavity (never have zero kinetic energy).

If the “particle” is a rotar with the external volume wave structure proposed in this book, then it is conceptually understandable why the “particle” must have a wave structure that produces nulls at the walls. In this example, a single particle moving relative to the box produces a single standing wave pattern with nulls at the walls. This standing wave pattern consists of two wave frequencies propagating in opposite directions. These two counter propagating waves always possess more energy than an isolated particle that is not confined.

The “particle in a box” thought experiment is an idealized thought experiment since in nature there are no cavities surrounded by impenetrable walls creating an infinite energy well. If such a cavity existed, the quantum mechanical properties of a particle (rotar) trapped inside would be revealed. In order for the rotar to meet these boundary conditions imposed by the walls, it is necessary for the rotar to possess slightly more energy than an isolated rotar. Recall that attraction bonding involves a loss of energy and hypothetical repulsive bonding, such as a particle in a box, requires a gain in energy. In order for the rotar to achieve zero amplitude at the two 100% reflectors of the box, it is necessary for two spacetime wave frequencies to be present rather than the single Compton frequency of an isolated rotar.

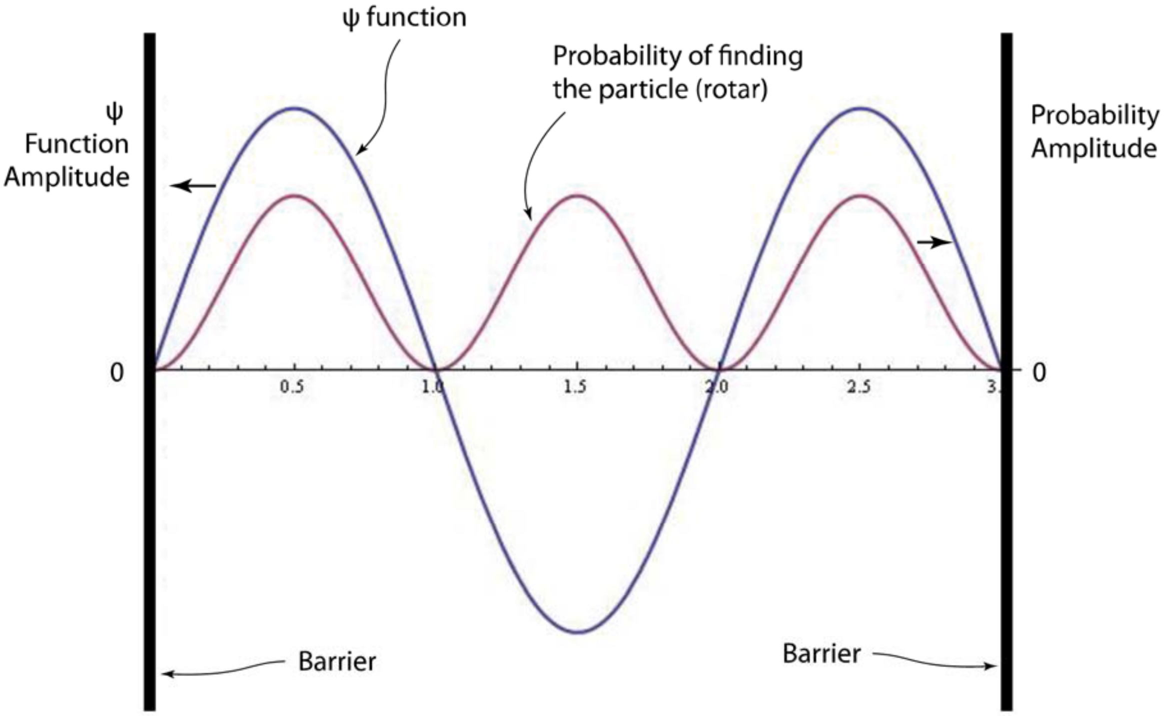

FIGURE 12-3 ψ function of a particle in a box (conventional model)

Figure 12-3 shows the conventional depiction of one possible Ψ function of a particle trapped in a small box with impenetrable walls. Different resonant modes are possible, so a three lobe resonance is chosen for ease of illustration. Note that the Ψ function represented in figure 12-3 has both positive and negative values (above and below the zero line). Quantum mechanics does not give a physical meaning to the Ψ function. Only the square of the Ψ function can be physically interpreted as the probability of finding a particle. The rotar model goes against this convention and gives a physical meaning to the Ψ function.

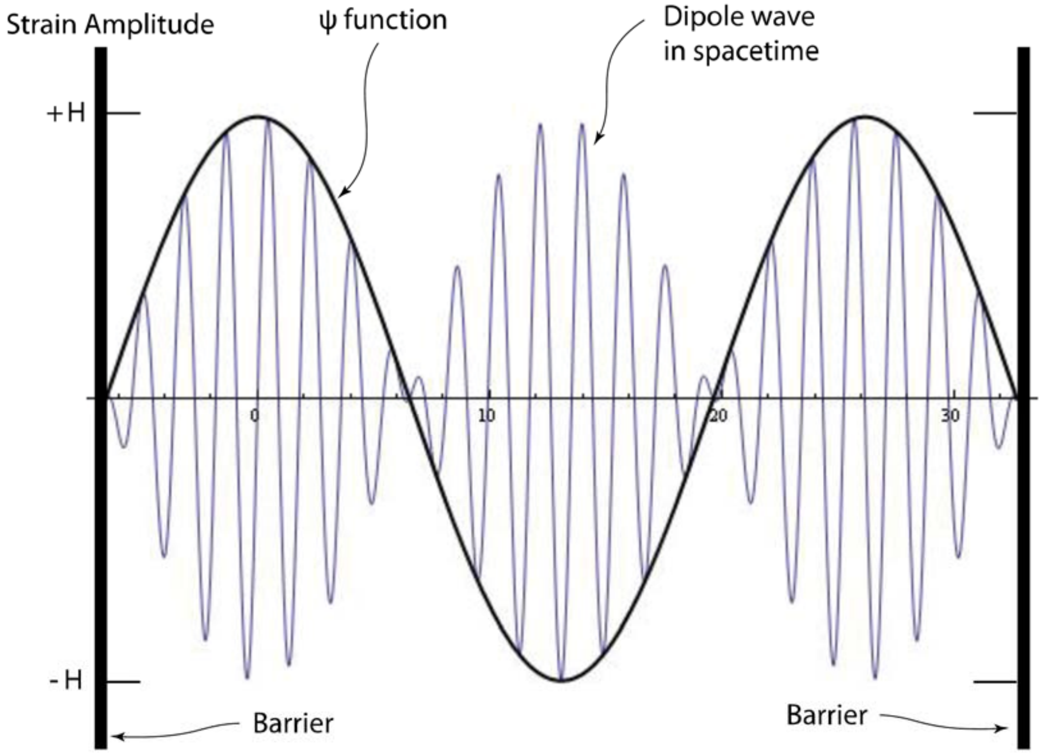

FIGURE 12-4 Spacetime wave model of the ψ function of a particle (rotar) in a box

The ψ function of a bound rotar is the wave envelope of the waves in spacetime that form the rotar.

Figure 12-4 shows the spacetime wave interpretation of the Ψ function of a particle in a box. We will reinterpret the particle in a box to a rotar trapped between two hypothetical barriers that are 100% reflectors for waves in spacetime. The box is essentially a repulsive type of confinement. Placing a rotar in a repulsive confinement requires that energy be added to the rotar in excess of the energy that a rotar would have if it was isolated. This added energy shows up in the rotar having two frequencies (one higher and one lower than the Compton frequency). Together they average more than the Compton frequency of an isolated rotar.

Placing a rotar in such a cavity changes the rotar's boundary conditions compared to an isolated rotar. In order for the rotar to meet the condition of zero amplitude at each of the two 100% reflectors, the rotar must possess two frequencies that are both propagating to the left and right in figure 12-4. These two frequencies traveling both directions produce the "stationary" standing wave pattern shown in this figure. This pattern looks similar to the de Broglie waves previously shown. However, de Broglie waves have the wave envelope moving faster than the speed of light while the wave envelope shown in figure 12-4 is stationary in the sense that its nodes and antinodes do not move.

Next, we will return back to the hydrogen atom that has its electron in the 1s orbital depicted in figure 12-1. The electron and proton are bound together by attraction. The combination lost 13.6 eV energy when they went from being an isolated electron and proton to being an electron bound in the 1s orbital of a hydrogen atom. New frequencies were introduced to the electron and the proton's quarks in this bonding process so that the average frequency of this combination is less than the sum of the Compton frequency of an isolated electron and isolated proton. All the orbitals of an electron in a hydrogen atom have a wave structure that involves two or more frequencies. The total of the energy is equal to the combination's energy in isolation minus the energy lost to form the hydrogen atom in the designated orbital. Orbital angular momentum also has a wave explanation that involves waves of slightly different frequencies propagating in opposite rotational directions around the proton. This is analogous to the waves having a rotating frame of reference.

While the Bohr atom model has been replaced by the quantum mechanical model, the point is that the superposition of counter propagating waves in the spacetime field traveling at the speed of light can achieve the desired orbital angular momentum. It is proposed that it is going to be possible to combine the spacetime wave model with the quantum mechanical atomic model to give a conceptually understandable model of an atom. The mechanism that eliminates energy loss (radiation loss) from an atom is unknown, but presumably it is similar to the mechanism proposed for stabilizing isolated rotars.

This explanation leaves a lot of questions unanswered. Perhaps the most obvious: Is there still a rotating dipole rotar volume buried somewhere within the bound electron's lobes? The electron retains its $\frac{1}{2}\,\hbar$ angular momentum in addition to orbital angular momentum present in most atomic orbitals. Further insights clearly will involve the marriage of quantum mechanics and improved versions of the spacetime wave theory of rotars. The difference in the spectrum of hydrogen and deuterium is due to the difference in the amount of nutation the two different mass nuclei experience. This seems to indicate that the electron retains a substantial amount of concentrated inertia within the electron cloud that is causing the nucleus to nutate.

The reason for bringing up the particle in a box exercise now is to make a point about bound particles. This lesson creates the erroneous impression that bound particles in nature can also possess a **positive** binding energy (the bound state is more energetic than the unbound state). The particle in a box exercise describes what would happen if a particle is surrounded by walls that are always repelling the particle. I am proposing that in nature, particles are always bound by attraction; not confined by repelling walls. Electrons in an atom are bound by attraction to the nucleus. Gravitational attraction binds a planet to a star. These are all examples of "negative binding energy". This means that bound state has lower total energy than the unbound component parts. Another way of saying this is that the bound state is an energy well. It is necessary to add energy to break the bond. From this, the following statement can be made:

Rotars bound by attraction always possess less energy than the same rotar when it is isolated. Attraction binding energy can be thought of as negative energy. Energy is emitted when rotars combine.

This seems very reasonable and not controversial. However, this goes against the commonly accepted model of a gluon which is depicted as a positive energy binding mechanism. The subject of gluons and quarks will follow, but first I want to support the contention that all other forms of binding in nature is by attraction forming an energy well (less energy than the unbound state).

In chapter #3 we determined that a particle has more internal energy in zero gravity than when the particle is in gravity. $(E_o = \Gamma E_g)$. Gravitational potential energy is a negative value that is referenced to zero at infinite distance. Suppose an observer using a zero gravity clock monitors the Compton frequency of the rotar as the rotar is restrained and slowly lowered towards a large mass. Gravitational energy is removed by the restraining mechanism as the rotar is slowly lowered into stronger gravity. The Compton frequency ω_c of the lowered rotar, measured by a zero gravity clock, decreases as gravity increases and more energy is removed. This decrease in frequency is not noticeable locally because of the gravitational dilation of time. Locally, a slow clock is used to monitor a slow Compton frequency. The point is that gravitational bonding energy is negative energy. The Compton frequency of a gravitationally bound rotar is lower than the same rotar not gravitationally bound when both frequencies are measured using a clock running at zero gravity rate of time.

For another example of a bond reducing energy, an electron and a proton release a 13.6 eV photon when they become electromagnetically bound together to form a hydrogen atom with the electron in the lowest energy level. This released energy represents the negative binding energy of the hydrogen atom. It is possible to go one step deeper in understanding this negative binding energy. An isolated electron has a Compton frequency of about 1.24×10^{20} Hz and the Compton frequency of a proton (sum of all components) is about 2.27×10^{23} Hz. When an electron and a proton are bound together to form a hydrogen atom, the sum of all the Compton frequencies is about 3.3×10^{15} Hz less than the when the electron and proton were isolated. This difference of 3.3 × 10^{15} Hz is the frequency of the 13.6 eV photon released when the hydrogen atom formed. Therefore it is possible to see the difference in energy when an electron and proton are bound to form a hydrogen atom. (To be perfect, this example needs to also account for the small amount of kinetic energy carried away by the hydrogen atom as it recoils from emitting the photon.)

A more extreme example is the bonding of an electron to a uranium nucleus which has been stripped of all electrons. This bonding is so strong that the bonding energy is equivalent to about ¼ the mass/energy of an electron. The energy lost when this bonding first takes place is removed by the emission of one or more gamma ray photons. Isolated particles are more energetic than bound particles. This concept will later be applied to bound quarks with some surprising implications.

Binding Energy in Chemical Bonds: Next, an example from chemistry. There are a few molecules such as ozone (O_3) and acetylene (C_2H_2) which are commonly described as being "endothermic". This means that starting with a standardized set of conditions from chemistry, it takes an input of energy (heat) to form the molecule. This would seem to imply that all endothermic molecules form positive energy bonds. The implication is that this is an example where the bound state is more energetic than the unbound state. For example, ozone requires an input of energy when it is formed from molecular oxygen O_2 under standardized conditions. However, we are probing a fundamental question about the nature of bonds. We must compare the bound state to the unbound state which in this case would be individual atoms. It takes 1½ molecules of O_2 to form 1 molecule of O_3 (written as: $3\ O_2 \rightarrow 2\ O_3$). To separate one of the O_2 molecules into two oxygen atoms takes about 2.6 eV/molecule or 249 kJ/mole. This gives the erroneous impression of the bound state can be more energetic than the unbound state. However, if we formed ozone starting with 3 atomic oxygen atoms, then this reaction releases energy when a molecule of O_3 is formed. Similarly, the formation of acetylene is an endothermic reaction if the standardized starting components of graphite and molecular hydrogen (H_2) are used. However, the formation of acetylene is an exothermic chemical reaction if the starting components are atomic carbon and atomic hydrogen. In fact, there are no endothermic chemical reactions if the starting material is individual atoms. Therefore, even chemistry supports the contention that bonds in nature reduce the energy of the component parts. In this case molecules always possess less energy than the component atoms when the atoms are isolated.

Binding Energy of Nucleons: While it is very difficult to make energy and force measurements inside a proton or neutron, we can obtain a hint of what is going on inside protons and neutrons by looking at the binding that occurs between nucleons. When protons and neutrons are bound together to form atomic nuclei, is there a gain or loss of energy? The answer is obvious. A helium atom (^4He) has less mass/energy than 2 deuterium atoms. The binding energy of nucleons is a negative form of energy (energy reduction compared to the sum of the unbound components). There is a decrease in mass (loss of energy) when hydrogen nuclei fuse to form nuclei of heavier atoms. At first it might appear that ^{235}U and other heavy atoms are an exception to this rule, but this is incorrect. The strongest bound atomic nucleolus is ^{56}Fe with a binding energy of 8.79 MeV per nucleon. ^{235}U has a binding energy of 7.79 MeV per nucleon and this is comparable to the binding energy per nucleon of carbon or nitrogen. Breaking ^{235}U apart releases energy because the two lighter nuclei formed have a greater binding energy per nucleon than ^{235}U. A greater binding energy means that excess energy must be released upon formation. The point is that even ^{235}U has less mass/energy than the energy of the protons and neutrons that form the uranium nucleus.

It is proposed that quarks are bound together to form hadrons by negative energy. The hadrons would have less energy than the total energy of the component quarks if the quarks were stable in isolation so that their energy in isolation could be experimentally measured.

Gluons, Quarks and Hadrons

Background: The previous discussion asserted that in nature the bound state was always a lower energy condition that the individual components in the unbound state (bound state is always an energy well). This concept is going to be important in the following discussion about quarks and gluons. The problem is that if we faithfully develop a model of the universe starting with the assumption that the universe is only spacetime, we obtain the strong force from the pressure exerted by the spacetime field. There is no need to postulate gluons! Since gluons are very much a part of modern particle physics, this seems to present a problem for the spacetime model of the universe. However, it will be argued here that all the functions currently attributed to gluons (color charge, etc.) can be converted to functions attributed to the rotar model of quarks existing in the pressure exerted by the spacetime field.

Previously we rejected virtual photons as the “messenger particles” that carried the electromagnetic force and rejected gravitons as the “messenger particles” that carried the gravitational force. The next remaining virtual messenger particle is the gluon and this is going to be questioned. There is no experimental observations that can be interpreted as being proof that virtual photons or gravitons exist but there is some experiments that seem to imply that gluons exist although they have never been directly observed. Also there is a vast amount of theoretical calculations that are modeling effects that are attributed to gluons. Therefore the discussion about gluons is going to be more nuanced. The analysis of quarks and gluons will begin with a discussion about the mass/energy of quarks.

Mass/Energy of Quarks: Since quarks do not exist in the unbound state, it is not possible to simply compare the energy of an unbound quark to a bound quark. The following is a quote from an article on quark masses written by A.V. Manohar and C.T. Sachrajda[2]

> "Quark masses therefore cannot be measured directly, but must be determined indirectly through their influence on hadronic properties. Although one often speaks loosely of quark masses as one would of the mass of the electron or muon, any quantitative statement about the value of a quark mass must make careful reference to the particular theoretical framework that is used to define it. It is important to keep this scheme dependence in mind when using the quark mass values tabulated in the data listings. Historically, the first determinations of quark masses were performed using quark models. The resulting masses only make sense in the limited context of a particular quark model, and cannot be related to the quark mass parameters of the Standard Model."

I will expand on this thought somewhat. Suppose that there is an experiment which collides protons and anti-protons together at high energy. The collision produces a complicated shower of particles that is hard to interpret. If protons are assumed to consist of point particle quarks plus gluons and virtual particle pairs forming and annihilating, then the interpretation of the results will be different than if the protons are assumed to be the rotar-model quarks possessing quantized angular momentum colliding in sea of dipole waves designated as the spacetime field. With this being said, we will first look at the widely accepted interpretations of these complicated experimental results.

The description of a proton differs greatly depending on the experiment. For example, in low energy collisions, a proton seems to be made of 3 quarks with each quark possessing approximately $^1/_3$ of the proton's energy. In high energy collisions a proton seems to have many quarks (over 10) with each quark possessing energy of only a few MeV. We will examine each model.

At the low energy limit a proton appears to have a total of 3 quarks - two up quarks and one down quark. In the low energy condition these 3 quarks are referred to as "constituent quarks". The two constituent "up" quarks of a proton appear to have energy of 336 MeV each[3]. The single down constituent quark appears to have energy of 340 MeV. Here is another description of the constituent quarks.

> Nonrelativistic quark models use constituent quark masses, which are of order 350 MeV for the u and d quarks. Constituent quark masses model the effects of dynamical chiral symmetry breaking… Constituent masses are only defined in the context of a particular hadronic model."[4]

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[2] Quark Masses Updated Jan 2012 by A.V. Manohar (University of California, San Diego) and C.T. Sachrajda (University of Southampton) http://pdg.lbl.gov/2013/reviews/rpp2012-rev-quark-masses.pdf

[3] Griffiths, D., (2008) *Introduction to Elementary Particles* p. 135, Wiley-Vch

[4] "Note on Quark Masses":http://pdg.lbl.gov/2010/reviews/rpp2010-rev-quark-masses.pdf

This name “constituent quarks” is used when describing the model that emerges from low energy experiments. The name “current quarks” is used to represent the quark model which is obtained in high energy collision experiments. In high energy collision experiments there appears to be many more than 3 quarks and each of these appears to have energy of only a few MeV. To reconcile this difference the difference between the low energy and high energy collision experiments, the 3 constituent quarks observed in low energy collisions are often visualized as being composed of a core current quark with energy of a few MeV which is surrounded by either a cluster of virtual particle-antiparticle pairs or surrounded by gluons. In either case, the total energy of what is interpreted to be a cluster is approximately $^1/_3$ of the proton energy.

According to the proposed spacetime model, the problem comes in interpreting high energy collisions. In the rotar model of a high energy collision, one or more of the 3 quarks momentarily absorbs far more energy than the rest energy of the quark. Recall the previous discussion of the difficulty determining the size of an electron from energetic collisions of the rotar model of an electron. The kinetic energy of the collision is momentarily converted into the internal energy of the electron (rotar model). This causes the electron’s radius to momentarily decrease so that it was always below the detectable limit of the experiment.

The collision of protons is more complicated, but one thing is clear. The energetic conditions which prevail at the moment of collision are not the same as an isolated proton. If the model of a quark is a point particle, then there is no internal structure and it is valid to assume that the quark retains its properties even in a violent collision. However, if each quark is assumed to have a rotar model, then this is three “fluffy” rotating dipole waves existing in the spacetime field. They each are a rotating dipole wave in spacetime possessing a quantized unit of angular momentum. This rotating wave is distributed over a volume of space. Adding the kinetic energy of the collision momentarily decreases the size of a quark. This changes the bonding conditions but retains a constant angular momentum. The rotar model of protons is in an early stage of development and cannot predict the results which would be expected in an energetic collision. However, it is possible to imply that the complicated results of energetic collisions can be misinterpreted if point particle quarks and gluon messenger particles are erroneously assumed.

The quarks observed in high energy collisions appear to be very different from the constituent quarks at the low energy limit. The three “current quarks” that form a proton appear to have energy less than 10 MeV. In this picture obtained from high energy collisions, only about 1% of the rest mass of a proton appears to be in the form the quarks. In this case about 99% of the mass/energy of a proton is therefore assigned primarily to the energy of gluons with some contribution from the kinetic energy of quarks. In other words, the gluons must possess positive energy in this model. More will be said about gluons later.

Alternative Explanation: The proposed alternative explanation of the mass of a quark is that up and down quarks would be intrinsically high energy rotating dipole waves if they were stable in isolation. They are strongly bound together by an interaction with the spacetime field when they form hadrons. There are no isolated first or second generation quarks because they simply do not attain stability as isolated rotars. (The top quark will be discussed later). When this model of a quark is bound into a hadron it is in a low energy state, an deep energy well. Attempting to remove quarks from a hadron against the strong force increases the quark's energy (Compton frequency) towards the higher energy state which would exist if a quark (rotar model) could exist in isolation. The energy exerted in attempting to remove a quark from a hadron requires so much energy that a new meson (pion) is formed before an isolated quark is obtained. When new mesons are formed, the binding force between former components of the split hadron decreases to near zero. Single first or second generation quarks are never produced.

However, to illustrate the concepts, we will imagine what it would be like if isolated quarks were allowed. It is proposed here (justified later) that if isolated up and down quarks existed, they would be rotating dipoles with energy substantially greater than 400 MeV. If up and down quarks existed as isolated rotars, then they would shed energy when they bond to form a proton or neutron. Hadrons come into existence already formed since this is the lowest energy state and the only form that has stability. However, it is informative to imagine the steps that would occur if a hadron was formed from isolated quarks.

Energy of Bound Quarks: The working proposal is that all the energy of a proton is contained in its three bound quark rotars (rotating dipole waves in spacetime). However, the model of the interaction of quantized waves should not be equated to the expected interaction if the quarks were hard shelled particles. Furthermore, it is proposed that the binding energy is so great that the bound quarks have much less energy than they would have as hypothetical isolated rotars. We will first survey the hadrons that are made of only up and down quarks to compare the energy of the up and down quarks under various bound conditions. The nucleons (protons and neutrons) have almost the same energy ~938 MeV. If we assume that all this energy can be traced to the energy of 3 rotating spacetime dipoles (3 quarks) then the implication is that up and down quarks have about the same energy. There are different proportions of up and down quarks, yet approximately the same total energy. We will assume that bound up and down quarks in a nucleon has energy of about 313 MeV (~ $^1/_3$ of the total).

There are two other families of hadrons that consist of only up and down quarks. These are the pi mesons (pions) and the delta baryons. The delta baryons have spin of $J = {}^3/_2$ rather than the spin of ½ for the nucleons. There are 4 delta baryons. These are:

Δ^{++} (uuu); Δ^{+} (uud); Δ^{o} (udd) and Δ^{-} (ddd).

These all have about the same energy (1,232 MeV) therefore the up and down quarks bound in this hadron have energy of about $^1/_3$ of this value: ~ 411 MeV.

The pions consist of a quark and an anti-quark such as an up quark and an anti-down quark. The net spin of the pions is zero (counter rotating dipoles). The energy of the pions is 139.5 MeV for the two charged pions (π^+ and π^-) and about 135 MeV for the neutral pion (π^o). This means that the up and down quarks in a pion have average energy of about 70 MeV for the charged pions (π^+ and π^-) and about 68 MeV for a neutral pion π^o.

Therefore we have examples where up and down quarks have energy ranging from 411 MeV to 68 MeV. The standard model deals with this difference by assuming that an isolated up or down quark has energy of only a few MeV. The extra energy required to reach 68 MeV, 313 MeV or 411 MeV is assumed to be predominately in the energy of the gluons.

Energy of a Hypothetical Isolated Quark: The proposed spacetime wave model of quarks offers a different answer. It says that an isolated rotar up or down quark would have energy substantially greater than 411 MeV. When quarks are bound into a hadron, the bonds are so strong that a large percentage of the hypothetical isolated energy is lost. It would be radiated away if it was possible to do this experiment. The difference between the 68 MeV, 313 MeV or 411 MeV reflects different amounts of binding energy.

The binding energy per nucleon in ^{56}Fe represents approximately 1% of a proton's energy. An electron bound to a uranium atom's nucleolus stripped of all other electrons has a binding energy that is about 25% of an isolated electron's energy. In order for an electron to attach to a stripped uranium atom nucleolus, it has to emit one or more gamma ray photons to shed a total of about 25% of the electron's energy. Actually part of the lost energy comes from the protons in the nucleus, but that is off the subject.

It is proposed that the binding energy of quarks in a hadron is much greater than these examples. To illustrate this concept, we will choose an energy substantially larger than 411 MeV for the energy of a hypothetical unbound up or down quark. For illustration, we will use the number of about 600 MeV for the energy of isolated up and down quarks. With this assumption, an isolated up or down quark would lose about 1/3 of its energy when it forms a delta baryon (411 MeV). It would lose about ½ of its energy when it forms a nucleon (313 MeV) and it would lose about 89% of its energy when it forms a neutral pi meson (68 MeV).

Electron vs. Proton Size: Before proceeding too far, it is desirable to do a calculation to see if the ideas proposed here are plausible. We will attempt to calculate the size of a proton. However, first it is necessary to recognize why a proton has a measurable size and an electron does not. A proton has a measurable size because a proton is made up of 3 fundamental rotars. The three quarks of a proton do not respond to a high energy collision as a single quantized unit. The property of unity only exists within a single quantized wave (rotar). A collision with a proton involves speed of light communication of forces between the three quarks of a proton. This means that the proton exhibits a physical size in a collision even though this size does not exhibit a hard boundary.

When an electron collides with one of the three quarks in a proton, it appears as if there is a collision between two point particles. The reason is the same as previously explained for a collision between two electrons. Both the electron and the quark are quantized rotating dipoles in the spacetime field. In a direct hit, they both convert the kinetic energy of the colliding electron to internal energy of the rotating dipole. This happens faster than the speed of light because preserving the quantized angular momentum results in the previously explained property of unity. The conversion of kinetic energy momentarily increases the Compton frequency of each rotar. In order for angular momentum to be conserved, the rotar radius $\lambda\!\!\!^{-}_c$ of each rotar momentarily decreases. The amount of decrease in size makes each rotar experimentally indistinguishable from a point particle because (as previously explained) the momentary radius is less than the resolution limit set by the uncertainty principle. The other two quarks that were part of the proton only learn about the collision through speed of light communication.

Calculation of Proton Radius: The presence of only three quantized waves means that a proton still exhibits substantial quantum mechanical properties such as no definite shape and the lack of a hard edge. Also the shape of a proton depends on the alignment of the spins of the quarks. An analysis[5] of all measurements of the proton radius concludes a most probable charge radius for a proton is: 0.877×10^{-15} meter $\pm\ 0.15 \times 10^{-15}$ meter

We will do a plausibility calculation to see if the proposed rotar model of a proton gives roughly the correct size. This calculation will assume that the proton is made of 3 rotars, each with energy of 313 MeV (5×10^{-11} J). We must decide how these three rotating dipoles fit together. Are there voids or excessive overlaps? It is known that protons are not necessarily spherical depending on the alignment of the spins of the up and down quarks. Still, the simplest assumption is a spherical proton with quarks that are so intimately bound that the proton has three times the volume of an individual rotar quark with radius $\lambda\!\!\!^{-}_c$. The plausibility calculation will assume this simplified model.

We will first calculate the rotar radius $\lambda\!\!\!^{-}_c$ of a rotar with energy of 5×10^{-11} Joule (313 MeV). Then we will increase this radius by a factor of $3^{1/3}$ to obtain the radius of a sphere with 3 times the volume of an individual rotar quark.

$\lambda\!\!\!^{-}_c = \hbar c/E_i$ substitute: $E_i = 313$ MeV $= 5 \times 10^{-11}$ J
$\lambda\!\!\!^{-}_c \approx 6.3 \times 10^{-16}$ meter radius of one quark with energy of 313 MeV
$\lambda\!\!\!^{-}_c \times 3^{1/3} \approx 9 \times 10^{-16}$ meter calculated proton radius (3 quarks)

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[5] http://arxiv.org/abs/hep-ph/0008137v1

The experimentally determined radius of a proton is: $8.77 \times 10^{-16} \pm 1.5 \times 10^{-16}$ meter, therefore the calculated radius of 9×10^{-16} meter agrees within the experimental error. This degree of accuracy is probably more than we deserve considering the crudeness of the calculation. In fact, the rotar model could be correct for charged leptons and too simplified to be applied to quarks which are tightly bound with very restrictive boundary conditions. Still, the calculation does give a reasonable answer and cannot be ignored. This calculation could easily have been off by many orders of magnitude if the rotar model was completely wrong.

It is also interesting to note that the density of the quarks in the above calculation is roughly 5.9×10^{17} kg/m^3. The density of the nucleus of an atom with many bound nucleons is subject to some interpretation, but is roughly 2.3×10^{17} kg/m^3. Therefore, the density of an atomic nucleus is roughly half the density of individual quarks. This is far different from the standard model that depicts quarks as point particles and therefore infinitely more dense than an atomic nucleolus.

To summarize, the rotar model of quarks implies that if quarks could exist in isolation, they would have substantially more energy than they have when bound together to form hadrons. In this case, the quarks would lose energy (emit photons) when they are bound together to form hadrons. This results in an energy well, just like all other bonds in nature. The rotar model depends of the existence of the spacetime field to stabilize the rotars. As previously stated, the spacetime-based model of the universe has only one truly fundamental force (the relativistic force) and that force is always repulsive. The bonding of the quarks is ultimately traceable to pressure exerted by the spacetime field.

Gluon Background: Next, we will examine gluons. According to the standard model, gluons are exchange particles that carry the strong force (the strong interaction) between quarks. Gluons carry the color charge and also participate in the strong interaction in addition to being a mediating exchange particle. The 8 types of gluons have color charge. While there are 3 color charges (red, green and blue), gluons carry complex combinations of these color charges. For example, a description of one of the 8 possible gluons is: (red-anti blue + blue-anti red). Gluons are also described as massless vector bosons with spin of 1 which have two polarization states. The standard model description of gluons is very complex and quantum electrodynamics calculations involving gluons are also complex.

According to theory, bonds between quarks become weaker as the distance decreases. Therefore quarks bound in hadrons are in a state of "asymptotic freedom". When quarks are in their unperturbed state, they can migrate within the hadron as if they are not tightly bound. However, the asymptotic freedom state only occurs when quarks maintain the prescribed distance relative to each other. If the distance is increased, the strong force increases. As the separation distance is increased, energy is being added to the hadron and the restoring force increases. The added energy supposedly goes into the energy of the gluons. The quarks supposedly maintain a constant energy of less than 10 MeV. When the separation distance between quarks reaches roughly 10^{-15} m, enough energy has been added to the gluons to form a new meson (quark –antiquark pair) and the restoring force drops to nearly zero. There are three problems with this.

1) This gluon bond model does not follow the example of the particles possessing less energy in the bound state than they have in isolation. It is true that we cannot obtain an isolated quark for comparison, but the point is that the model is that each quark retains a constant energy as the quarks are being separated. The work being done does not go into increasing the energy of the quarks. This is not a typical energy well.
2) The gluons possess positive energy and are traveling at the speed of light. Since the proton has energy density of about 3×10^{35} J/m^3, if almost all the energy is attributed to gluons this implies that the gluons should exert pressure of at least 10^{35} N/m^2. The pressure of this high gluon energy density should destroy protons, not bind them together. How do the gluons achieve attraction?
3) Why does the force start at zero and increase with distance? This is "explained" by physicists postulating that as the quarks are separated, the gluons form "flux tubes" and this concentration actually increases the force of attraction even though the distance is increasing. What is the physics behind this concept? What supplies the force to constrain the size of the flux tubes? Depending on the volume of the flux tubes, the confined gluons should exert even more pressure than 10^{35} N/m^2. All of this is so far removed from anything else in nature that it speaks to the problems created the concept of gluons.

The experimental evidence for the existence of gluons is that very energetic collisions of electrons and positrons sometimes produce "three jet events" (a jet is a narrow shower of particles). The explanation for these three jet events is that at least one of the three jets resulted from a gluon "hadronize" into normal particles (colorless hadrons) which results in the narrow shower of particles known as a jet.

The Relativistic Force: As previously stated, the spacetime model has only one truly fundamental force: the relativistic force. This force is generated when energy, traveling at the speed of light, is deflected in some way. For example, the absorption, emission or reflection of a photon results in the transfer of linear momentum. The relativistic force F_r is the name given when multiple linear momentum transfers can be considered to be a continuous force. The equation is $F_r = P_r/c$ where P_r is relativistic power propagating at the speed of light. The relativistic force is always repulsive. As previously explained the relativistic force can appear to be an attracting force when the spacetime field exerts the relativistic force in a way that brings particles together. For example, the electrostatic or gravitational attraction is actually the result of the spacetime field applying unequal pressure on rotars producing a net force of attraction. This is an introduction of how the relativistic force also produces what we perceive to be the strong force without gluons.

All rotars possess energy density which implies that they have internal pressure. The rotar pressure is: $\mathbb{P}_r = (\omega_c^4\hbar/c^3) = E_i/\bar{\lambda}_c^3$. To stabilize this internal pressure the spacetime field must exert an opposing pressure. If this pressure is balanced on all sides, then there is no net force. However, other rotars in the vicinity result in a distortion of the spacetime field and this in turn results in an unbalanced pressure (a net force) exerted on the rotar. When this net force is in the direction of the other rotar, then we say that there is a force of attraction between the two rotars.

The maximum force (F_m) that a rotar can exert was previously shown to be $F_m = \mathbb{P}_r\bar{\lambda}_c^2 = E_i^2/\bar{\lambda}_c$. Care must be used in applying this equation because E_i is the instantaneous internal energy and $\bar{\lambda}_c$ is the instantaneous rotar radius. For example, in a collision, the kinetic energy gets temporarily added to the rotar's internal energy E_i. Therefore at the instant of the collision the value of E_i increases and the value of $\bar{\lambda}_c$ decreases. The result is that the value of F_m is greater in a collision than the theoretical value for a rotar not undergoing a collision.

It is possible to do a rough calculation of the value of the maximum force that the 3 quarks that make up a proton can exert. We will start by assuming that the proton's energy of 938 MeV is evenly distributed among its 3 quarks (rotars). If each quark has energy of about 313 MeV or 5×10^{-11} J, then the value of the maximum force available to the three quarks in the unperturbed state of asymptotic freedom is about $F_m \approx 80{,}000$ N. This maximum force calculation does not attempt to identify whether the rotar can actually exert this maximum force, it is merely the upper limit.

In chapter 7 the section titled "Asymptotic Freedom" gave the explanation of how the strong force can be zero at the asymptotic freedom separation distance. Recall that at this separation distance opposing forces between the spacetime field and the repulsion of adjacent particles offset each other so the net force on a quark at the asymptotic freedom separation distance is zero. However, displacing a quark in either direction (closer or further from the other quarks) produces a net force which attempts to restore the separation to the asymptotic freedom separation. The energy required to change the separation distance is stored in the quark increasing its rotational frequency. Recall the hypothetical assumption that an up or down quark in a proton has about 313 MeV but it would have energy of about 600 MeV if it could exist as a stable isolated particle. This is the energy well previously discussed. In this example, removing a quark from a proton would require about 300 MeV but a pion forms at 135 MeV, so this happens first and the restoring force falls to nearly zero.

We can do a rough calculation to see if this model is reasonable. We know that the radius of a proton is about 8.8×10^{-16} m and pions are formed when a quark is displaced by roughly this distance. It is possible to do a rough calculation to see how far a quark would have to move against against a constant 80,000 N force before enough energy would be stored to make a pion with energy of 135 MeV ($E_i \approx 2.2\times10^{-11}$ J)? The answer is about 2.7×10^{-16} m. This calculation represents an unrealistic lower limit because the force would not go from zero at the asymptotic freedom separation distance to the full maximum force of 80,000 N abruptly. Instead, there would be a gradual increase starting at zero and ending at some force probably less than 80,000 N. Another simplified calculation of the separation distance required to make a pion would start at zero force at the asymptotic freedom separation and linearly increase the force to 80,000 N at the total energy required to make a pion. In this case the separation distance where a pion is formed would be roughly 5.5×10^{-16} m. Even this over simplified assumption clearly gives an answer in the range of proton radius. Again, this calculation could have been off by many orders of magnitude.

Gluons Not Needed for Bonding: The point of this discussion is to support the contention that the spacetime-based model of the universe can explain the strong force using only the single universal force: the relativistic force. The spacetime-based model of the universe is not developed sufficiently to make predictions about the properties of specific fundamental particles. In particular, it is not possible to say whether a gluon-like particle with spin of 1 exists. The main reason for postulating the existence of a gluon (a messenger particle that conveys the strong force) has been removed. However, something causes 3 jet events in energetic collisions of electrons and positrons. Quantum chromodynamics assigns additional functions to gluons besides being a messenger particle and these additional functions are still required. The rules of the color force which currently require 8 gluons may still require 8 bosons but with redefined wave-based characteristics. Therefore gluons are not needed for bonding, but some of the other functions currently assigned to gluons will need to be reinterpreted.

Stability of Hadrons: Suppose that we imagine starting with the superfluid spacetime field that lacks angular momentum, then we introduce one unit of $\frac{1}{2}\hbar$ quantized angular momentum. Merely stating the amount of angular momentum does not specify the energy, frequency, amplitude, rotational size, etc. that this angular momentum might take. The spacetime field has characteristics that determine what combination achieves long term stability such as an electron and what is semi-stable such as a muon or tauon. There is an infinite number of other possible combinations of frequency, amplitude, rotational size that do not possess any stabilizing characteristics from the surrounding spacetime field. These totally unstable combinations last for only a unit of time equal to $1/\omega_c$ where ω_c is the hypothetical Compton angular frequency. For frequencies in the general range of the known particles, the survival time would be roughly in the range of 10^{-25} to 10^{-20} seconds. The few combinations of angular momentum, frequency, amplitude, etc. that achieve stability are the rare exception.

This is mentioned as an introduction to a discussion of the stability of hadrons. While the leptons are stable or semi-stable as individual rotars, the quarks are not. Somehow two or three quarks acting together can find stability where individual quarks do not. Do the hadrons that find stability achieve this stability by exhibiting the standing wave properties of a single unit? It is possible to answer this question by looking at the diffraction pattern of neutrons passing through a crystal. The diffraction pattern produced by a neutron (3 quarks) implies a de Broglie wavelength that is characteristic of the neutron's total mass $(\lambda_d = h/mv)$ rather than the mass of the three individual quarks with approximately one third this total mass.

Apparently the stability condition required for vacuum energy to stabilize a neutron results in frequency summation in the external volume. In other words, the 3 quarks present in the neutron lose their individuality at the boundary of the neutron. Externally, the vacuum energy stabilizes a neutron by treating it as a single unit. The standing waves generated in the vacuum energy apparently are equivalent to a Compton frequency characteristic of the entire energy of the neutron. The de Broglie waves generated by a neutron imply a single wavelength of the bidirectional standing waves in the neutron's external volume. Besides neutrons, larger composite particles such as alpha particles and even entire molecules exhibit diffraction patterns characteristic of the total energy. An improved rotar model should address the issue of frequency summation further.

Formation of the First Hadrons: The formation of rotars in the Big Bang was previously described as a trial and error process where a few combinations of angular momentum, frequency, and amplitude condensed out of the chaotic energetic waves in spacetime present in the early stages of the Big Bang. It is now proposed that besides single rotating spacetime dipoles, nature also found a few combinations of rotating dipoles that could achieve stability. These also condensed out of the energetic waves in the spacetime field as already formed hadrons. The source of the angular momentum required to form quarks, leptons and photons will be addressed in chapters 13 and 14. It will be shown that even the starting condition of the universe (Planck spacetime) must have possessed quantized angular momentum.

Presumably the first hadrons that condensed out of the energetic waves in spacetime created by the Big Bang were highly energetic hadrons made from generation III and II quarks. The probable sequence that eventually arrives at the dominance of protons and neutrons in the universe today will have to be developed by others.

W and Z Bosons: So far this analysis has not mentioned W^+, W^- and Z bosons. There is clearly a large body of experimental observations that support these particles in the standard model. However, like gluons, it is proposed that these bosons have a wave explanation. W and Z particles have $\hbar$ spin characteristic which is normally associated with a boson. However W and Z particles also have rest mass which is normally associated with a fermion (spin ½ $\hbar$). Clearly this is more complicated than previously encountered with other fermions or bosons.

Is there any other case discussed in this book where a boson (spin $\hbar$) possesses rest mass? The answer is: yes. In the first chapter we discussed the case of photons confined in a reflecting box. Photons have $\hbar$ spin yet when they are confined in some way they are forced to have a specific frame of reference and they acquire rest mass. In fact, it was pointed out that any time a photon has energy of $E \neq pc$, the photon will have rest mass. When a photon is confined between two reflectors it can be thought of as propagating in both directions simultaneously. Since momentum is a vector, the two vectors cancel and $p = 0$. This condition gives the photon rest mass even though the photon is a boson. Therefore even a photon propagating through glass is propagating at less than the speed of light in a vacuum and $E \neq pc$.

The point of this example is that bosons, with spin $\hbar$, can have rest mass if they interact with fermions (rotars) in a way that results in $E \neq pc$. Apparently spacetime and the hadron structure must have a type of resonance that occurs at 1.22×10^{26} s^{-1} (W boson 80,38 GeV) and 1.39×10^{26} s^{-1} (Z boson 91.19 GeV).

Imagine two quarks acting something like mirrors momentarily confining a W or Z boson. With Compton wavelengths of 1.54×10^{-17} m and 1.36×10^{-17} m (W and Z respectively) these are the size range that plausibly could interact with the rotar structure of hadrons. The W and Z bosons would have a standing wave structure which would look like standing waves interacting with the wave structure of the two quarks. This would give these W or Z bosons rest mass and the short range properties normally associated with the weak force. This is not a complete explanation, but it does show how the spacetime model of forces and particles can accommodate W and Z bosons. Hopefully others will analyze this further.

The concept of the Higgs field and Higgs boson was originally developed to "explain" how W and Z bosons acquired rest mass (inertia). While I favor the previous explanation of how W and Z bosons acquire inertia, the rest of the scientific community currently believes that the Higgs field interacts with W and Z bosons and that interaction gives them rest mass. In the spacetime model of the universe, the spacetime field is the only one truly fundamental field. Multiple resonances within the spacetime field are responsible for all the various particles. These multiple resonances can be thought of as separate fields. In that sense, it is possible to say that there is a Higgs field the same way that all other particles can be considered to have their own fields (resonances). Since the spacetime model of the universe has not been developed sufficiently to make predictions about W and Z particles, it is not possible to conclusively say how W and Z bosons obtain their inertia. Therefore it is hypothetically possible that the mechanism might include an interaction with the Higgs resonance (Higgs field). However, as previously explained, fermions exhibit rest mass through the same mechanism that confined photons exhibit rest mass. Fermions do not require a Higgs field to obtain inertia.

Neutrinos

Neutrino Introduction: Neutrinos are the least understood of the "fundamental particles". There are three types or "flavors" of neutrinos (electron neutrinos, muon neutrinos and tau neutrinos). These are three flavors are sometimes designated m_1, m_2 and m_3 respectively. Previously the standard model considered neutrinos to be massless particles but experiments prove that neutrinos can change from one type of neutrino to another type of neutrino as a neutrino propagates through space. This "neutrino flavor oscillation" is interpreted as indicating that neutrinos must have some rest mass. The reasoning is that anything traveling at the speed of light cannot experience time and therefore neutrino flavor oscillation implies that neutrinos must be traveling at less than the speed of light. The flavor oscillation data could not give absolute values for neutrino mass, but the data could give an indication of the difference between the square of the masses[6]. For example, this difference can be expressed as: $\Delta m_{12}^2 \approx 7.6 \times 10^{-5}$ eV^2 and $\Delta m_{23}^2 \approx 2.4 \times 10^{-3}$ eV^2. Now there has been the first experimental results which purport to give an absolute value of the sum of the rest mass of the three flavors of neutrinos[7] as 0.32 ± 0.08 eV. I will interpret this as the average rest mass since the flavor oscillation is sequential. This was not a direct measurement of mass. Instead it combined cosmological measurements and a theory of the effect neutrino mass should have on these cosmological measurements. Therefore, this measurement could be wrong if the theory is wrong. Still, this mass/energy is reasonable and will be used in further discussion of neutrinos both here and in chapter 13. For example, using a value of 0.32 eV for the mass of the muon neutrino and using the previously mentioned values of the difference in the square of the masses we obtain the following: An electron neutrino should be about 1.2×10^{-4} eV less than a muon neutrino and a tau neutrino should be about 3.7×10^{-3} eV larger than a muon neutrino. Therefore this estimate implies that the tau neutrino is about 1% more energetic than the electron and muon neutrinos.

The spacetime wave model of the universe can accommodate neutrinos that have a small rest mass. The starting assumption (the universe is only spacetime) is so restrictive that it greatly narrows the possibilities for physical models. All particles that exhibit rest mass are proposed to generally have the rotar model. Besides the difference in mass, there is obviously a big difference in properties between an electron and an electron neutrino. This implies that there should be a tangible difference in the models of these two spacetime particles. This difference is unknown at the present time. However, since the mechanism for giving a neutrino rest mass, energy and angular momentum is the same as an electron, we will start by using the same general rotar model for an isolated, stationary neutrino as for an isolated, stationary electron.

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[6] K. Nakamura *et al*. (2010). "Review of Particle Physics". *Journal of Physics G* **37**: 1.

[7] Battye, R. A., Moss, A., Evidence for Massive Neutrinos from Cosmic Microwave Background and Lensing Observations, Phys. Rev. Lett. **112**, 051303 (2014)

Modeling a Neutrino: If we assume that the three neutrinos have energy in the range of 0.32 eV, this implies that an isolated neutrino in its rest frame has a Compton angular frequency of $\omega_c \approx 5\times10^{14}$ s^{-1} and a rotar radius of about 6×10^{-7} m. This large size and low frequency for rotars would seem to present a problem for the rotar model that can be illustrated with an example. A muon decays into an electron, an electron antineutrino and a muon neutrino. The muon has a rotar radius of about 1.9×10^{-15} m and a Compton angular frequency of about 1.6×10^{23} s^{-1}. If neutrinos have rest mass, how is it possible for the decay of a muon to produce neutrinos that are about 10^8 times larger radius than the muon? ($\sim 10^{-7}$ m compared to $\sim 10^{-15}$ m)

This apparent incompatibility occurs because we are erroneously comparing the size and frequency of isolated rotars in a rest frame when we should be looking at these characteristics when rotars are in the very close proximity to other rotars at the moment of decay. Recall that when an electron collides with a proton or another electron, there is a moment when all the kinetic energy of the electron is converted to internal energy of the electron. This momentarily increases the electron's Compton frequency and momentarily contracts its rotar radius. A 50 GeV electron collision causes the electron to momentarily decrease its rotar radius by a factor of about 100,000 and increase its frequency by the same factor.

It is proposed that a neutrino created in a particle decay (a muon decay for example) is initially created in the high energy, compressed condition characteristic of a collision. This extra energy is converted to the ultra-relativistic velocities of the three decay products produced by the muon decay. This can be seen from the following example: Suppose that we imagine reversing the decay process. The decay products consisting of an electron, an electron antineutrino and a muon neutrino would reverse directions and produce a collision that forms a muon. This collision would be highly relativistic and momentarily return the three decay products to their energetic, compressed state present when the muon initially decayed. In fact, the sum of the frequencies of the three decay products in the compressed state (before separation) would equal the muon's Compton frequency. In this explanation, the neutrinos would not develop the large size and lower frequency until they separate from the other rotars and each is viewed in its rest frame.

Almost all the quantized angular momentum in the universe is contained in neutrinos and photons. All the other leptons and quarks together contain less than one part in 10^8 compared to quantized angular momentum of photons and neutrinos. This makes neutrinos an important consideration when examining the evolution of the universe. Therefore, neutrinos will be discussed again in chapters 13 and 14 on cosmology.