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STRUCTURING THE *NEW* PROTON

A Sub-nuclear Shell Model

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ABSTRACT

Experiments performed at the HERA Ring Accelerator, Hamburg, Germany have provided a "New View of the Proton" [1] which shows that the "new" proton contains not just three quarks but a large number of quarks, anti-quarks and gluons. A model is presented here which confirms this. It in fact, shows the complete internal quark/gluon structure of the proton, neutron, π^o, K^o, η^o mesons, and the muon. It also includes a possible quark (without gluons) structure for the electron and even the photon. Thus, all particles found in nature may have a quark structure.

The model also shows that although precise mass cannot be assigned to either quarks or gluons, it can be assigned to each gluon/quark pair and to each (of many) quark triads and anti-triads.

Finally, in addition, the model shows the emergence of genuine negative mass in the pairing of quark triads and anti-triads. Perhaps, even more important, it unifies the strong and electromagnetic forces.

1. www.desy.de/f/hera/engl/chap2.html

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INTRODUCTION

Experiments at the Hadron-Electron Ring Accelerator (HERA) at Hamburg have shown conclusively that the (new) proton contains not just three quarks, but a large number of quarks, antiquarks, and gluons[1]. What is needed now is a model which shows the complete arrangement or structure of the proton, the exact number of entities or composites in it, and the precise mass or energy associated with each. This should ultimately add up to the proton mass.

This paper provides such a model, a complete model. The numbers emerging are precise. Given composites of quarks, antiquarks, and gluons are shown to exist in a nuclear type shell structure with quark triads and antitriads filling levels of a deep 3 dimensional parabolic well provided by negative pairing energies (cumulative). One triad (uud) remains unpaired. Each triad and anti-triad contains 8 gluons of precise associated mass (associated means that, since quarks and gluons do not exist in isolation, mass is assigned only to each gluon/quark pair). In this model, there is no distinction between mass and energy, nearly all mass is vibrational interaction energy, quantized precisely for each gluon/quark pair. This includes negative mass/energy.

The model has been expanded to include the structure and mass of four other hadrons, the neutron, π^o, K^o, η^o mesons, and also leptons. The electron structure is a $\bar{u}\bar{u}\bar{d}$ or $\bar{u}\bar{u}\bar{s}$ anti-triad vibrating in a lowest allowed zero point non-gluon state ($1m_e$). Other gluonic quark triads and antitriads have precise vibrational masses quantized in electron/positron rest masses ($2m_e$).

Finally, the model presented shows a form of unification of the strong and electromagnetic forces.

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. Now it is recognized that the uncertainty principle does not allow individual electrons or positrons to exist in small spaces such as the interior of a proton or neutron, but this model shows that the electron, ordinarily considered a point particle with no internal structure, does indeed have an internal structure. It is a $\bar{u}\bar{u}\bar{d}$ or $\bar{u}\bar{u}\bar{s}$ antitriad vibrating in a lowest allowed zero point non-gluon state. Thus, other gluonic triads and antitriads which vibrate at higher levels with energies quantized in $2m_e$ are not in conflict with the uncertainty principle.

To explain this sub-nuclear shell structure, let us first review the nuclear shell model. In 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. Below are listed the so-called magic numbers representing filled levels.

Nuclear Magic Numbers

3 D harmonic oscillator	with spin orbit coupling
2	2
8	8
20	(14) semi-magic
40	20
70	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. Magic numbers involved in the proton structure are 20, 40, 112, and 126, with the last two numbers representing a different lower tier of levels (to be explained later).

To show the proton structure, let us first examine the neutral kaon and anti-kaon structure as these are involved in the proton structure. The naïve 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 $u\bar{u}+u\bar{u}+d\bar{s}$. 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 magic 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 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 (this will support a claim for the existence of negative mass!). With these claims, the following relation yields triad and anti triad masses and a pairing energy:

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

Substitution of the appropriate quark charges yields for triads or anti triads:

$M(uud \text{ or } uus) = 112 m_e$

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

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

Relation 1. Quark - Mass Relation

In the last relation, it is assumed that each quark interacts only with its counterpart antiquark, 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 -14.6m_e rather than -14.0m_e . This makes the pairing energy for a TAT pair -126.6 m_e . (Note that the pairing energy is greater than the mass/energy of each triad or anti-triad). Calculations can now be made for 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, 2x974.0 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 suggests a sharing with other anti triads).

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).

STRUCTURE AND MASS OF THE *NEW* NEUTRON

Structure: The structure of the *new* neutron can now be established. As with the proton, the neutron contains a double parabolic well provided by TAT pairing energies. One well is identical to that of the proton, i.e. an equivalent $\bar{K}^o$ structure. The other well is occupied by ddu and $\bar{d}\bar{d}\bar{u}$ triads and antitriads, and, as in the proton, one $\bar{d}\bar{d}\bar{u}$ is missing, leaving behind one unpaired ddu triad. In this well, however, four, rather than two triads plus antitriads are paired together (i.e. two triads plus two antitriads with one pairing energy). The number of triads plus antitriads in this well is 28 – 3 or 25, with 7 pairing energies (note the magic number 28 and later the η^o structure).

Mass: Relation 1 showed the mass of each ddu or $\bar{d}\bar{d}\bar{u}$ to be 70 m_e. Thus the new neutron mass is: 974.0 + 1750.0 – 886.2 m_e

= 1837.8 (known 1838.7 m_e)

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 π^o, K^o, and η^o mesons contain precisely 8, 20, and 28 quark triads and antitriads (note the missing 2 in the magic number sequence, to be addressed later).

THE *NEW* MESONS

STRUCTURE AND MASS OF ETA MESON

Structure: 3D parabolic well provided by cumulative pairing energies

Well is occupied by 7 double ddu- $\bar{d}\bar{d}\bar{u}$ neutral triads and antitriads (total 28 triads plus antitriads), combined with 7 pairing energies.

(conventionally, this is equivalent to 7 uds- $\bar{u}\bar{d}\bar{s}$ pairs)

Mass: $28x70\ m_e + 7(-126.6\ m_e)$

$=1073.8\ m_e$ (known $1072.1\ m_e$)j

K^o STRUCTURE AND MASS PREVIOUSLY SHOWN

STRUCTURE AND MASS OF NEUTRAL PION

Structure: The neutral pion contains a mixture of triads and antitriads:

one uud-$\bar{u}\bar{u}\bar{s}$ or $\bar{u}\bar{u}\bar{d}$-uus pair

one ddu- $\bar{d}\bar{d}\bar{u}$ pair

one double ddu- $\bar{d}\bar{d}\bar{u}$ pair (or one uds- $\bar{u}\bar{d}\bar{s}$ pair)

3 pairing energies

Mass:: $2x112\ m_e + 2x70\ m_e + 2x140\ m_e + 3\ (-126.6\ m_e)$

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

THE *NEW* LEPTONS

STRUCTURE AND MASS OF MUON

Structure: As in the proton and neutron which had two parabolic wells corresponding to two neutral mesons, the muon also contains a double well corresponding to two π^o structures, lacking one of each pair in one well. This leaves three unpaired entities:

one $\bar{u}\bar{u}\bar{d}$ or $\bar{u}\bar{u}\bar{s}$

one ddu

one double $\bar{d}\bar{d}\bar{u}$ (or one $\bar{u}\bar{d}\bar{s}$)

Note the 3 unpaired entities for muon decay discussed later.

Mass: $2 \times 264.2\ m_e + (-112\ m_e - 70\ m_e - 140\ m_e)$

$= 206.4\ m_e$ (known $206.8\ m_e$)

Now it was shown that the muon has unpaired $\bar{u}\bar{u}\bar{d}$ or $\bar{u}\bar{u}\bar{s}$, udd , and $\bar{u}\bar{d}\bar{s}$ triads and antitriads which indicates the muon decays as:

$\bar{u}\bar{u}\bar{d}$ or $\bar{u}\bar{u}\bar{s} \rightarrow e^-$

udd $\rightarrow \bar{\nu}_e$

$\bar{u}\bar{d}\bar{s} \rightarrow \nu_\mu$

Whether the neutrinos, like the electron, retain the quark structures given above (without gluons) is not known . Note that triads decay to antineutrinos, antitriads to neutrinos.

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 single non-gluon uud - $\bar{u}\,\bar{u}\,\bar{s}$ or $\bar{u}\,\bar{u}\,\bar{d}$ - uus internal structure. Zero mass is possible since triad-anti triad interactions generate negative mass energy. The single TAT pair may represent the missing 2 (triad + anti triad) in the given meson sequence 8, 20, and 28 shown earlier. If so, this represents a form of unification of the strong and electromagnetic forces.

Summary of Particle Structure and Mass

Table 1 below summarizes the combinations of 70, 112, and 140m_e constituents and the pairing energies which yield quite accurately the known masses of the proton, neutron, neutral mesons K^o, η^o, π^o, and the muon. Note that the number of pairing energies is not arbitrary, but because 70, 112, 140 and 126 are all multiples (harmonics) of 14, the number is dictated by the decimal fraction -0.6.in -126.6. This and the association with magic numbers makes it highly unlikely that these numbers could be accidental.

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

Particle or Anti-Particle	**Constituents**			**Pairing Energies**	**Mass (m_e)**	
	$112m_e$	**$70m_e$**	**$140m_e$**	**($-126.6m_e$)**	**Calculated**	**Known**
π^o	2	2	2	3	264.2	264.1
K^o	20	-	-	10	974.0	973.9
η^o	-	-	14	7	1073.8	1072.1
μ^-	3	3	3	6	206.4	206.8
p	39	-	-	20	1836.0	1836.2
n	20	1	12	17	1837.8	1838.7

CONCLUSION

The hadron electron ring accelerator (HERA) at Hamburg has achieved the highest resolution ever of any collider (including CERN) for viewing the internal structure of the proton. Experiments conducted there show conclusively that the proton contains a very high density of quarks, anti quarks and gluons. The model presented here not only confirms this, but shows in detail, the complete internal structure of the proton, a network of these entities. In addition, expansion of the model provides a quark structure for other particles found in nature, the neutron, mesons, leptons and even the photon, which lays the claim that all particles found in nature have quark structures. 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 a better understanding of the internal structure of the proton and neutron, it is anticipated that new inroads will be made into the process 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 author).

ADDENDUM

VERIFICATION OF MODEL

The best way to confirm or verify a new theoretical model is to design an experiment for proof. In this case, the experiment may have already been carried out but miss-interpreted. Collision experiments performed initially at the DESY laboratories PETRA collider showed 3-jet events, i.e. 3 groups of particles emitted in collisions of particles in 3 different directions. These later were repeated by experiments at the HERA collider where high energy electrons collided with high energy protons. These experiments provided the clearest view of proton structure ever achieved. The 3-jet events were interpreted as the first sound evidence for the existence of gluons, i.e. a collision between an electron and a single gluon in the proton. This interpretation by DESY physicists is plausible. An alternative explanation, however, and this author's view is that the 3-jet events actually represent the complete break up or disintegration of a single quark triad or anti-triad.

Question Remaining

If the electron does indeed have a quark structure without gluons as proposed in this model, might the electron orbitals in an atom actually represent the location or motion of the 3 $\bar{u}\bar{u}\bar{d}$ or $\bar{u}\bar{u}\bar{s}$ antiquarks which comprise the electron?