Unified Field Theory and the Configuration of Particles

Zhiliang Cao, Henry Gu Cao

Abstract: The Standard Model of particle physics is a theory concerning electromagnetic, weak, and strong nuclear interactions, which mediate the dynamics of known subatomic particles. The current formulation was finalized based on the existence of quarks. Because of its success in explaining a wide variety of experimental results, the Standard Model is sometimes regarded as a "theory of almost everything". Mathematically, the standard model is a quantized Yang-Mills theory. Therefore, the Standard Model falls short of being a complete theory of fundamental fields. It neither explains force hierarchy nor predicts the structure of the universe. Fortunately, Unified Field Theory (UFT) explains fundamental forces and structures of sub-atomic particles and grand universe. One of the important applications of the Unified Field Theory is that the mass of each sub-atomic particle has a formula. These formulas are structural formulas which can calculate mass of the particles. The mass of a particle decides its structure and characteristics.

Keywords: *Particle Physics, Unified Field Theory, Quantum Chromodynamics, Standard Model*

1. Introduction

Unified Field Theory (e.g. [1],[2],[3]) provides particles' configurations, a capability that no existing theory has. This paper compares UFT and Standard Model (e.g. [4],[5]-[38]) as the first step to present UFT as a better theory.

The Standard Model has following assumptions:

*1. There are six quarks that have either **1⁄3 or 2⁄3** times the elementary charge.*

*2. The relatively **constant** coupling force of Strong Interactions between quarks and gluons because all carry a type of charge called "color charge." Color charge is analogous to electromagnetic charge, but it comes in three types rather than one, and it results in a different type of force, with different rules of behavior. These rules are detailed in the theory of quantum chromodynamics (QCD), which is the theory of quark-gluon interactions.*

3. The weak force is $\mathbf{10^{32}}$ *times stronger than gravity.*

This paper will begin with the paradox of the Standard Model. It also addresses the force hierarchy problem of the current particle physics theories as well as fundamental questions unanswered by the existing theories. Then the paper will reexamine the existence of quarks and the theory of QCD (fig. 1). The paper also provides structural mass formulas for each particle.

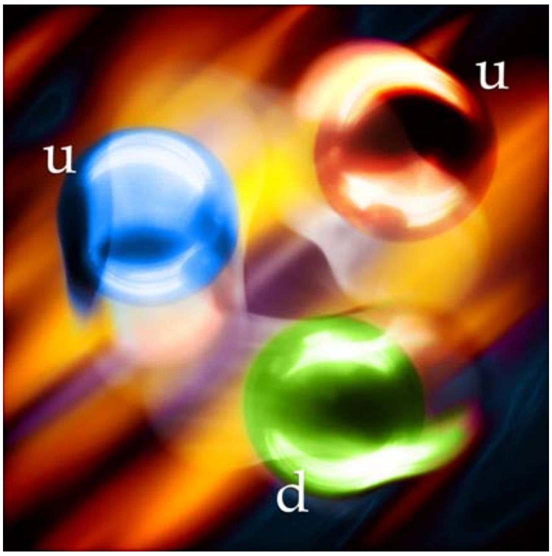

Fig. 1. QCD Proton Model

The up quark or u quark has an electric charge of +2/3 e. The down quark or d quark has an electric charge of -1/3 e. Unfortunately, there has been no particle with 1/3 or 2/3 of unit charge observed, meaning that no free quark has ever been observed. Therefore, the claim that "*There are six quarks that have either **1⁄3 or 2⁄3** times the elementary charge*" has never been experimentally confirmed. To make it plausible, the Quark Theory assumes the following QCD behaviors:

1. The force between quarks does not diminish as they are separated. Because of this, it would take an infinite amount of energy to separate two quarks; they are forever bound into hadrons such as the proton and the neutron.

2. In very high-energy reactions, quarks and gluons interact very weakly.

2. Paradox of Standard Model

2.1. Paradox of Inseparable Quarks

Fig. 2. Quarks' Bonding Coil

The resistance force created from coil (fig. 2) is proportional to the distortion of coil as a result of Hooke's Law.

There are two possible cases relating to the distortion of quarks and gluons:

1. In close distance: If the quarks and gluons interact weakly in very high-energy reaction, then quarks should be separated out during the interaction. The high energy introduced momentum can break weak bonding (interaction) forces.

2. In relatively far distance: If the quarks and gluons have stronger bonding forces than Strong forces, then quarks and gluons in one proton will be able to interact with quarks and gluons in another proton. Therefore, proton-proton interaction should have a stronger force.

The inseparable quarks' claim conflicts with the following observations:

1. In very high-energy reactions, quarks and gluons interact very weakly.

*2. The coupling force of Strong Interactions between quarks and gluon is relatively **constant**.*

2.2. Paradox of Bonding Forces

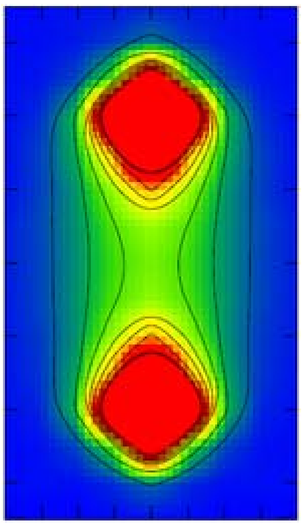

Fig. 3. Particle Force Carriers

In Standard Model's QCD theory, the Strong Forces are carried via gluon. When two particles interact, one particle throw a force carrier particle at the second particle. Based on Conservation of Momentum, both particles will move further away from each other to conserve their momentum. In QCD theory, the particles will get closer. The mechanism of exchanging force carrier particles between two particles is controversial since the particle does not follow the Conservation of Momentum. Therefore, the Standard Model in principle violates the Conservation of Momentum.

2.3. Force Hierarchy

Strong force is at the top of the force hierarchy (e.g. [39], [40]-[50]), followed by electromagnetic force, weak force, and gravity, which is the weakest force.

2.3.1. Force Carriers

In current particle physics, forces between particles arise from the exchange of other particles. These force carrier particles are bundles of energy (quanta) of a particular kind of field as follows:

The electromagnetic force can be described by the exchange of virtual photons.

The nuclear force binding protons and neutrons can be described by an effective field of which mesons are the excitations.

At sufficiently large energies, the strong interaction between quarks can be described by the exchange of virtual gluons.

Beta decay is an example of an interaction due to the exchange of a W boson, but not an example of a force.

Gravitation may be due to the exchange of virtual gravitons.

The following conclusions can be made:

1. The idea of force carrier particles (fig. 3) is controversial.

2. "Virtual photons", "gravitons" and "virtual gluons" are not plausible particles. The use of these unknown particles for the sake of theory is clearly inaccurate.

3. Even with the help of the force carriers, the force hierarchy is not explained properly.

3. UFT vs. Standard Model

The purpose of a theory is to explain some aspects of the world. Thus many kinds of explanations are rightly called theories.

The characteristics of good theories are:

1. Easy to obtain confirmations, or verifications;
2. Not refutable by any conceivable event is non-scientific;
3. Assert that things operate in one way and rule out other possibilities;
4. Less testability leads to less risk, therefore, a good theory is less testable.
5. Have a clearly defined scope.
6. The logical induction is certain.

3.1. Standard Model is Questionable

The Standard Model does not meet any of the above characteristics.

1. Standard Model can not exist without Quarks, but Quarks have never been observed directly;
2. Imagine a scenario where person A and person B are standing on ice, with person A holding ball C. When person A throws ball C at person B, ball C should bring person B closer to person A according to QCD theory. In reality, the two

people will move away from each other. This simple scenario falsifies the force carrier theory of Standard Model.

3. The conservation of Charge Parity (CP) is an important law in Standard Model, but many various experiments have observed violations in Charge Parity.
4. The theory contains many questionable theories that can be easily challenged.
5. Wolfgang Pauli’s exclusive law is applicable only in the scope of the electron particle wave in an atom, but the law is not applicable for strong and weak interactions inside a subatomic particle.
6. Standard Model relies on untenable theories such as Quarks, force carriers, and quantum field theories. Its logical induction undertakes many unreasonable assumptions. Therefore, its logical induction is uncertain.

3.2. UFT Particle Theory is a Good Theory

UFT theory meets all the characteristics of a good theory.

1. It can be easily confirmed using mass formula that is applicable for any random particle. Any known particle has a proper mass formula that follows Unified Field Theory. Therefore the possible mass for particles are in a limited value set.
2. UFT follows simple rules, such as the Fibonacci sequence, addition, multiplication, and division. It can not be refuted by any non-scientific event.
3. The explanation rules out any arbitrary mass value for a particle. The mass value determines the properties of a particle due to the certainties of wave resonance.
4. The particles are built with simple unit charge waves. The existence of the wave can be confirmed by the stability of the electron. No other tests are needed.
5. UFT uses the Torque (e.g. [3]) model as the foundation for other building blocks, such as fundamental forces, unit charge, photon, Planck length and size of Universal Grid (e.g. [3]).
6. UFT is built on a simple relationship between space-time-energy (e.g. [3]) and their only possible 3D Torque model. The inductions of the theory are mathematically certain.

UFT provides predictions of unknown particles for the future research works.

4. Unified Field Theory and Particles

4.1. Fundamental Particles

The particle is formed as result of the proper energy distortion wave resonance:

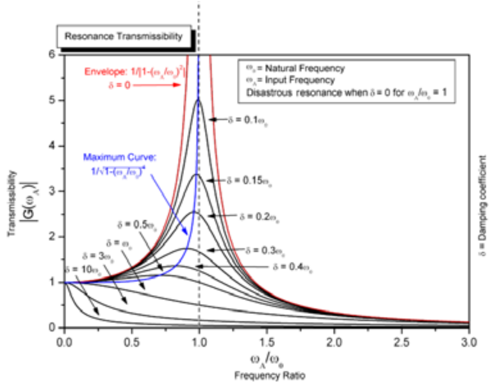

Fig. 4. Resonance Transmissibility

Any known slow particle is constructed by a basic structure with the unit charge (electron) mass as its unit.

The sub-atomic particles are composed of fundamental waves, since UTF has no concept of a fundamental particle. The fundamental waves are:

2*3

2*2

A = 2*3*5

B = 2*2*4

A^2 = (2*3*5)* (2*3*5)

B^2 = (2*2*4)* (2*2*4)

The simplified mass formula is a summation of the above formula. While the generic mass formula is:

$$\iiint_v (\prod_1^n f_i) dv$$

$$\iiint_v f_i dv = S_i$$

Where,

f_i is Torque wave distortion measure by electron mass unit in a unit of space.

S_i is the individual wave of the basic wave structures.

For a basic structure, the energy formula can be:

$$\iiint_v (\prod_1^n f_i) dv = \prod_1^n \left(\iiint_v f_i dv \right)$$

Or,

$$E = \prod_1^n S_i$$

A particle has many basic components. The total energy can be expressed as,

$$\sum_1^N E_i + \sum E_{x,y}$$

Where,

E_i (i=1, 2, …, N) is energy of basic component

$E_{x,y}$(x, y = 1, 2, …, N) is interaction energy between two basic components.

The interactions inside a particle can be either strong or weak.

The strong interaction’s unit is:

$$\frac{137}{\prod_1^n S_i}$$

When interacting on the shell, the weak interaction’s unit is:

$$\frac{1}{137*137}$$

When waves resonate with one another, the weak interaction unit is:

$$\frac{1}{137*137*\prod_{1}^{n} S_i}$$

When waves are dissonant with one another, the compensate wave interaction unit is:

$$\frac{\prod_{1}^{x} P_i}{\prod_{1}^{y} Q_i}$$

Leptons have complex wave fractional series that do not have simple formulas.

The waves' bonding energy is similar to the structure of a rope (fig. 5).

The fibers form threads, threads form thicker threads, thick threads form thin ropes, thin ropes form ropes, ropes form thick ropes and etc.

When threads form thin ropes, the twisting directions of threads and thin ropes are opposite. The waves in a particle structure have different charges as well. In a basic wave structure, the parent wave and child wave have different charges, and the total charge can only be one: minus one or zero. The complex particle itself can possess a charge count bigger than one.

Fig. 5. Bonding Rope of the particle waves

4.2. The Theoretical Basis of Mass Formula

The electron has one Torque Grid distortion on its shell. It becomes the base of the other particles. Particle structures can be mathematically derived with mass formulas.

Any wave in the particle has a single unit charge so that it can be in resonance with the electron distortion. The total charge of the particle is the summation of the waves' charges.

4.3. Wave Axes and 3D Shapes

Each major wave structure goes through the center of the particle. These structures are axes of the overall 3D structure of the particle.

4.3.1. Three Axes

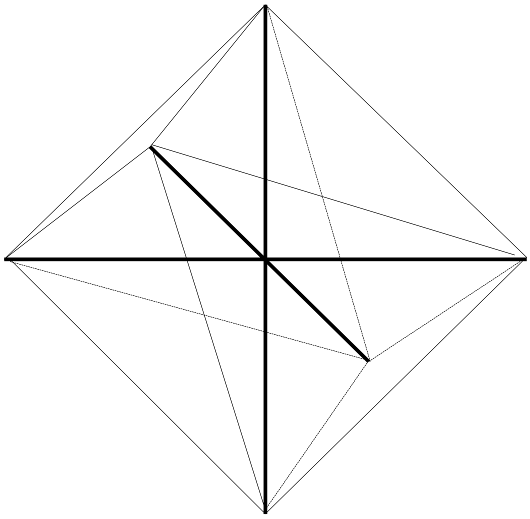

Fig. 6. Three Axes Octahedron shape

4.3.2. Four Axes

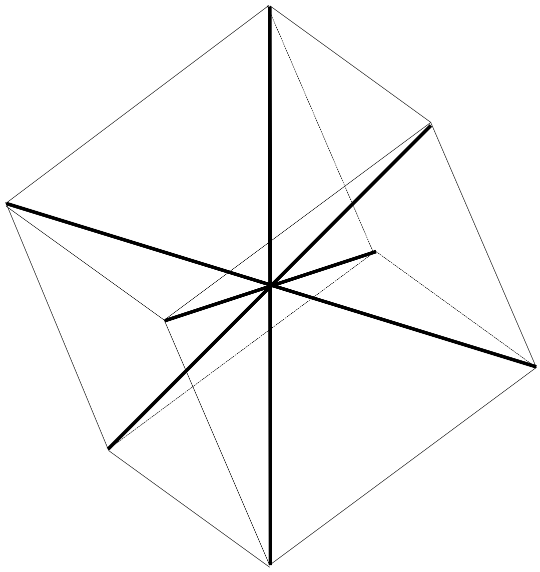

Fig. 7. Four Axes Cube

5. Proton

Assume:

A = 2*3*5;

B = 2*2*4;

The structural formula for proton (e.g. [51],[52]-[77]) is $2A^2 + A + 2*3$

The mass of a proton is:

938.272013(23)MeV

The mass of an electron is:

0.510998910(13)MeV

If we use the electron as a unit, the mass of the proton is:

$1836.15267(e) = 2A^2 + A + 2*3 + 0.15267$

5.1. Configuration of the Proton

The mass formula explains the Proton's mass. The additional mass 0.15267 provides hints of configuration of proton.

The structure $2A^2$ strong interaction:

137/900 = 0.152222

The weak interaction between (2*3) and eight faces (fig. 6) of A and $2A^2$:

8/(137*137) = 0.000426

Wave 2*3 does not have factor 5 in A (2*3*5). Since wave 2*3 is moving around. It interacts only half of the factor 5. The resonance weak interaction wave is:

(5/2)/(137*137*2*3) = 0.000022

The number matches exactly to the known Proton interactive mass 0.15267:

0.152222 + 0.000426 + 0.000022 = 0.15267

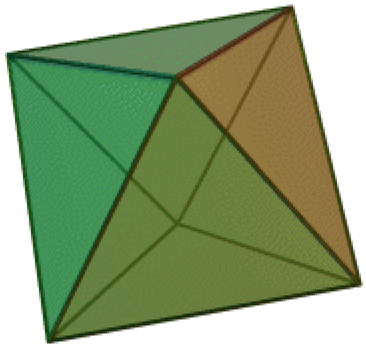

Fig. 8. Proton Octahedron shape

6. Neutron

The structural formula for neutron (e.g. [78],[79]-[113]) is

$2A^2$ + A + 2*3 + 2.5

Using electron mass as unit, the mass of a proton is:

1838.68365987

= $2A^2$ + A + 2*3 + 2.5 + 0.15267 + 0.030987

6.1. Configuration of Neutron

The Neutron is a complex particle with the Proton as its base particle plus 2.5 mass waves.

The 2.5 wave has a strong interaction with two A^2 structure with bonding energy of:

137/(900*2.5*2) = 0.030444

The weak interaction of 2.5 with ten ends of axes A, $2A^2$, 3, and 3:

10/(137*137) = 0.0005328

Weak interaction between 2.5 and 2*3*5 related to opposite charge:

1/(137*137*6)= 0.00001

0.030444 + 0.0005328 + 0.00001 = 0.030987

The number matches exactly with the known Neutron mass.

7. Unstable Particles

7.1. Hadrons

7.1.1. Rho

The structural formula for Rho (e.g. [114], [115], [116]) is:

A^2 + $2B^2$ + 2A + 2B + 2*2 + 2*3 + 3

There are three axes (fig. 6):

(A^2 + 2A+3) + (B^2 + B) + (B^2 + B) + 2*3 + 2*2

Using electron mass as unit, the mass of a Rho is:

1517.42= A^2 + $2B^2$ + 2A + 2B + 2*2 + 2*3 + 3 + 0.42

Strong interactions:

2* B^2 + 2*2:

2*137/(256*4) = 0.27

A^2 + $2B^2$

137/900 = 0.15

Total: 0.27+0.15 = 0.42

A^2 has higher energy and less stable. It tends to annihilate first in the decaying process.

A^2 + $2B^2$ + 2A + 2B + 2*2 + 2*3 + 3 + 0.42

➔ (B^2 + B + 0.1317) + (B^2 + 2*4 + 0.1426) + 980.1457

7.1.2. Charged Pion

The structural formula is (with three Axes):

B^2 + 4*4 + 1

Using electron mass as unit, the mass of a Pion is:

273.1317= B^2 + 4*4 + 1 + 0.1317

Strong interaction between B^2 and (4*4 + 1), estimated factor is 4+1/16 = 4.0625:

137/(256*4.0625) = 0.1317

(4*4 + 1) gets destroyed first during the decaying process:

B^2 + 4*4 + 1 + 0.1317 ➔ (B^2 + 2*4 + 0.1426) + 1 + 7.9891

7.1.2. Neutral Pion

The structural formula is

B^2 + 2*2 + 2*2

Using electron mass as its unit, the mass of a Pion is:

264.1426= B^2 + 2*2 + 2*2 + 0.1426

Strong interaction between B^2 and (2*2) + (2*2):

137/(256*4) + 137/((256*4)*4*4) = 0.14215

Weak interaction:

(2*2*2)/(137*137) = 0.000426

0.14215 + 0.000426 = 0.1426

Structure 2*2 can either annihilate along with the other structure, or, it can be decayed to:

$e^+ + e^-$

7.2. Leptons

7.2.1. Muon

The structural formula for muon (e.g. [117], [118]-[129]) is

2*(2*2*4*6) + 2*(2*3) + 2 + 0.76828

There are some special Lepton waves:

0.5 + 0.5/3 + 0.5/(2*3) + 0.5/((2+3)*2*3) + 0.5/((2+3+6)* ((2+3)*2*3)) + 0.5/((2+3+6+30)*330)

= 0.76822

Plus weak interaction:

1/(137*137) + 1/(137*137*6) = 0.00006

0.76828 = 0.76822 + 0.00006

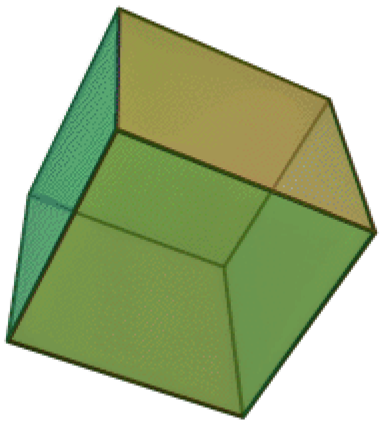

Fig. 9. Muon Cube shape

7.2.2. Tauon

The structural formula for Tauon (e.g. [129], [130]-[136]) is

2*(9*10*19) + 19+19+19 + 0.181

There are some special Tauon waves:

1/19 + 1/10 + 1/(9+10+19) + 1/(19*(9+10+19)) = 0.18033

Plus weak interaction on seven faces:

2*7/(137*137) = 0.00075

0.18033 + 0.00075 = 0.18108

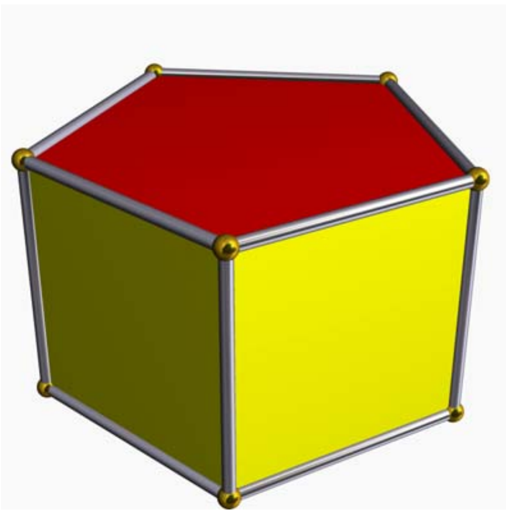

Fig. 10. Tauon Pentagonal prism

7.3. Bosons

7.3.1. Higgs Boson

The structural formula for Higgs Boson is

(3*6*9)*(3*6*9) * 3 * 3 + (2*3*5)*(2*3*5)*2*5 +2*5 = 245206

Higgs Boson has no special significance other than having a (3*6*9)*(3*6*9) strong interactive wave.

7.3.2. W Boson

The structural formula for W Boson is

((3*6*9)*(3*6*9) -2*3*5)*2*3 + 2*3*5 + 5.5 = 157309.5

W Boson has a (3*6*9)*(3*6*9) strong interactive wave and negative bonding energy of (-30) for the (3*6*9)*(3*6*9) wave structure.

7.3.3. Z Boson

The structural formula for W Boson is

(3*6*9)*(3*6*9)*2*3 + 3*6*9*15 + 3*3*3 + (2*6*8)*(2*6*8)*2 + 2*6*8 = 178449

W Boson has no a (3*6*9)*(3*6*9) strong interactive wave and a (2*6*8)*(2*6*8) strong interactive wave structure. It has neither A nor B structure.

8. Celon

There are two known particles travelling at the speed of light: photon and neutrino (e.g. [137],[138]-[177]). A photon's wave length equals the wavelength of the "particle wave". A neutrino's wave length unit is 1/137 of electron's size.

Particle type Celon is named after the Latin word *Celeritas*, meaning swiftness; both photon and neutrino travels at the speed of light, and they are categorized as Celons.

8.1. Photon

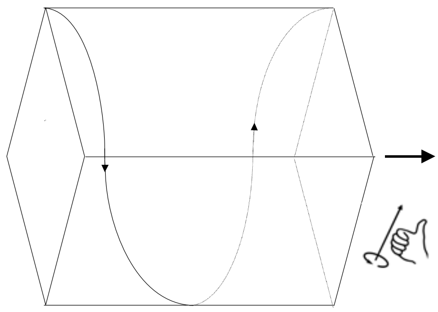

Fig. 11. Photon movements

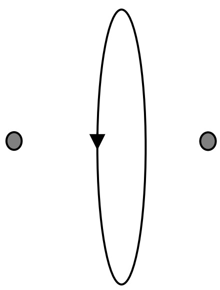

Fig. 12. Photon Torque distortions

A photon (fig. 11) has a circular torque distortion (fig. 12) propelling itself forward in one direction along the torque line. Since the particle keeps moving, the photon both stretches and twists. The stretching is synchronized with the energy distortion on the grids. The center point has one Grid size distortion while energy distortion of its wavelength is one grid distortion as well.

8.2. Neutrino

A neutrino has a high energy spinning motion with weak interact range as its wavelength. The existence of the particle relays on the oscillation of the wave:

3*5*8 + 3*5 + 2 = 137

There is no physical Torque Grid. The subtle relationship among time, space, energy, and force is the reason behind the formation of Torque Grid. The above oscillation creates first level sub-grid structure that is 1/137 of the Torque Grid. The smaller size has 137 times the stiffness. The same unit charge force produces one sub-grid size distortion on the shell of the sub-grid. The sub-grid can be further divided by a factor of 137 into second level sub-grid. This process can be repeated an unknown number of repetitions.

The unit energy of a Torque grid (zero level) structure is 1. The unit energy of a first level sub-grid structure is 1/(137*137). The unit energy of a second level sub-grid structure is 1/(137*137*137*137).

The Unified Field Theory provides imperfect explanations of neutrino mass. Nevertheless, the mass formula can be used to predict neutrino from the new T2 lepton.

8.2.1. Electron Neutrino

When a neutron decays to a proton and electron, it release an electron neutrino:

$n \rightarrow p + e^- + v_e^-$

Or,

$2A^2 + A + 2*3 + 0.15267 + 2.5 + 0.030987 \rightarrow$

$2A^2 + A + 2*3 + 0.15267 + 1 + 1.530987$

$1 + 1.530987 \rightarrow e^- + 1.530987$

$1.530987 \rightarrow v_e^- + E_{kinetic} + E_{photon}$

Some of the oscillation waves are in the original wave form and released as neutrinos. In this case, there are more than one neutrinos. There is no anti-neutrino in existence in Unified Field Theory.

The observed energy of v_e^- can be from 0 to 2.2 eV (0.0000011 e).

387/(137*137*137*137) = 0.0000011

8.2.2. Muon Neutrino

The structure of muon is:

$2*(2*2*4*6) + 2*(2*3) + 2 + 0.76828 \rightarrow e^- + v_u^-$

Neutrinos will be formed via 0.5 + 0.5/3 + 0.5/(2*3) + 0.5/((2+3)*2*3) + 0.5/((2+3+6)* ((2+3)*2*3)) + 0.5/((2+3+6+30)*330).

If 0.5 forms other energy, then, neutrino energy will be:

0.5/3 + 0.5/(2*3) + 0.5/((2+3)*2*3) + 0.5/((2+3+6)* ((2+3)*2*3)) = 0.2682

Or,

137 KeV

The observed energy of Muon neutrino can be from 0 to 170 KeV (0.34 e).

6379 /(137*137) = 0.34

8.2.3. Tauon Neutrino

The structure of tauon is:

2*(9*10*19) + 19+19+19 + 0.181

1 of the above electron units of the quantity of 19 will become (e^- + v_t^-). The energy of Tau neutrino is from 19+19 = 38.

30+8 = 38

30 + 2*0.181 = 30.362

When the neutrino mass is 30.362 e:

15.5 MeV

The observed energy of Tauon neutrino can be from 0 to 15.5 MeV.

8.2.4. Neutrino Flavors

Neutrinos are formed via different process and therefore, they have different structures known as flavors. There is no limit to the energy of a neutrino.

9. Predictions

9.1. New Leptons

The structure of T2 is:

2*(11*12*23) + 23+23+23 + 0.1495 = 6141.1495 (3138.120811187736 MeV)

1/23 + 1/12 + 1/(11+12+23) + 1/(23*(11+12+23)) = 0.1495

Neutrino: 36+2*0.1495 = 36.3, or: 18.55 MeV

The structure of T3 is (may be harder to identify):

2*(14*15*29) + 29+29+29 + 0.119 = 12267.119 (6268.484658648432 MeV)

1/29 + 1/15 + 1/(14+15+29) + 1/(29*(14+15+29)) = 0.119

...

9.2. New Bosons

It may not be practical to discover new Bosons. We list the possible structure of new particles so that future experiments can verify the Unified Field Theory.

The structural formula for I Boson is

(4*8*12)*(4*8*12)*4*4 + (3*6*9)*(3*6*9) * 3 * 3 + (2*3*5)*(2*3*5)*2*5 +2*5

= 2604502

The structural formula for J Boson is

(5*10*15)* (5*10*15) *5*5 + (4*8*12)*(4*8*12)*4*4 + (3*6*9)*(3*6*9) * 3 * 3 + (2*3*5)*(2*3*5)*2*5 +2*5

= 16667002

....

9.3. New Hadron

The structural formula for this new Hadron is:

2*3*(2*3*5)*(2*3*5) + 2*2* (2*2*4)* (2*2*4) + 2*(2*3)*(2*3) + 1

= 6497 (3320 MeV)

10. Conclusions

A particle configuration has the following rules:

1. The particles are formed by charged energy waves with the electron mass as their unit.
2. The multiplication Fibonacci series forms energy ropes that are the basic structure of the particle.
3. Strong interactions and weak interactions add additional energy to the particles' mass.
4. Leptons rely on their wave series to gain their stabilities, since they lack Strong interactions.
5. Each major wave structure forms an axis in the particle. The shape of a particle is decided by these axes.
6. Neutrinos' movement in the space is similar to that of the photon. Neutrinos and Photons are categorized as Celons.
7. Unified Field Theory predicts the existence of new particles, such as new Leptons and new Bosons. Most practically verifiable particles are new Lepton T2 with mass of 3138.120811187736 MeV and a new Hadron with mass of 3320 MeV. The experiment findings will provide proof of Unified Field Theory.

References

[1] Cao, Zhiliang, and Henry Gu Cao. "SR Equations without Constant One-Way Speed of Light." International Journal of Physics 1.5 (2013): 106-109.

[2] Cao, Henry Gu, and Zhiliang Cao. "Drifting Clock and Lunar Cycle." International Journal of Physics 1.5 (2013): 121-127.

[3] Zhiliang Cao, Henry Gu Cao. Unified Field Theory. American Journal of Modern Physics. Vol. 2, No. 6, 2013, pp. 292-298. doi: 10.11648/j.ajmp.20130206.14.

[4] R. Oerter (2006). The Theory of Almost Everything: The Standard Model, the Unsung Triumph of Modern Physics (Kindle ed.). Penguin Group. p. 2. ISBN 0-13-236678-9.

[5] Sean Carroll, Ph.D., Cal Tech, 2007, The Teaching Company, Dark Matter, Dark Energy: The Dark Side of the Universe, Guidebook Part 2 page 59, Accessed Oct. 7, 2013, "...Standard Model of Particle Physics: The modern theory of elementary particles and their interactions ... It does not, strictly speaking, include gravity, although it's often convenient to include gravitons among the known particles of nature..."

[6] In fact, there are mathematical issues regarding quantum field theories still under debate (see e.g. Landau pole), but the predictions extracted from the Standard Model by current methods are all self-consistent. For a further discussion see e.g. Chapter 25 of R. Mann (2010). An Introduction to Particle Physics and the Standard Model. CRC Press. ISBN 978-1-4200-8298-2.

[7] S.L. Glashow (1961). "Partial-symmetries of weak interactions". Nuclear Physics 22 (4): 579–588. Bibcode:1961NucPh..22..579G. doi:10.1016/0029-5582(61)90469-2.

[8] S. Weinberg (1967). "A Model of Leptons". Physical Review Letters 19 (21): 1264–1266. Bibcode:1967PhRvL..19.1264W. doi:10.1103/PhysRevLett.19.1264.

[9] A. Salam (1968). N. Svartholm, ed. "Elementary Particle Physics: Relativistic Groups and Analyticity". Eighth Nobel Symposium. Stockholm: Almquvist and Wiksell. p. 367.

[10] F. Englert, R. Brout (1964). "Broken Symmetry and the Mass of Gauge Vector Mesons". Physical Review Letters 13 (9): 321–323. Bibcode:1964PhRvL..13..321E. doi:10.1103/PhysRevLett.13.321.

[11] P.W. Higgs (1964). "Broken Symmetries and the Masses of Gauge Bosons". Physical Review Letters 13 (16): 508–509. Bibcode:1964PhRvL..13..508H. doi:10.1103/PhysRevLett.13.508.

[12] G.S. Guralnik, C.R. Hagen, T.W.B. Kibble (1964). "Global Conservation Laws and Massless Particles". Physical Review Letters 13 (20): 585–587. Bibcode:1964PhRvL..13..585G. doi:10.1103/PhysRevLett.13.585.

[13] F.J. Hasertet al. (1973). "Search for elastic muon-neutrino electron scattering". Physics Letters B 46 (1): 121. Bibcode:1973PhLB...46..121H. doi:10.1016/0370-2693(73)90494-2.

[14] F.J. Hasert et al. (1973). "Observation of neutrino-like interactions without muon or electron in the Gargamelle neutrino experiment". Physics Letters B 46 (1): 138. Bibcode:1973PhLB...46..138H. doi:10.1016/0370-2693(73)90499-1.

[15] F.J. Hasert et al. (1974). "Observation of neutrino-like interactions without muon or electron in the Gargamelle neutrino experiment". Nuclear Physics B 73 (1): 1. Bibcode:1974NuPhB..73....1H. doi:10.1016/0550-3213(74)90038-8.

[16] D. Haidt (4 October 2004). "The discovery of the weak neutral currents". CERN Courier. Retrieved 8 May 2008.

[17] "Details can be worked out if the situation is simple enough for us to make an approximation, which is almost never, but often we can understand more or less what is happening." from The Feynman Lectures on Physics, Vol 1. pp. 2–7

[18] S. Braibant, G. Giacomelli, M. Spurio (2009). Particles and Fundamental Interactions: An Introduction to Particle Physics. Springer. pp. 313–314. ISBN 978-94-007-2463-1.

[19] G.S. Guralnik (2009). "The History of the Guralnik, Hagen and Kibble development of the Theory of Spontaneous Symmetry Breaking and Gauge Particles". International Journal of Modern Physics A 24 (14): 2601–2627. arXiv:0907.3466. Bibcode:2009IJMPA..24.2601G. doi:10.1142/S0217751X09045431.

[20] B.W. Lee, C. Quigg, H.B. Thacker (1977). "Weak interactions at very high energies: The role of the Higgs-boson mass". Physical Review D 16 (5): 1519–1531. Bibcode:1977PhRvD..16.1519L. doi:10.1103/PhysRevD.16.1519.

[21] "Huge $10 billion collider resumes hunt for 'God particle'". CNN. 11 November 2009. Retrieved 2010-05-04.

[22] M. Strassler (10 July 2012). "Higgs Discovery: Is it a Higgs?". Retrieved 2013-08-06.

[23] "CERN experiments observe particle consistent with long-sought Higgs boson". CERN. 4 July 2012. Retrieved 2012-07-04.

[24] "Observation of a New Particle with a Mass of 125 GeV". CERN. 4 July 2012. Retrieved 2012-07-05.

[25] "ATLAS Experiment". ATLAS. 1 January 2006. Retrieved 2012-07-05.

[26] "Confirmed: CERN discovers new particle likely to be the Higgs boson". YouTube. Russia Today. 4 July 2012. Retrieved 2013-08-06.

[27] D. Overbye (4 July 2012). "A New Particle Could Be Physics' Holy Grail". New York Times. Retrieved 2012-07-04.

[28] "New results indicate that new particle is a Higgs boson". CERN. 14 March 2013. Retrieved 2013-08-06.

[29] "BABAR Data in Tension with the Standard Model". SLAC. 31 May 2012. Retrieved 2013-08-06.

[30] BaBar Collaboration (2012). "Evidence for an excess of B ? D(*) t- ?t decays". Physical Review Letters 109 (10): 101802. arXiv:1205.5442. Bibcode:2012PhRvL.109j1802L. doi:10.1103/PhysRevLett.109.101802.

[31] "BaBar data hint at cracks in the Standard Model". e! Science News. 18 June 2012. Retrieved 2013-08-06.

[32] J. Bagdonaitel et al. (2012). "A Stringent Limit on a Drifting Proton-to-Electron Mass Ratio from Alcohol in the Early Universe". Science 339 (6115): 46. Bibcode:2013Sci...339...46B. doi:10.1126/science.1224898.

[33] C. Moskowitz (13 December 2012). "Phew! Universe's Constant Has Stayed Constant". Space.com. Retrieved 2012-12-14.

[34] "Particle chameleon caught in the act of changing". CERN. 31 May 2010. Retrieved 2012-07-05.

[35] S. Weinberg (1979). "Baryon and Lepton Nonconserving Processes". Physical Review Letters 43 (21): 1566. Bibcode:1979PhRvL..43.1566W. doi:10.1103/PhysRevLett.43.1566.

[36] P. Minkowski (1977). "µ ? e ? at a Rate of One Out of 109 Muon Decays?". Physics Letters B 67 (4): 421. Bibcode:1977PhLB...67..421M. doi:10.1016/0370-2693(77)90435-X.

[37] R. N. Mohapatra, G. Senjanovic (1980). "Neutrino Mass and Spontaneous Parity Nonconservation". Physical Review Letters 44 (14): 912–915. Bibcode:1980PhRvL..44..912M. doi:10.1103/PhysRevLett.44.912.

[38] M. Gell-Mann, P. Ramond and R. Slansky (1979). F. van Nieuwenhuizen and D. Z. Freedman, ed. Supergravity. North Holland. pp. 315–321. ISBN 0-444-85438-X.

[39] http://profmattstrassler.com/articles-and-posts/particle-physics-basics/the-hierarchy-problem/

[40] R. Barbieri, G. F. Giudice (1988). "Upper Bounds on Supersymmetric Particle Masses". Nucl. Phys. B 306: 63. Bibcode:1988NuPhB.306...63B. doi:10.1016/0550-3213(88)90171-X.

[41] Stephen P. Martin, A Supersymmetry Primer

[42] K. Meissner, H. Nicolai (2006). "Conformal Symmetry and the Standard Model". Physics Letters B648: 312–317. arXiv:hep-th/0612165. Bibcode:2007PhLB..648..312M. doi:10.1016/j.physletb.2007.03.023.

[43] Zee, A. (2003). Quantum field theory in a nutshell. Princeton University Press. Bibcode:2003qftn.book.....Z.

[44] N. Arkani-Hamed, S. Dimopoulos, G. Dvali (1998). "The Hierarchy problem and new dimensions at a millimeter". Physics Letters B429: 263–272. arXiv:hep-ph/9803315. Bibcode:1998PhLB..429..263A. doi:10.1016/S0370-2693(98)00466-3.

[45] N. Arkani-Hamed, S. Dimopoulos, G. Dvali (1999). "Phenomenology, astrophysics and cosmology of theories with submillimeter dimensions and TeV scale quantum gravity". Physical Review D59: 086004. arXiv:hep-ph/9807344. Bibcode:1999PhRvD..59h6004A. doi:10.1103/PhysRevD.59.086004.

[46] For a pedagogical introduction, see M. Shifman (2009). "Large Extra Dimensions: Becoming acquainted with an alternative paradigm". Crossing the boundaries: Gauge dynamics at strong coupling. Singapore: World Scientific. arXiv:0907.3074.

[47] M. Gogberashvili, Hierarchy problem in the shell universe model, Arxiv:hep-ph/9812296.

[48] M. Gogberashvili, Our world as an expanding shell, Arxiv:hep-ph/9812365.

[49] M. Gogberashvili, Four dimensionality in noncompact Kaluza-Klein model, Arxiv:hep-ph/9904383.
[50] CMS Collaoration, "Search for Microscopic Black Hole Signatures at the Large Hadron Collider," http://arxiv.org/abs/1012.3375
[51] P.J. Mohr, B.N. Taylor, and D.B. Newell (2011), "The 2010 CODATA Recommended Values of the Fundamental Physical Constants" (Web Version 6.0). This database was developed by J. Baker, M. Douma, and S. Kotochigova. Available: http://physics.nist.gov/constants [Thursday, 02-Jun-2011 21:00:12 EDT]. National Institute of Standards and Technology, Gaithersburg, MD 20899.
[52] W.N. Cottingham, D.A. Greenwood (1986). An Introduction to Nuclear Physics. Cambridge University Press. p. 19.
[53] R.K. Adair (1989). The Great Design: Particles, Fields, and Creation. Oxford University Press. p. 214.
[54] J.-L. Basdevant, J. Rich, M. Spiro (2005). Fundamentals in Nuclear Physics. Springer. p. 155. ISBN 0-387-01672-4.
[55] H. Nishino et al. (Kamiokande collaboration) (2009). "Search for Proton Decay via p ? e+ p0 and p ? µ+ p0 in a Large Water Cherenkov Detector". Physical Review Letters 102 (14): 141801. arXiv:0903.0676. Bibcode:2009PhRvL.102n1801N. doi:10.1103/PhysRevLett.102.141801.
[56] S.N. Ahmed et al. (SNO Collaboration) (2004). "Constraints on nucleon decay via invisible modes from the Sudbury Neutrino Observatory". Physical Review Letters 92 (10): 102004. arXiv:hep-ex/0310030. Bibcode:2004PhRvL..92j2004A. doi:10.1103/PhysRevLett.92.102004. PMID 15089201.
[57] A. Watson (2004). The Quantum Quark. Cambridge University Press. pp. 285–286. ISBN 0-521-82907-0.
[58] W. Weise, A.M. Green (1984). Quarks and Nuclei. World Scientific. pp. 65–66. ISBN 9971-966-61-1.
[59] S. Dürr, Z. Fodor, J. Frison, C. Hoelbling, R. Hoffmann, S. D. Katz, S. Krieg, T. Kurth, L. Lellouch, T. Lippert, K. K. Szabo, and G. Vulvert (21 November 2008). "Ab Initio Determination of Light Hadron Masses". Science 322 (5905): 1224–7. arXiv:0906.3599. Bibcode:2008Sci...322.1224D. doi:10.1126/science.1163233. PMID 19023076.
[60] C. F. Perdrisat, V. Punjabi, M. Vanderhaeghen (2007). "Nucleon Electromagnetic Form Factors". Prog Part Nucl Phys 59 (2): 694–764. arXiv:hep-ph/0612014. Bibcode:2007PrPNP..59..694P. doi:10.1016/j.ppnp.2007.05.001.
[61] Sigfrido Boffi & Barbara Pasquini (2007). "Generalized parton distributions and the structure of the nucleon". Rivista del Nuovo Cimento 30. arXiv:0711.2625. Bibcode:2007NCimR..30..387B. doi:10.1393/ncr/i2007-10025-7.
[62] Randolf Pohl, Aldo Antognini, François Nez, Fernando D. Amaro, François Biraben, João M. R. Cardoso, Daniel S. Covita, Andreas Dax, Satish Dhawan, Luis M. P. Fernandes, Adolf Giesen, Thomas Graf, Theodor W. Hänsch, Paul Indelicato, Lucile Julien, Cheng-Yang Kao, Paul Knowles, Eric-Olivier Le Bigot, Yi-Wei Liu, José A. M. Lopes, Livia Ludhova, Cristina M. B. Monteiro, Françoise Mulhauser, Tobias Nebel, Paul Rabinowitz, et al. (8 July 2010). "The size of the proton". Nature 466 (7303): 213–216. Bibcode:2010Natur.466..213P. doi:10.1038/nature09250. PMID 20613837. Retrieved 2010-07-09.
[63] Antognini, A.; Nez, F.; Schuhmann, K.; Amaro, F. D.; Biraben, F.; Cardoso, J. M. R.; Covita, D. S.; Dax, A.; Dhawan, S.; Diepold, M.; Fernandes, L. M. P.; Giesen, A.; Gouvea, A. L.; Graf, T.; Hänsch, T. W.; Indelicato, P.; Julien, L.; Kao, C. -Y.; Knowles, P.; Kottmann, F.; Le Bigot, E. -O.; Liu, Y. -W.; Lopes, J. A. M.; Ludhova, L.; Monteiro, C. M. B.; Mulhauser, F.; Nebel, T.; Rabinowitz, P.; Dos Santos, J. M. F.; Schaller, L. A. (2013). "Proton Structure from the Measurement of 2S-2P Transition Frequencies of Muonic Hydrogen". Science 339 (6118): 417–420. doi:10.1126/science.1230016. PMID 23349284. edit
[64] New proton measurements may throw physics a curve
[65] "The Proton Just Got Smaller". Photonics.Com. 12 July 2010. Retrieved 2010-07-19.
[66] Researchers Observes Unexpectedly Small Proton Radius in a Precision Experiment
[67] Headrick, J.M.; Diken, E.G.; Walters, R. S.; Hammer, N. I.; Christie, R.A. ; Cui, J.; Myshakin, E.M.; Duncan, M.A.; Johnson, M.A.; Jordan, K.D. (2005). "Spectral Signatures of Hydrated Proton Vibrations in Water Clusters". Science 308 (5729): 1765–69. Bibcode:2005Sci...308.1765H. doi:10.1126/science.1113094. PMID 15961665.
[68] R.H. Petrucci, W.S. Harwood, and F.G. Herring (2002). General Chemistry (8th ed.). p. 41.
[69] Romer A (1997). "Proton or prouton? Rutherford and the depths of the atom". Amer. J. Phys. 65 (8): 707. Bibcode:1997AmJPh..65..707R. doi:10.1119/1.18640.
[70] Rutherford reported acceptance by the British Association in a footnote to a 1921 paper by O. Masson in the Philosophical Magazine (O. Masson, Phil. Mag. 41, 281, 1921)
[71] Pais, Inward Bound, first edition, Oxford Press, 1986, page 296. Pais reported that he believed the first science literature use of the word proton occurs in the article Nature, 106: 357, 1920.
[72] "Apollo 11 Mission". Lunar and Planetary Institute. 2009. Retrieved 2009-06-12.
[73] "Space Travel and Cancer Linked? Stony Brook Researcher Secures NASA Grant to Study Effects of Space Radiation". Brookhaven National Laboratory. 12 December 2007. Retrieved 2009-06-12.
[74] B. Shukitt-Hale, A. Szprengiel, J. Pluhar, B.M. Rabin, and J.A. Joseph. "The effects of proton exposure on neurochemistry and behavior". Elsevier/COSPAR. Retrieved 2009-06-12.
[75] N.W. Green and A.R. Frederickson. "A Study of Spacecraft Charging due to Exposure to Interplanetary Protons". Jet Propulsion Laboratory. Retrieved 2009-06-12.
[76] H. Planel (2004). Space and life: an introduction to space biology and medicine. CRC Press. pp. 135–138. ISBN 0-415-31759-2.
[77] G. Gabrielse (2006). "Antiproton mass measurements". International Journal of Mass Spectrometry 251 (2–3): 273–280. Bibcode:2006IJMSp.251..273G. doi:10.1016/j.ijms.2006.02.013.
[78] 1935 Nobel Prize in Physics. Nobelprize.org. Retrieved on 2012-08-16.
[79] Sir James Chadwick's Discovery of Neutrons. ANS Nuclear Cafe. Retrieved on 2012-08-16.
[80] Nakamura, K (2010). "Review of Particle Physics". Journal of Physics G: Nuclear and Particle Physics 37 (7A): 075021. Bibcode:2010JPhG...37g5021N. doi:10.1088/0954-3899/37/7A/075021. PDF with 2011 partial update for the 2012 edition
[81] Nudat 2. Nndc.bnl.gov. Retrieved on 2010-12-04.
[82] E. Rutherford (1920). "Nuclear Constitution of Atoms". Proceedings of the Royal Society A 97: 374. Bibcode:1920RSPSA..97..374R. doi:10.1098/rspa.1920.0040.
[83] Rutherford, E. (1920). "Bakerian Lecture. Nuclear Constitution of Atoms". Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences 97 (686): 374. Bibcode:1920RSPSA..97..374R. doi:10.1098/rspa.1920.0040. JSTOR 93888.
[84] Brown, Laurie M. (1978). "The idea of the neutrino". Physics Today 31 (9): 23. doi:10.1063/1.2995181.
[85] Friedlander G., Kennedy J.W. and Miller J.M. (1964) Nuclear and Radiochemistry (2nd edition), Wiley, pp. 22–23 and 38–39
[86] "V. A. Ambartsumian— a life in science". Astrophysics 51 (3): 280. 2008. Bibcode:2008Ap.....51..280T. doi:10.1007/s10511-008-9016-6.
[87] Bothe, W.; Becker, H. (1930). "Künstliche Erregung von Kern-?-Strahlen" [Artificial excitation of nuclear ?-radiation]. Zeitschrift für Physik 66 (5–6): 289. Bibcode:1930ZPhy...66..289B. doi:10.1007/BF01390908.
[88] Becker, H.; Bothe, W. (1932). "Die in Bor und Beryllium erregten ?-Strahlen" [G-rays excited in boron and beryllium]. Zeitschrift für Physik 76 (7–8): 421. Bibcode:1932ZPhy...76..421B. doi:10.1007/BF01336726.
[89] Joliot-Curie, Irène and Joliot, Frédéric (1932). "Émission de protons de grande vitesse par les substances hydrogénées sous l'influence des rayons ? très pénétrants" [Emission of high-speed protons by hydrogenated substances under the influence of very penetrating ?-rays]. Comptes Rendus 194: 273.
[90] Chadwick, J. (1933). "Bakerian Lecture. The Neutron". Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences 142 (846): 1. Bibcode:1933RSPSA.142....1C. doi:10.1098/rspa.1933.0152.
[91] Chadwick, James (1932). "Possible Existence of a Neutron". Nature 129 (3252): 312. Bibcode:1932Natur.129Q.312C. doi:10.1038/129312a0.
[92] "Das Jahr 1932 Die Entdeckung des Neutrons". Wolfgang Pauli. Sources in the History of Mathematics and Physical Sciences 6. 1985. p. 105. doi:10.1007/978-3-540-78801-0_3. ISBN 978-3-540-13609-5.
[93] Atkins, P.W. and J. de Paula, P.W. (2006) "Atkins' Physical Chemistry" (8th edition), W.H. Freeman, p. 451
[94] Herzberg, G. (1950) Spectra of Diatomic Molecules (2nd edition), van Nostrand Reinhold, pp. 133–140

[95] Particle Data Group Summary Data Table on Baryons. lbl.gov (2007). Retrieved on 2012-08-16.
[96] Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach, Third Edition K. Heyde Taylor & Francis 2004. Print ISBN 978-0-7503-0980-6. eBook ISBN 978-1-4200-5494-1. DOI: 10.1201/9781420054941.ch5. full text
[97] "Pear-shaped particles probe big-bang mystery" (Press release). University of Sussex. 20 February 2006. Retrieved 2009-12-14.
[98] A cryogenic experiment to search for the EDM of the neutron. Hepwww.rl.ac.uk. Retrieved on 2012-08-16.
[99] Search for the neutron electric dipole moment: nEDM. Nedm.web.psi.ch (2001-09-12). Retrieved on 2012-08-16.
[100] SNS Neutron EDM Experiment. P25ext.lanl.gov. Retrieved on 2012-08-16.
[101] Measurement of the Neutron Electric Dipole Moment. Nrd.pnpi.spb.ru. Retrieved on 2012-08-16.
[102] Miller, G.A. (2007). "Charge Densities of the Neutron and Proton". Physical Review Letters 99 (11): 112001. Bibcode:2007PhRvL..99k2001M. doi:10.1103/PhysRevLett.99.112001.
[103] Spyrou, A.; et al. (2012). "First Observation of Ground State Dineutron Decay: 16Be". Physical Review Letters 108: 102501. Bibcode:2012PhRvL.108j2501S. doi:10.1103/PhysRevLett.108.102501.
[104] Felipe J. Llanes-Estrada, Gaspar Moreno Navarro., Felipe J.; Gaspar Moreno Navarro (2011). "Cubic neutrons". arXiv:1108.1859v1 [nucl-th].
[105] Byrne, J. Neutrons, Nuclei, and Matter, Dover Publications, Mineola, NY, 2011, ISBN 0486482383, pp. 32–33.
[106] Clowdsley, MS; Wilson, JW; Kim, MH; Singleterry, RC; Tripathi, RK; Heinbockel, JH; Badavi, FF; Shinn, JL (2001). "Neutron Environments on the Martian Surface". Physica Medica 17 (Suppl 1): 94–6. PMID 11770546.
[107] Science/Nature | Q&A: Nuclear fusion reactor. BBC News (2006-02-06). Retrieved on 2010-12-04.
[108] Byrne, J. Neutrons, Nuclei, and Matter, Dover Publications, Mineola, NY, 2011, ISBN 0486482383, p. 453.
[109] Kumakhov, M. A.; Sharov, V. A. (1992). "A neutron lens". Nature 357 (6377): 390–391. Bibcode:1992Natur.357..390K. doi:10.1038/357390a0.
[110] Physorg.com, "New Way of 'Seeing': A 'Neutron Microscope'". Physorg.com (2004-07-30). Retrieved on 2012-08-16.
[111] "NASA Develops a Nugget to Search for Life in Space". NASA.gov (2007-11-30). Retrieved on 2012-08-16.
[112] "Facing up to secondary neutrons". Medical Physics Web. May 23, 2008. Retrieved 2011-02-08.
[113] Heilbronn, L.; Nakamura, T; Iwata, Y; Kurosawa, T; Iwase, H; Townsend, LW (2005). "Expand+Overview of secondary neutron production relevant to shielding in space". Radiation Protection Dosimetry 116 (1–4): 140–143. doi:10.1093/rpd/nci033. PMID 16604615.
[114] Rujula, Georgi, Glashow (1975) "Hadron Masses in Gauge Theory." Physical Review D12, p.147
[115] H. Georgi. (1990) "Vector Realization of Chiral Symmetry." inSPIRE Record
[116] C. Amsler et al. (2008): Quark Model
[117] J. Beringer et al. (Particle Data Group) (2012). "PDGLive Particle Summary 'Leptons (e, mu, tau, ... neutrinos ...)'". Particle Data Group. Retrieved 2013-01-12.
[118] New Evidence for the Existence of a Particle Intermediate Between the Proton and Electron", Phys. Rev. 52, 1003 (1937).
[119] Yukaya Hideka, On the Interaction of Elementary Particles 1, Proceedings of the Physico-Mathematical Society of Japan (3) 17, 48, pp 139–148 (1935). (Read 17 November 1934)
[120] S. Carroll (2004). Spacetime and Geometry: An Introduction to General Relativity. Addison Wesly. p. 204
[121] Mark Wolverton (September 2007). "Muons for Peace: New Way to Spot Hidden Nukes Gets Ready to Debut". Scientific American 297 (3): 26–28. doi:10.1038/scientificamerican0907-26.
[122] "Physicists Announce Latest Muon g-2 Measurement" (Press release). Brookhaven National Laboratory. 30 July 2002. Retrieved 2009-11-14.
[123] J. Adam et al. (MEG Collaboration) (2013). "New Constraint on the Existence of the mu+ -> e+ gamma Decay". Physical Review Letters 110 (20): 201801. arXiv:1303.0754. Bibcode:2013PhRvL.110t1801A. doi:10.1103/PhysRevLett.110.201801.
[124] Fleming, D. G.; Arseneau, D. J.; Sukhorukov, O.; Brewer, J. H.; Mielke, S. L.; Schatz, G. C.; Garrett, B. C.; Peterson, K. A. et al. (28 Jan 2011). "Kinetic Isotope Effects for the Reactions of Muonic Helium and Muonium with H2". Science 331 (6016): 448–450. Bibcode:2011Sci...331..448F. doi:10.1126/science.1199421. PMID 21273484.
[125] TRIUMF Muonic Hydrogen collaboration. "A brief description of Muonic Hydrogen research". Retrieved 2010-11-7
[126] Pohl, Randolf et al. "The Size of the Proton" Nature 466, 213–216 (8 July 2010)
[127] "The Muon g-2 Experiment Home Page". G-2.bnl.gov. 2004-01-08. Retrieved 2012-01-06.
[128] "(from the July 2007 review by Particle Data Group)" (PDF). Retrieved 2012-01-06.
[129] Hagiwara, K; Martin, A; Nomura, D; Teubner, T (2007). "Improved predictions for g-2g-2 of the muon and aQED(MZ2)". Physics Letters B 649 (2–3): 173. arXiv:hep-ph/0611102. Bibcode:2007PhLB..649..173H. doi:10.1016/j.physletb.2007.04.012.
[130] L. B. Okun (1980). Leptons and Quarks. V.I. Kisin (trans.). North-Holland Publishing. p. 103. ISBN 978-0444869241.
[131] Perl, M. L.; Abrams, G.; Boyarski, A.; Breidenbach, M.; Briggs, D.; Bulos, F.; Chinowsky, W.; Dakin, J. et al. (1975). "Evidence for Anomalous Lepton Production in e+e- Annihilation". Physical Review Letters 35 (22): 1489. Bibcode:1975PhRvL..35.1489P. doi:10.1103/PhysRevLett.35.1489.
[132] J. Beringer et al. (Particle Data Group) (2012). Leptons. "Review of Particle Physics". Journal of Physics G 86 (1): 581–651. Bibcode:2012PhRvD..86a0001B. doi:10.1103/PhysRevD.86.010001.
[133] D. Fargion, P.G. De Sanctis Lucentini, M. De Santis, M. Grossi (2004). "Tau Air Showers from Earth". The Astrophysical Journal 613 (2): 1285. arXiv:hep-ph/0305128. Bibcode:2004ApJ...613.1285F. doi:10.1086/423124.
[134] M.L. Perl (1977). "Evidence for, and properties of, the new charged heavy lepton". In T. Thanh Van (ed.). Proceedings of the XII Rencontre de Moriond. SLAC-PUB-1923.
[135] Riazuddin (2009). "Non-standard interactions". NCP 5th Particle Physics Sypnoisis (Islamabad,: Riazuddin, Head of High-Energy Theory Group at National Center for Physics) 1 (1): 1–25.
[136] Brodsky, Stanley J.; Lebed, Richard F. (2009). "Production of the Smallest QED Atom: True Muonium (μ+μ-)". Physical Review Letters 102 (21): 213401. arXiv:0904.2225. Bibcode:2009PhRvL.102u3401B. doi:10.1103/PhysRevLett.102.213401.
[137] S. Fukuda et al., hep-ex/0103032, Phys. Rev. Lett. 86,5651 (2001); hep-ex/0103033, Phys. Rev. Lett. 86, 5656(2001).
[138] Q. R. Ahmad et al.,, nucl-ph/0106015, Phys. Rev. Lett.87, 071301 (2001).
[139] B. T. Cleveland, T. J. Daily, R. Davis, Jr., J. R. Distel,K. Lande, C. K. Lee, and P. S. Wildenhain, Astrophys.J. 496, 505 (1998).
[140] J. N. Abdurashitov, V. N. Gavrin, S. V. Girin, V. V. Gorbachev,T. V. Ibragimova, A. V. Kalikhov, N. G. Khairnasov,T. V. Knodel, I. N. Mirmov, A. A. Shikhin, E. P.Veretenkin, V. M. Vermul, V. E. Yants, G. T. Zatsepin,T.J. Bowles, W. A. Teasdale, D. L. Wark, M. L. Cherry, J.S. Nico, B. T. Cleveland, R. Davis, Jr., K. Lande, and P.S. Wildenhain, S. R. Elliott and J. F. Wilkerson, astroph/9907113, Phys. Rev. C 60, 055801 (1999).
[141] W. Hampel, J. Handt, G. Heusser, J. Kiko, T. Kirsten,M. Laubenstein, E. Pernicka, W. Rau, M. Wojcik, Y. Zakharov,R. v. Ammon, K. H. Ebert, T. Fritsch, E. Henrich,L. Stielglitz, F. Weirich, M. Balata, M. Sann, F. X.Hartmann, E. Bellotti, C. Cattadori, O. Cremonesi, N.Ferrari, E. Fiorini, L. Zanotti, M. Altmann, F. v. Feilitzsch,R. M¨oßbauer, S. W¨anninger, G. Berthomieu, E.Schatzmann, I. Carmi, I. Dostrovsky, C. Bacci, P. Belli,R. Bernabei, S. d'Angelo, L. Paoluzi, M. Cribier, J. Rich,M. Spiro, C. Tao, D. Vignaud, J. Boger, R. L.Hahn, J.K. Rowley, R. W. Stoenner, and J. Weneser, Phys. Lett.B 447, 127 (1999).
[142] Y. Fukuda et al., Phys. Rev. Lett. 77, 1683 (1996).
[143] See www.sns.ias.edu/↑ jnb/Meetings/Lownu/index.htmland www-sk.icrr.u-tokyo.ac.jp/lownu/index.html.
[144] V. A. Kuzmin, Zh. Eksp. Teor. Fiz. 49, 1532 (1965) (Sov.Phys. JETP 22, 1051 (1966)).
[145] J. N. Bahcall, M. H. Pinsonneault, and S. Basu, astroph/0010346, Astrophys. J. 555, 990 (2001).
[146] A. S. Brun, S. Turck-Chi`eze, and P. Morel, astroph/9806272, Astrophys. J. 506, 913 (1998).
[147] A. Piepke, Nucl. Phys. B (Proc. Suppl.) 91, 99 (2001).
[148] G. Alimonti et al., (BOREXINO collaboration), hepex/0012030, Astroparticle Physics 16, 205 (2002).

[149] M. Altmann, M. Balata, P. Belli, E. Bellotti, R. Bernabei,E. Burkert, C. Cattadori, G. Cerichelli, M Chiarini,M. Cribier, S. d'Angelo, G. Del Re, K. H. Ebert, F. v.Feilitzsch, N. Ferrari, W. Hampel, J. Handt, E. Henrich,G. Heusser, J. Kiko, T. Kirsten, T. Lachenmaier, J. Lanfranchi,M. Laubenstein, D. Motta, W. Rau, H. Richter,S. W¨anninger, M. Wojcik, L. Zanotti, hep-ex/0006034,Phys. Lett. 490, 16 (2000).
[150] V. N. Gavrin, V. N. Kornoukhov, and G. T. Zatsepin,Institute for Nuclear Research of the Academy of Sciencesof the USSR Report No. P-0690, 1991.
[151] V. N. Gavrin, V. E. Gurentsov, V. N. Kornoukhov, A.1 February 2008 SAGE JETP 12M. Pshukov, and A. A. Shikhin, Institute for NuclearResearch of the Academy of Sciences of the USSR ReportNo. P-0698, 1991.
[152] J. N. Abdurashitov, V. N. Gavrin, A. V. Kalikhov, V.L. Matushko, A. A. Shikhin, V. E. Yants, and O. S.Zaborskaya, to be published in Proceedings of the XIthInt. School on Particles and Cosmology, Baksan, Russia,April 2001.
[153] J. N. Abdurashitov, E. L. Faizov, V. N. Gavrin, A. O. Gusev,A. V. Kalikhov, T. V. Knodel, I. I. Knyshenko, V. N.Kornoukhov, I. N. Mirmov, A. M. Psukhov, A. M. Shalagin,A. A. Shikhin, P. V. Timofeyev, E. P. Veretenkin, V.M. Vermul, G. T. Zatsepin, T. J. Bowles, S. R. Elliott, J.S. Nico, W. A. Teasdale, D. L. Wark, J. F. Wilkerson, B.T. Cleveland, T. Daily, R. Davis, K. Lande, C. K. Lee,P. S. Wildenhain, M. L. Cherry, and R. T. Kouzes, Phys.Lett. B 328, 234 (1994).
[154] S. R. Elliott, Nucl. Instrum. Methods Phys. Res. A 290,158 (1990).
[155] B. T. Cleveland, Nucl. Instrum. Methods Phys. Res. 214,451 (1983).
[156] B. T. Cleveland, Nucl. Instrum. Methods Phys. Res. A416, 405 (1998).
[157] V. N. Gavrin, Proceedings of the XIXth InternationalConf. on Neutrino Physics and Astrophysics, Sudbury,Canada, 16–21 June 2000, ed. by J. Law, R. W. Ollerhead,and J. J. Simpson, Nucl. Phys. B (Proc. Suppl.)91, 36 (2000).
[158] V. N. Gavrin, V. N. Kornoukhov, and V. E. Yants, Institutefor Nuclear Research of the Academy of Sciencesof the USSR Report No. P-0703, 1991.
[159] V. N. Gavrin, S. N. Danshin, A. V. Kopylov, and V.E. Cherekhovsky, Institute for Nuclear Research of theAcademy of Sciences of the USSR Report No. P-0494,1986.
[160] V. N. Gavrin and Yu. I. Zacharov, Institute for NuclearResearch of the Academy of Sciences of the USSR ReportNo. P-0560, 1987.
[161] M. Cribier, B. Pichard, J. Rich, J. P. Soirat, M. Spiro,Th. Stolarczyk, C. Tao, D. Vignaud, P. Anselmann, A.Lenzing, C. Schlosser, R. Wink, and J. K. Rowley, Astropart.Phys. 6, 129 (1997).
[162] V. N. Gavrin, V. V. Gorbachev, T. V. Ibragimova, and B.T. Cleveland, Yad. Phys. 65, 1309 (2002); Phys. AtomicNuclei 65, 1276 (2002).
[163] J. N. Abdurashitov, V. N. Gavrin, S. V. Girin, V. V. Gorbachev,T. V. Ibragimova, A. V. Kalikhov, N. G. Khairnasov,T. V. Knodel, V. N. Kornoukhov, I. N.Mirmov, A.A. Shikhin, E. P. Veretenkin, V. M. Vermul, V. E. Yants,G. T. Zatsepin, T. J. Bowles, J. S. Nico, W. A. Teasdale,D. L. Wark, M. L. Cherry, V. N. Karaulov, V. L. Levitin,V. I. Maev, P. I. Nazarenko, V. S. Shkol'nik, N. V. Skorikov,B. T. Cleveland, T. Daily, R. Davis, Jr., K. Lande,C. K. Lee, P. S. Wildenhain, Yu. S. Khomyakov, A. V.Zvonarev, S. R. Elliott, and J. F. Wilkerson, Phys. Rev.Lett. 77, 4708 (1996).
[164] J. N. Abdurashitov, V. N. Gavrin, S. V. Girin, V. V.Gorbachev, T. V. Ibragimova, A. V. Kalikhov, N. G.Khairnasov, T. V. Knodel, V. N. Kornoukhov, I. N. Mirmov,A. A. Shikhin, E. P. Veretenkin, V. M. Vermul,V. E. Yants, G. T. Zatsepin, Yu. S. Khomyakov, A. V.Zvonarev, T. J. Bowles, J. S. Nico, W. A. Teasdale, D. L.Wark, M. L. Cherry, V. N. Karaulov, V. L. Levitin, V. I.Maev, P. I. Nazarenko, V. S. Shkol'nik, N. V. Skorikov,B. T. Cleveland, T. Daily, R. Davis, Jr., K. Lande, C. K.Lee, P. S. Wildenhain, S. R. Elliott, and J. F. Wilkerson,hep-ph/9803418, Phys. Rev. C. 59, 2246 (1999).
[165] W. Hampel and L. Remsberg, Phys. Rev. C 31, 666(1985).
[166] V. Berezinsky, G. Fiorentini, and M. Lissia, hepph/9904225, Astropart. Phys. 12, 299 (2000).
[167] G. L. Fogli, E. Lisi, D. Montanino, and A. Palazzo, hepph/9910387, Phys. Rev. D 61, 073009 (2000).
[168] J. Pulido and E. Kh. Akhmedov, hep-ph/9907399, Astropart.Phys. 13, 227 (2000).
[169] P. A. Sturrock and J. D. Scargle, astro-ph/0011228, Astrophys.J. 550, L101-L104 (2001).
[170] J. N. Bahcall, hep-ph/0108148, Phys. Rev. C 65 025801(2002).
[171] J. N. Bahcall, hep-ph/9710491, Phys. Rev. C 56, 3391(1997).
[172] J. N. Bahcall et al., nucl-th/9601044, Phys. Rev. C 54,411 (1996).
[173] J. N. Bahcall, M. C. Gonzalez-Garcia, and C. Pe˜na-Garay, hep-ph/0111150, JHEP 0204, 007 (2002).
[174] After the appearance of our preprint we learned that similararguments to ours have been used to make predictionsfor what will be measured by BOREXINO. See S.M. Bilenky, T. Lachenmaier, W. Potzel, and F. v. Feilitzsch,hep-ph/0109200, Phys. Lett. 533, 191 (2002).
[175] J. N. Bahcall, M. C. Gonzalez-Garcia, and C. Pe˜na-Garay, hep-ph/0106258, JHEP 0108, 014 (2001).
[176] P. I. Krastev and A. Yu. Smirnov, hep-ph/0108177, Phys.Rev. D 65, 073022 (2002).
[177] M.C. Gonzalez-Garcia, M. Maltoni, and C. Pe˜na-Garay,hep-ph/0108073.