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# THE COMPLETE INTERNAL STRUCTURE, THE ORIGIN OF MASS, AND THE SOURCE OF MIXING, ENTANGLEMENT, AND OSCILLATIONS, IN THE LOWER STABLE HADRONS AND LEPTONS

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ABSTRACT

A new model of particle structure is presented for the lowest stable hadrons and **leptons** which shows first: the complete internal quark/gluon structure of the proton, neutron, η, $K^o$, $\bar{K}^o$, and $\pi^o$ mesons and **(surprisingly)** the muon. It can be extended to include **without gluons**: the electron, neutrinos, and even the photon.

Second, it shows the origin of mass. While mass cannot be assigned to individual quarks which do not exist alone, it can be assigned in totality to a small number of gluons of positive and negative **associated** mass ($\pm 14m_e$). This makes the basic unit of mass the electron mass.

Third, it shows that mixing of internal quark states (like the neutral kaon) is common in all particles. In fact, it shows the source of mixing, entanglement, and oscillations.

The key to this discovery is the finding that quarks do not exist as single isolated quark-antiquark pairs but only as triads and antitriads. Quark-antiquark pairing does occur but only within a quark triad-antitriad pair. With these claims, a thorough analysis of particle properties, especially mass, yields the precise structure and mass of internal structures; essentially a small number (possibly a string or helix) of quark triad-antitriad pairs. The proton and neutron, in addition, each contain one unpaired triad- uud and ddu respectively. Proof for the model is presented which involves a quark structure for the muon and its subsequent decay.

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## INTRODUCTION

At the time quarks were discovered in the 1960's by Gell-Mann and Zweig, it was assumed that the proton and neutron each contained just three quarks – uud and ddu – exchanging 8 or so virtual gluons. The mass of these quarks then was assumed to be approximately 1/3 the mass of the proton, with the down quark slightly greater than the mass of the up quark since the neutron had slightly greater mass.

More than 50 years of experiments and analysis have proved these claims not to be valid. Experiments first carried out at Germany's HERA accelerator have shown that the proton contains not just three quarks and 8 gluons, but a large number of quarks, antiquarks, and gluons. Many other experiments have shown that quarks have very little mass, less than 1% the mass of the proton.

The problem now at hand is to determine exactly how many and what type of quarks make up the proton and other hadrons and what is the source and precise value of masses. Many physicists have concluded that nearly all of the mass of the proton comes, not from quarks, but from the gluons interacting with them. Gluons supposedly have no mass, so it is assumed that the energy of gluons interacting with each other somehow shows up as mass in the proton, providing in fact most of its mass. Some authors have concluded that the proton is just a "glob of gluons with 3 quarks embedded in it", which means giving up on ever finding more suitable internal structures. A new model is presented here which solves these problems. It provides precise internal quark structures along with their masses, which yield quite accurately the masses of the lowest stable hadrons, including the proton, neutron, $\eta$, $K^o$, $\bar{K}^o$, and $\pi^o$ mesons and (surprisingly) the muon.

The key to these discoveries were the findings or claims that:

1. Quarks only exist as triads or antitriads, not as single isolated quark – antiquark pairs, as assumed for some mesons. Quark/antiquark pairing does occur, but only within a triad-antitriad pair.
2. Strange and antistrange quarks play a major role in all of the given stable hadron structures. In fact, of all the triad-antitriads pairs which comprise the hadrons, precisely half contain strange or antistrange quarks(with the possible exception of the proton and neutron with principal non-strange triads). Note that strange quarks do not couple to other strange or antistrange quarks! A rule appears to require equal numbers of strange and anitstrange quarks for $\eta$, $\bar{K}^o$ + $K^o$, $\pi^o + \bar{\pi}^o$ and $\mu^-$, which involves some mixing.
3. Gluons in the hadrons and muon mentioned are of two types. Those with positive energy and others with negative energy. Precise positive mass is associated with each gluon/quark pair or gluon/antiquark pair. Precise negative mass is assigned to each gluon/quark-antiquark pair. Quarks themselves cannot be assigned mass.
4. The basic unit of mass is the electron mass ($m_e$). The mass of all quark structures inside the listed hadrons and muon is in multiples with a minor exception $14m_e$.
5. All particles - hadrons, leptons, and even the photon have quark structures. The difference is that the lowest leptons and photon contain no gluons.

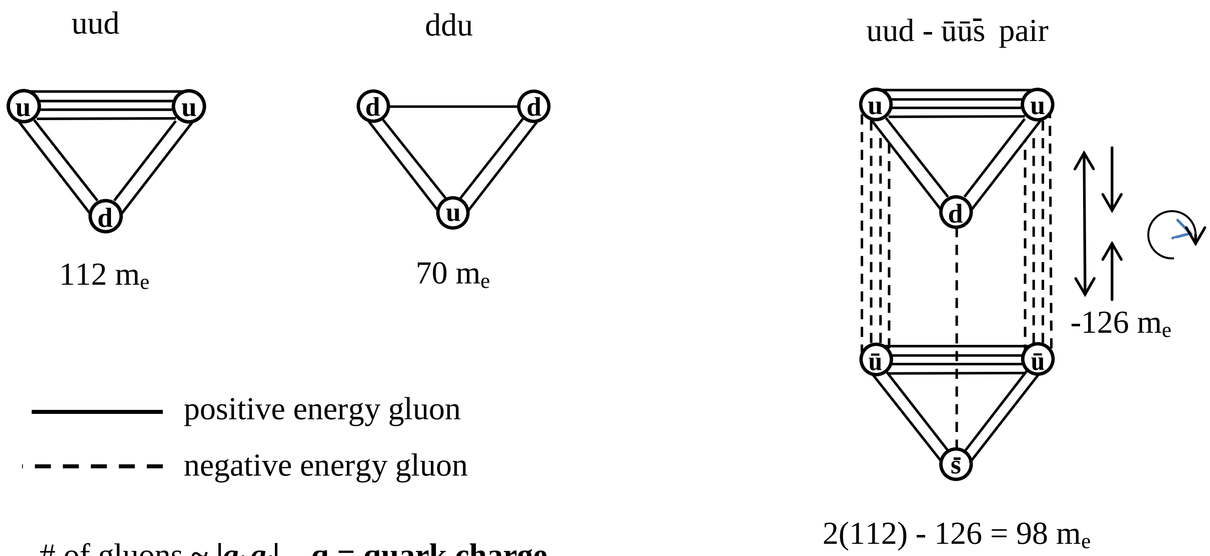
Proof that these findings are valid lies in the fact that the mass of all internal quark structures found in the hadrons listed are (in $m_e$) cumulative occupation numbers of the 3d quantum harmonic oscillator as initially used in the nuclear shell model i.e. filled levels of a 3d parabolic well. Examples for a uud triad, a udd triad, and a TAT pairing energy are $112m_e$, $70m_e$ , and $-126m_e$. Note that these numbers are all multiples of $14m_e$ (important).

Cumulative occupation numbers also exist for the number of triads plus antitriads in the neutral mesons 8, 20, 28. (note that the parabolic well is likely provided by negative pairing energies).

Finally, the proton, neutron, and muon contain the equivalent of 2 mesons lacking one or three quark triads and antitriads. These findings strongly suggest a string or strand structure (single strands for the spin 0 mesons, double as in DNA, for the spin ½ proton, neutron, and muon).

Hard proof for the model is provided by an internal structure for the muon and its known decay, which explains how and why neutrino oscillations occur.

As a conclusion to the introduction see figures 1 and 2. These self-explanatory structures will be derived and analyzed in detail in the next section. Note that in calculating mass/energy, the strange quark is treated the **same** as the down quark.




\# of gluons ~ $|q_i q_j|$ **q = quark charge**
associated mass/energy per gluon = ± 14 $m_e$

**Figure 1. Basic quark/gluon structures in the lowest stable hadrons**

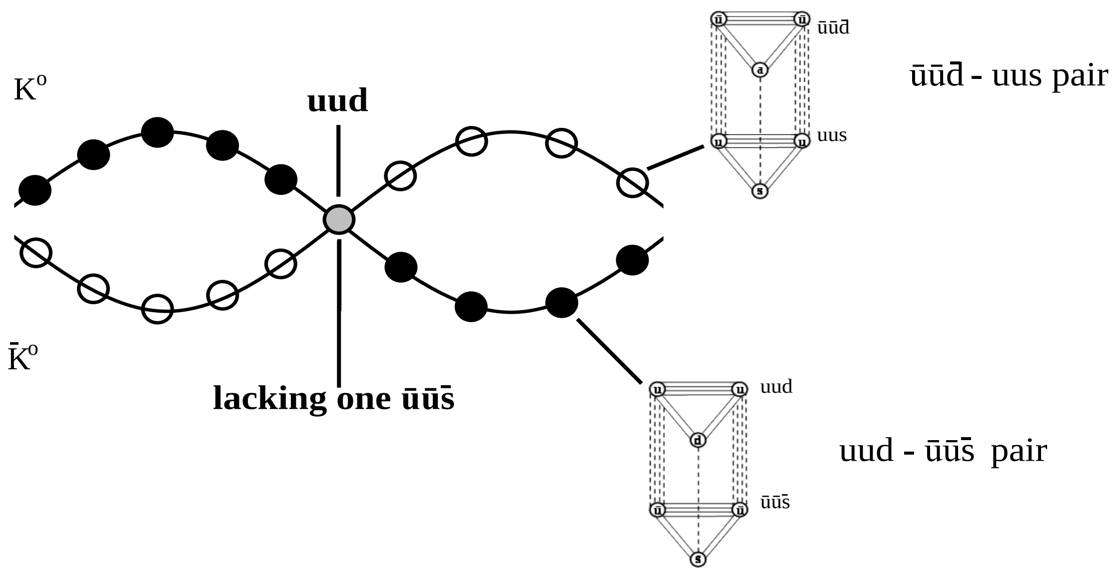



Figure 2. Double strand view of the proton
$M(K^o + \bar{K}^o) - 112\ m_e$ = proton mass

## THE MODEL

The nuclear shell model for protons and neutrons has had some, but limited success in explaining the structure and properties of nuclei. The analysis presented here shows that that model, which involves the residual strong force, is simply the tip of an iceberg, a reflection of what is happening at a deeper level, inside the proton and neutron, where the full strong force is dominant. This analysis shows that a nearly identical shell model exists inside the proton and neutron, with levels of a deep three dimensional parabolic well occupied by quark triads and antitriads. Large negative pairing energies between them provide cumulatively, the deep well (and this extends throughout the nucleus).

The success of this model is due in part to the fact that the units of mass or energy used were electron rest masses ($m_e$) rather than the customary Mev/$c^2$ units, with numerous gluonic triad and antitriad masses and pairing energies all quantized in units of $14m_{e.}$ (which is identified as the mass/energy associated with each of the 8 gluons).

The electron is seen, not as an infinitesimal point without structure, but as an $\bar{u}\bar{u}\bar{d}$ or $\bar{u}\bar{u}\bar{s}$ antitriad vibrating in a lowest allowed zero point **non-gluon** state.

To explain the sub-nuclear shell structure, let us first review the nuclear shell model. In one version of that model, protons and neutrons occupy levels of a deep three dimensional parabolic well (harmonic oscillator levels) provided by the residual strong force, to which is added spin-orbit coupling. Thus, filled levels (and sublevels) represent exceptionally stable nuclei. Following are listed cumulative occupation (magic) numbers representing filled levels.

**Cumulative Occupation Numbers**

| 3d **harmonicoscillator** | **with spin orbit coupling** |
|---|---|
| 2 | 2 |
| 8 | 8 |
| 20 | **14** |
| 40 | 20 |
| 7**0** | 28 |
| **112** | 50 |
| | 82 |
| | **126** |

Note that there are in fact, two separate wells, one for protons and one for neutrons.

In the model presented for the proton, as stated, quark triads and antitriads occupy the various levels. Occupation numbers involved in the proton structure are 20, 40, 112, and 126.

To show the proton structure, let us first examine the neutral kaon and anti-kaon structure as these are involved in the proton structure. A common view is that $K^o$ and $\bar{K}^o$ have simple quark structures $d\bar{s}$ and $\bar{d}s$ respectively. The model presented shows that this is partially true. Here the $K^o$ structure actually contains uud-$\bar{u}\bar{u}\bar{s}$ triad-anti triad (TAT) pairs which couple to $u\bar{u}+u\bar{u}+d\bar{s}$ as shown in figure 1. Furthermore, there is not just one TAT pair but 10. The same applies to $\bar{K}^o$ whose structure contains 10 $\bar{u}\bar{u}\bar{d}$-uus TAT pairs which couple to $u\bar{u}+u\bar{u}+\bar{d}s$ (note the occupation number 20 triads + antitriads). Now the mass of each triad and anti triad and pairing energy can be calculated from a semi-empirical formula involving only quark charges. This formula implies that quarks in a triad interact in pairs and the superposition principle holds for three quarks. That is, a 3 body interaction becomes the sum of 3 two body interactions. In addition, the interaction between quarks and between antiquarks generates positive mass energy, while the interaction between a quark and anti quark generates negative mass energy. With these claims, the following relation yields triad and anti triad masses and a pairing energy:

$$\text{MASS} = \pm 126 m_e/e^2 \sum^{3} \left| q_i q_j \right| \quad i \neq j \qquad \textbf{Eq. 1}$$

Substitution of the appropriate quark charges yields:

$$M(\text{uud or uus}) = 112 m_e = M(\bar{u}\,\bar{u}\,\bar{d} \text{ or } \bar{u}\,\bar{u}\,\bar{s})$$

$$M(\text{ddu or } \bar{d}\,\bar{d}\,\bar{u}) = 70 m_e = M(\text{sdu or } \bar{s}\,\bar{d}\,\bar{u})$$

$$M(\text{uud-}\bar{u}\,\bar{u}\,\bar{s}) = -126 m_e \text{ ------ pairing energy*}$$

**Relation 1. Decoding basic quark structures and their mass**

In the last relation, it is assumed that each quark interacts only with its counterpart anti-quark, i.e. $u\bar{u} + u\bar{u} + d\bar{s}$. Note that 70 and 112 are consecutive cumulative occupation numbers of the three dimensional harmonic oscillator through levels 4 and 5. Thus, the mass/energy associated with each triad and anti triad is assumed purely vibrational. Like the nuclear magic number 126, the negative pairing energy apparently involves a form of rotation (spin-orbit coupling in the nuclear model).

Note also that 70, 112 and 126 $m_e$ are all multiples of 14 $m_e$ (e.g. 112=14x8). From this, one concludes that the mass associated with each vibrational gluon is $\pm$ 14 $m_e$. Thus:

$$1g/dd = 14\, m_e$$

$$2g/ud = 28\, m_e$$

$$4g/uu = 56\, m_e$$

$$1g/d\bar{s} = -14\, m_e$$

$$4g/u\bar{u} = -56\, m_e$$

*Note that the extra ninth gluon in pairing is found to require a slightly greater magnitude apparently due to rotation, empirically -14.6$m_e$ rather than -14.0$m_e$. This makes the pairing energy for a TAT pair -126.6 $m_e$. **Note the importance of this**! It is found that the pairing energy -126.6 is the same for both neutral and charged triads and anti triads. Thus, since 70, 112, and 126 are all multiples of 14, a close examination of various hadron masses can reveal the number of pairing energies in each and thus the number of triads and anti-triads! Calculations can now be made for various particle masses:

## *NEW* NEUTRAL KAON STRUCTURE AND MASS

**Structure**: 3D parabolic well provided by cumulative pairing energies

$K^o$: 10 uud-$\bar{u}\bar{u}\bar{s}$ triad-anti triad pairs

$\bar{K}^o$: 10 $\bar{u}\bar{u}\bar{d}$-uus triad-anti triad pairs

Pairing energies 10 each

**Mass**: 10 x 112 $m_e$ + 10 x 112 $m_e$ . + 10 (-126.6 $m_e$ )

= 974.0 $m_e$ (known 973.9 $m_e$ )

## THE *NEW* PROTON STRUCTURE AND MASS

**Structure**: Double 3D Parabolic well provided by cumulative pairing energies

Equivalent to $K^o$ + $\bar{K}^o$ structures given above

Lacking one $\bar{u}\bar{u}\bar{s}$ antitriad, thus leaving one unpaired uud triad

**Mass**: From above, 2 x 974.0 $m_e$ - 112.0 $m_e$

= 1836.0 $m_e$ (known 1836.2 $m_e$)

(Note that the pairing energy of the unpaired uud triad remains, which indicates a sharing with other antitriads).

From the above structure, the precise number of fundamental particles in the proton can now be calculated. The *new* proton thus contains 60 quarks, 57 antiquarks, and 492 gluons (312 positive, 180 negative associated mass).

The previous analysis showed the complete internal structure of the proton, neutron, and neutral kaon, along with a claim the electron also has a quark antitriad, non-gluon structure. Support for this analysis can be given if the model can be expanded to include other hadrons and possibly leptons. The following shows that the stable $\pi^o$, $K^o$, and $\eta^o$ mesons contain precisely 8, 20, and 28 quark triads and antitriads (note the missing 2 in the magic number sequence)

## THE *NEW* MESONS

## STRUCTURE AND MASS OF η MESON

Structure: 3d parabolic well occupied by 7 double mixed neutral ddu/sdu - $\bar{d}\bar{d}\bar{u}/\bar{s}\bar{d}\bar{u}$ pairs, in total 28 triads plus antitriads. Each triad pair has mass/energy 2 x 70 or 140 $m_e$ (same for each anti-triad pair). Further analysis shows that each mixed pair has net spin ½. And with pairing (-126.6 $m_e$), each of 7 complete pairs has net spin 0 (important). This mixing will be shown later to be related to neutrino oscillations.

Mass: $28 \times 70\ m_e + 7(-126.6\ m_e)$

$= 1073.8\ m_e$ (known 1074.0 old or 1072.1 $m_e$ newer value)

## STRUCTURE AND MASS OF THE *NEW* NEUTRON

Structure: The structure of the *new* neutron can now be established. Equivalent to a mixed structure of $\bar{K}^o + \eta$ mesons lacking 140 $m_e$ and 70 $m_e$ triads or antitriads leaving unpaired one 70 $m_e$ udd triad.

Mass: $(974.0 + 1073.8 - 140)m_e$

$= 1837.8$ (known 1838.7 $m_e$)

## STRUCTURE AND MASS OF NEUTRAL PIONS $\pi^o$ AND $\bar{\pi}^o$

Structure: The neutral pions contain a mixture of triads and antitriads; 3 pairs total:

one uud- $\bar{u}\bar{u}\bar{s}$ pair (in $\pi^o$) or $\bar{u}\bar{u}\bar{d}$-uus pair (in $\bar{\pi}^o$) as in $K^o$ and $\bar{K}^o$

one ddu- $\bar{s}\bar{d}\bar{u}$ pair (in $\pi^o$) or $\bar{d}\bar{d}\bar{u}$ - sdu pair (in $\bar{\pi}^o$)

one double ddu/sdu - $\bar{d}\bar{d}\bar{u}/\bar{s}\bar{d}\bar{u}$ pair (as in $\eta^o$)

3 pairing energies

Mass: $2 \times 112\ m_e + 2 \times 70\ m_e + 2 \times 140\ m_e + 3\ (-126.6\ m_e)$

$= 264.2\ m_e$ (known $264.1 m_e$)

## PROOF

Proof is now provided that the model for hadrons is indeed valid.

STRUCTURE AND MASS OF MUON

It was shown that the proton and neutron contain 2 neutral mesons, lacking 1 and 3 quark triads or antitriads of given mass:

$$M(K^o + \bar{K}^o) - M(p) = 112\ m_e$$
$$M(K^o + \eta) - M(n) = 140\ m_e + 70\ m_e$$

From this, one might conclude that another spin ½ baryon might exist with a $\pi^o + \bar{\pi}^o$ internal structure. Although no such baryon of low mass exists, there is a spin ½ lepton, where mass is not explained, i.e. the muon. If it can be shown that:

$M(\pi^o + \bar{\pi}^o) - M(\mu^-)$ equals similar significant triads, this would provide proof for the hadron model.

Thus, it is found that:

$M(\pi^o + \bar{\pi}^o) - M(\mu^-) = 322\ m_e$, and

**$322 m_e = (112 + 140 + 70)\ m_e$ … (significant!!)**

This implies that the muon has 3 unpaired triads or antitriads, one charged and two different neutrals and since the muon decays to 3 such entities, it can be assumed that the muon decays as:

$$\bar{u}\bar{u}\bar{d} \text{ or } \bar{u}\bar{u}\bar{s} \rightarrow e^-$$
$$ddu \text{ or } sdu \rightarrow \bar{\nu}_e$$
$$\text{double mixed } \bar{d}\bar{d}\bar{u} / \bar{s}\bar{d}\bar{u} \rightarrow \nu_\mu$$

Note that triads decay to antineutrinos, antitriads to neutrinos. The significance of the last decay is major. **The mixed pair provides a reason for why neutrino oscillations can occur. The analysis also gives a reason for the existence and mass of the muon.**

**Summary of Particle Structure and Mass**

Table 1 below summarizes the combinations of 70, 112, and 140$m_e$ constituents and the pairing energies which yield quite accurately the known masses of the proton, neutron, neutral mesons $K^o$, $\eta^o$, $\pi^o$, and the muon.

**Table 1. Combinations of triads, antitriads, and pairing energies comprising 6 stable particles (and their antiparticles)**.

| Particle or Anti-Particle | Constituents 112$m_e$ | 70$m_e$ | 140$m_e$ | Pairing Energies (-126.6$m_e$) | Mass Calculated | ($m_e$) Known |
|---|---|---|---|---|---|---|
| $\pi^o$ | 2 | 2 | 2 | 3 | 264.2 | 264.1 |
| $K^o$ | 20 | - | - | 10 | 974.0 | 973.9 |
| $\eta^o$ | - | - | 14 | 7 | 1073.8 | 1074.0 |
| $\mu^-$ | 3 | 3 | 3 | 6 | 206.4 | 206.8 |
| p | 39 | - | - | 20 | 1836.0 | 1836.2 |
| n | 20 | 1 | 12 | 17 | 1837.8 | 1838.7 |

## THE NON-GLUON PARTICLES

NOW THE QUESTION ARISES:
Do the electrons and the neutrinos retain the quark structures given in muon decay, but **without gluons** or do they decay to infinitesimal points as generally accepted for leptons? There are arguments for both sides.

For retaining quark structures:

1. The muon, which is a lepton, was shown to have a definite quark structure.
2. The electron and neutrinos have intrinsic spin angular momentum, which in general implies a spacial extension.
3. A quark structure opens the possibility that electron orbitals in an atom actually represent the motion or location of its three antiquarks. If so, our interpretation of quantum mechanics will require major revision.
4. May explain why in weak decay $K^o$ always decays to $e^-$ and $\bar{K}^o$ to $e^+$. $K^o$ and $e^-$ both can contain $\bar{s}$ quarks only. $\bar{K}^o$ and $e^+$ both can contain s quarks only.

It is thus the author's view that the electron is seen as an **$\bar{u}\bar{u}\bar{d}$ or $\bar{u}\bar{u}\bar{s}$ antitriad** (or mixture) vibrating in a lowest zero point non-gluon state. The electron neutrino is seen as an **$\bar{u}\bar{d}\bar{d}$ or $\bar{u}\bar{d}\bar{s}$ antitriad** and the antineutrino as an **udd or uds triad** (or mixture).

## **THE *NEW* PHOTON**

In theory, a real photon may be regarded as continually creating and annihilating virtual electron-positron pairs. Experimentally, a photon can become a real electron-positron pair provided it has sufficient energy and momentum is conserved. Considering the given electron and positron quark structures, this strongly suggests that a real photon has a non-gluon uud - $\bar{u}\bar{u}\bar{s}$ $\bar{u}\bar{u}\bar{d}$ - uus mixed state internal structure. Of major importance is that this mixed state of the photon can be used to explain the phenomenon of **single photon interference** such as in a Michaelson Interferometer.

The quark structure for the photon may represent unification of the electromagnetic and other forces.

## CONCLUSIONS

Nearly 50 years of quark research and analysis has failed to provide the mass of individual quarks or gluon interaction energies, whose combinations should add up to the proton and other hadron masses. This should not be surprising since quarks and gluons do not, and cannot, exist alone. The model presented, however, shows that by combining both quark and gluon properties (mass/energy) the desired results can be achieved.

Equation 1 thus represents the first step in decoding the "Complete Internal Structure and Origin of Mass in the New Proton" and other particles. It shows that precise mass can only be assigned to each gluon/quark pair, whose combinations (triad-anti triad pairs) do add up to the proton and other hadron masses.

The main proof for the model is a meaningful, significant quark structure and decay mode for the muon. **The accuracy of numbers indicates that this is not accidental**. It also provides for expansion of quark structures (without gluons) to include the electron, neutrinos, and even the photon. **It also gives a reason for the existence and mass of the muon.**

Mixed states for all particles (like the neutral kaon) can explain the unusual behavior of some particles, such as neutrino oscillations, single photon interference, and possibly electron quantum orbitals in an atom. It is anticipated that further work will show precise quark/gluon structures for other hadrons, particularly the lower spin ½ λ, Σ, Ξ, and Ω baryons. Finally, with knowledge of the complete internal structure of the proton and neutron as presented it is the author's hope and expectation that **new inroads will be made in the area of controlled fusion.**

References: 1. www.desy.de/f/hera/engl/chap2.html The new view of the proton as seen by HERA

2. Copyright under previous title: "A decoding of the complete internal structure of the lower stable hadrons and leptons and the origin of mass" – July 2000 by John R. Springer