THE SEARCH FOR YANG-MILLS MAGNETIC MONOPOLES: MIGHT THEY ACTUALLY BE HIDING IN PLAIN SIGHT AS PROTON AND NEUTRONS?

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PREFACE

In 1970, in high school chemistry class, at age 16, I learned for the first time that the proton and neutron are more massive than the electron by a factor of about 1840. I asked the teacher, Steven C. Oppenheimer, nephew of J. Robert, why this was so. Naively, I assumed that some theorist had already explained this ratio. I will never forget his answer:

"They are experimental numbers. Nobody really knows why they are what they are. If you figure that out, it would be big news."

After more than 40 years of working and educating myself to answer that question, in February and March of 3013 I finally succeeded. In the process I also learned a great deal about nuclear binding and mass excess and many other things. The final of four peer-reviewed papers, which contains this answer, was published April 30, 2013.

Today is my first lecture (of hopefully many to come) to explain how I have solved this problem, and a few others along the way.

I CLAIM THAT THE FOLLOWING ARE PROVABLY TRUE, BASED ON KNOWN EXPERIMENTAL DATA

1) Theoretically, proton and neutrons are the Magnetic Monopoles of "non-commuting" gauge field theories. (So nobody is left behind, we will first discuss the meaning of "non-commuting," and will review Maxwell's equations which specify that there are NO magnetic monopoles in <u>ordinary</u> electrodynamics for "<u>commuting</u>" fields.)

2) Protons and neutrons are best thought of as "resonant cavities," wherein the binding energies at which they fuse are determined strictly by the masses of the up and down quarks that they contain. (Recall, a proton contains two up quarks and one down quark (duu), and a neutron contains two down quarks and one up quark (udd).) (PS: Protons and Neutrons are the most important examples of the class of three-quark entities known as "baryons.")

3) Each free proton and neutron ("nucleon") intrinsically contains 7.64 MeV and 9.81 MeV of mass/energy respectively which is used to confine its quarks. When these nucleons bind into composite nuclei, some, never all, of this energy is released, and the related mass deficit goes into nuclear binding. The mass/energy that does not get released for binding remains in reserve to continue confining quarks.

4) Once we consider the Fermi vacuum expectation value (vev) of ~246 GeV, the same line of analysis that explains binding energies, leads to an entirely theoretical explanation of the proton and neutron masses as function of only: a) the up mass and electric charge, b) the down mass and electric charge, c) the Fermi vev and d) one empirical parameter that is directly related to the "mixing angles" among the three generations of quarks. (The answer to my pursuit of 40+ years.)

5) Nuclear Physics is Governed by Maxwell's four (1861-1873) or two (1905-1915) Equations all combined into one equation, using non-commuting gauge fields, together with Dirac's theory of Fermions, together with the Fermi-Dirac-Pauli Exclusion Principal.

6) Atoms themselves comprise core *magnetic* charges (nucleons) paired with orbital *electric* charges (electrons and elusive neutrinos), with <u>the periodic table itself thereby revealing an electric/magnetic symmetry of Maxwell's equations</u> which has often been pondered, but has heretofore gone unrecognized in the 140 years since Maxwell first published his Treatise on Electricity and Magnetism.

THESE RESULTS ARE NEW PHYSICS, AND THEY ANSWER THEORETICAL QUESTIONS THAT NUCLEAR AND PARTICLE PHYSICISTS HAVE STRUGGLED WITH FOR DECADES. I WILL TRY TODAY TO GIVE YOU A SOLID OVERVIEW OF ALL OF THIS. I AM HAPPY IN Q&A TO OFFER A "THESIS DEFENSE" AS TO ANY OF THESE POINTS, OR OTHERS MADE HERE.

THIS IS ALL DEVELOPED IN THE FOLLOWING FOUR PAPERS

1) Yablon, J. R., Why Baryons Are Yang-Mills Magnetic Monopoles, Hadronic Journal, Volume 35, Number 4, 401-468 (2012)
Link: http://www.hadronicpress.com/issues/HJ/VOL35/HJ-35-4.pdf

2) J. Yablon, "Predicting the Binding Energies of the 1s Nuclides with High Precision, Based on Baryons which Are Yang-Mills Magnetic Monopoles," Journal of Modern Physics, Vol. 4 No. 4A, 2013, pp. 70-93. doi: 10.4236/jmp.2013.44A010.
Link: http://www.scirp.org/journal/PaperInformation.aspx?PaperID=30817

3) J. Yablon, "Grand Unified SU(8) Gauge Theory Based on Baryons which Are Yang-Mills Magnetic Monopoles," Journal of Modern Physics, Vol. 4 No. 4A, 2013, pp. 94-120. doi: 10.4236/jmp.2013.44A011.
Link: http://www.scirp.org/journal/PaperInformation.aspx?PaperID=30822

4) J. Yablon, "Predicting the Neutron and Proton Masses Based on Baryons which Are Yang-Mills Magnetic Monopoles and Koide Mass Triplets," Journal of Modern Physics, Vol. 4 No. 4A, 2013, pp. 127-150. doi: 10.4236/jmp.2013.44A013.
Link: http://www.scirp.org/journal/PaperInformation.aspx?PaperID=30830

<u>45 MIN</u>: THE SLIDES BELOW DO CONTAIN ALL THE IMPORTANT HIGHLIGHTS FROM ALL FOUR PAPERS (~140 PAGES). IN THE INTEREST OF TIME, I WILL SPEND MORE TIME ON SOME SLIDES AND LESS (OR NONE) ON OTHERS. <u>IF I GLOSS OVER SOMETHING TOO QUICKLY, THEN</u>:

<u>15 MIN</u>: DURING THE Q&A, <u>I WILL BE HAPPY TO GO BACK</u> AND DELVE INTO MORE DETAIL ON PARTICULAR POINTS OF INTEREST TO YOU. PLEASE SAVE YOUR QUESTIONS!

THERE WILL BE SOME MATH EQUATIONS ON THESE SLIDES. UNLESS YOU ARE ALREADY FAMILIAR WITH THESE MATHS, JUST STAY FOCUSED ON THE DISCUSSION AND THE OVERALL FLOW. <u>THE ONE EXCEPTION IS THE DISCUSSION ABOUT NON-COMMUTING NUMBERS, WHICH IT IS IMPORTANT TO UNDERSTAND.</u> THAT IS WHERE WE WILL START.

YOU CAN READ FASTER THAN I CAN SPEAK. SO I PUT MORE MATERIAL INTO THE SLIDES SO I CAN SAY LESS AND WE CAN PROCEED FASTER. <u>READ THE SLIDES WHILE I AM SPEAKING.</u>

PART I – ANCHORING IN CONSERVATIVE, TESTED FOUNDATIONS

"ON THE SHOULDERS OF GIANTS"

MATHEMATICAL UNDERPINNINGS

Commuting Numbers

$$5\times3=3\times5=15$$

$$5\times3-3\times5=0$$

$$[5,3]=0$$

Generalization: $[A,B]=0$

Non-Commuting "Numbers"

$$[A,B]\neq0$$

$$AB\neq BA$$

Obviously, ordinary numbers are commuting. The simplest example of a non-Commuting "number" is a matrix. We will take a look at a few examples momentarily.

During the 20th century, it was discovered that mathematical objects thought to be commuting during the 19th century, are in fact non-commuting. Indeed, the key advances in 20th century physics largely center on the discovery of objects that do not commute which had previously been assumed to be commuting.

Important Examples of Non-Commuting Numbers

$$\left[x, p_x\right] = i\hbar$$

(Heisenberg Canonical Quantization → Uncertainty Principle (Fourier Transform))

$$\left[D_\mu, D_\nu\right] A_\alpha = R^\sigma{}_{\alpha\mu\nu} A_\sigma$$

(Riemann Curvature Tensor, Curved Spacetime (1866/1915))

$$\left[(L+S), H\right] = 0; \quad \left[L, H\right] \neq 0; \quad \left[S, H\right] \neq 0$$

(Conservation / Observability of Spin + Orbital Angular Momentum)

$$\sigma^{\mu\nu} = \tfrac{i}{2}\left[\gamma^\mu, \gamma^\nu\right]; \quad \eta^{\mu\nu} = \tfrac{1}{2}\left\{\gamma^\mu, \gamma^\nu\right\} = \tfrac{1}{2}\left(\gamma^\mu \gamma^\nu + \gamma^\nu \gamma^\mu\right)$$

(Dirac covariants, polarization and magnetization. Also, Minkowski metric tensor from <u>anti</u>-commutator –vierbein / tetrad to get to $g_{\mu\nu}$)

$$\left[G^\mu, G^\nu\right] \neq 0$$

(Non-Commuting vector potential gauge fields G^μ : <u>Central to Today's Discussion</u>)

Today's Math and Physics Lesson: Follow the Commutators!

These and other non-commuting numbers, trace their modern origins to 1843, seven decades before the quantum revolution, where today's story begins.

Quaternions: The First Non-Commuting Algebra

William Rowan Hamilton
Dublin, Ireland – 1843

In 1843, imaginary numbers $i=\sqrt{-1}$ are still fairly new. Hamilton seeks in to generalize $i^2=-1$ to three dimensions by creating two more numbers *j*, *k* different from *i* which also are specified by $j^2=k^2=-1$, in order to describe rotations in three space dimensions (which rotations do not commute).

In a seminal flash, he conceives the answer to his quest, and uses his penknife to carve in the side of the Brougham Bridge:

$$i^2 = j^2 = k^2 = ijk = -1$$

(PS: Dirac's $i\gamma^0\gamma^1\gamma^2\gamma^3\gamma^5=1$ is a generalization of $ijk=-1$, in spacetime**)**

This inscription survives (and is maintained) as a piece of scientific history to this day. These numbers *i*, *j*, *k* are called "quaternions," and by design are *non-commuting numbers*.

Unbeknownst to Hamilton, much of Twentieth Century Quantum physics would either be built directly from his quaternions, or inspired by the non-commuting nature of his quaternions (e.g., Heisenberg commutation relations). Today, we shall show how these are at the root as well, of protons and neutrons being a special type of magnetic monopole.

Spin Matrices SU(2), Wolfgang Pauli – 1925

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} \quad \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

$$x, y, z \rightarrow 1, 2, 3$$

$$\sigma_1^2 = \sigma_2^2 = \sigma_3^2 = -i\sigma_1\sigma_2\sigma_3 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = I$$

$$*** \Rightarrow \left[\sigma_i, \sigma_j\right] = 2i\varepsilon_{ijk}\sigma_k \Leftarrow ***$$

$$\varepsilon_{123} = \varepsilon_{231} = \varepsilon_{312} = +1; \quad \varepsilon_{132} = \varepsilon_{321} = \varepsilon_{213} = -1; \quad \varepsilon_{ijk} = 0 \text{ otherwise}$$

These matrices are a *concrete representation* of Hamilton's quaternions. The Lie Group is called SU(2). The 2 is the 2x2 dimension of the matrix, the S is because these have no trace. U describes a property known as "unitarity."

Example of how to use the Spin Matrices to "Dagger" a Vector:

$$X_i = (x, y, z)$$

$$\not{X} = \sigma_i x_i = \begin{pmatrix} z & x - iy \\ x + iy & -z \end{pmatrix}$$

Non-Abelian Theory: Chen Ning Yang and Robert Mills – 1954

Generalization of $\left[\sigma_i, \sigma_j\right] = 2i\varepsilon_{ijk}\sigma_k \Rightarrow \left[\lambda_i, \lambda_j\right] = 2if_{ijk}\lambda_k$

Example: SU(3)

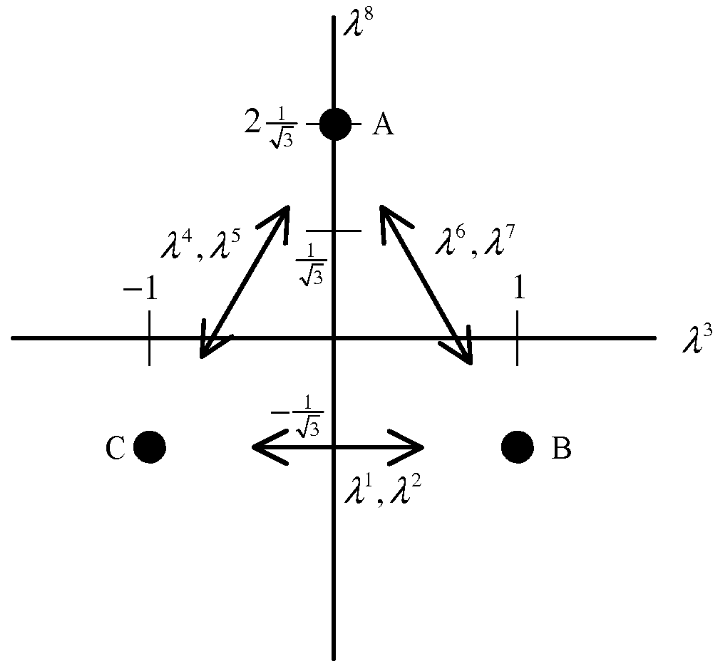
$$\lambda_8 = \frac{1}{\sqrt{3}}\begin{pmatrix} 2 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix} \quad \lambda_3 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

$$\lambda_1 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix} \lambda_2 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -i \\ 0 & i & 0 \end{pmatrix} \lambda_4 = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix} \lambda_5 = \begin{pmatrix} 0 & 0 & -i \\ 0 & 0 & 0 \\ i & 0 & 0 \end{pmatrix} \lambda_6 = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \lambda_7 = \begin{pmatrix} 0 & -i & 0 \\ -i & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$N_i = \left(n_1, n_2, n_3, n_4, n_5, n_6, n_7, n_8\right)$$

How to use: $$\mathbb{N} = \lambda_i N_i = \begin{pmatrix} \frac{1}{\sqrt{3}} 2n_8 & n_6 - in_7 & n_4 - in_5 \\ n_1 + in_2 & -\frac{1}{\sqrt{3}} n_8 + n_3 & n_1 - in_2 \\ n_6 + in_7 & n_4 + in_5 & -\frac{1}{\sqrt{3}} n_8 - n_3 \end{pmatrix}$$

These Yang-Mills Matrices Have a Geometric Picture, in what is called an "Internal Symmetry Space." For SU(N), we have N-1 "Degrees of Freedom" and N "eigenstates." Below is the Picture for SU(3). (Later, when talking about generation replication, I will use $\therefore$ as a shorthand for this Figure – remember this.)



Most Importantly, Yang-Mills Theories <u>have been proven to describe Physical Reality</u>. They are not just wishful mathematical thinking about physics. And, in these theories, $\left[G^{\mu}, G^{\nu}\right] \neq 0$.

THEORETICAL PHYSICS UNDERPINNINGS

Maxwell's "Four Equations" – 1861-1873
A "multimedia" presentation:

And God said

1) $\oiint \vec{E} \cdot d\vec{A} = Q / \varepsilon_0$

2) $\oiint \vec{B} \cdot d\vec{A} = 0*$

3) $\oint \vec{E} \cdot d\vec{l} = 0* - \iint_S \frac{\partial \vec{B}}{\partial t} \cdot d\vec{A}$

4) $\oint \vec{B} \cdot d\vec{l} = \mu_0 I + \mu_0 \varepsilon_0 \iint_S \frac{\partial \vec{E}}{\partial t} \cdot d\vec{A}$

and then there was <u>light</u> ($\mu_0 \varepsilon_0 = c^2$).

***and also <u>matter</u> if the magnetic monopoles are non-zero!**

Special and General Relativity, Spacetime – 1905, 1909 and 1915

With the consolidation of space and time into spacetime, Maxwell's equations are consolidated from four down to two:

$J^{\nu} = \partial_{\mu} F^{\mu\nu} = \left(g^{\mu\nu} \partial_{\sigma} D^{\sigma} - \partial^{\mu} D^{\nu} \right) G_{\mu}$ (electric charge equation, 1) and 4))

$P^{\sigma\mu\nu} = \partial^{\sigma} F^{\mu\nu} + \partial^{\mu} F^{\nu\sigma} + \partial^{\nu} F^{\sigma\mu}$ (magnetic monopole equation, 2) and 3))

How do magnetic monopoles become zero? Start with a field strength:

$F^{\mu\nu} = \partial^{\mu} G^{\nu} - \partial^{\nu} G^{\mu} - i\left[G^{\mu}, G^{\nu} \right]$ (final $\left[G^{\mu}, G^{\nu} \right]$ term not known till after Yang and Mills)

Assume gauge fields <u>commute</u>, $\left[G^{\mu}, G^{\nu} \right] = 0$**. Keep in mind** $\left[\partial_{\mu}, \partial_{\nu} \right] A_{\alpha} = R^{\sigma}{}_{\alpha\mu\nu} A_{\sigma}$ **.**
Substitute $F^{\mu\nu} = \partial^{\mu} G^{\nu} - \partial^{\nu} G^{\mu}$ **into** $P^{\sigma\mu\nu}$**. By identity, <u>even in curved spacetime</u>:**

$$\begin{aligned} P^{\sigma\mu\nu} &= \partial^{\sigma} F^{\mu\nu} + \partial^{\mu} F^{\nu\sigma} + \partial^{\nu} F^{\sigma\mu} \\ &= \partial^{\sigma} \left(\partial^{\mu} G^{\nu} - \partial^{\nu} G^{\mu} \right) + \partial^{\mu} \left(\partial^{\nu} G^{\sigma} - \partial^{\sigma} G^{\nu} \right) + \partial^{\nu} \left(\partial^{\sigma} G^{\mu} - \partial^{\mu} G^{\sigma} \right) \\ &= \left[\partial^{\sigma}, \partial^{\mu} \right] G^{\nu} + \left[\partial^{\mu}, \partial^{\nu} \right] G^{\sigma} + \left[\partial^{\nu}, \partial^{\sigma} \right] G^{\mu} = \left(R_{\tau}{}^{\nu\sigma\mu} + R_{\tau}{}^{\sigma\mu\nu} + R_{\tau}{}^{\mu\nu\sigma} \right) G^{\tau} = \mathbf{0} \end{aligned}$$

In the mathematically-concise language of "differential forms," this (first Bianci) identity is written as dd=0: "the exterior derivative of an exterior derivative is zero." (First Bianchi identity: $R_{\tau}{}^{\nu\sigma\mu} + R_{\tau}{}^{\sigma\mu\nu} + R_{\tau}{}^{\mu\nu\sigma} = \mathbf{0}$ **)**

<u>It is an identity rooted in and enforced by spacetime geometry!</u>

But, if the Gauge Fields are <u>Non-Commuting</u>, then $\left[G^\mu, G^\nu\right] \neq 0$. Then, we must use the complete "Yang-Mills" field strength:

$$F^{\mu\nu} = \partial^\mu G^\nu - \partial^\nu G^\mu - i\left[G^\mu, G^\nu\right]$$

For non-commuting fields, the magnetic monopoles <u>do exist</u>:

$$\boxed{\begin{aligned} &P^{\sigma\mu\nu} = \partial^\sigma F^{\mu\nu} + \partial^\mu F^{\nu\sigma} + \partial^\nu F^{\sigma\mu} \\ &= \mathbf{0} - i\left(\partial^\sigma\left[G^\mu, G^\nu\right] + \partial^\mu\left[G^\nu, G^\sigma\right] + \partial^\nu\left[G^\sigma, G^\mu\right]\right) \neq 0 \end{aligned}}$$

The "0" of dd=0 still remains part of this equation, but the magnetic monopole becomes <u>non-zero</u> precisely because $\left[G^\mu, G^\nu\right] \neq 0$.

<u>PREVIEW</u>: THESE NON-ZERO MAGNETIC MONOPOLES ARE PROTONS AND NEUTRONS! THE "0" OF dd=0 CAUSES QUARK CONFINEMENT. BUT BEFORE WE CAN SEE THIS, WE ALSO NEED TO POPULATE THESE MONOPOLES WITH THREE QUARKS. HOW DO WE DO THIS? (Note, the monopoles have three additive terms.)

INVERTING MAXWELL'S ELECTRIC CHARGE EQUATION

We can always write Maxwell's electric charge equation $J^\nu = \partial_\mu F^{\mu\nu} = F(G^\nu)$ **in <u>inverted</u> form wherein the gauge fields are an <u>inverse</u> function of the charge density, where we use a proportion to 1/m² to balance mass dimensionality, i.e.:**

$$G_\nu = F^{-1}\left(J^\sigma\right) \equiv I_{\sigma\nu} J^\sigma \propto \left(1/m^2\right) J_\nu$$

Furthermore, <u>Dirac's theory of Fermion wavefunctions</u> ψ **tells us the conserved (continuity) current density is** $J_\nu = \overline{\psi}\gamma_\nu\psi$**. So we this inverse:**

$$G_\nu = F^{-1}\left(J^\sigma\right) \equiv I_{\sigma\nu} J^\sigma \propto \left(1/m^2\right) J_\nu = \left(1/m^2\right)\overline{\psi}\gamma_\nu\psi$$

We can then use this to replace every occurrence of G^μ **in the magnetic monopole** $P^{\sigma\mu\nu} = -i\left(\partial^\sigma\left[G^\mu, G^\nu\right] + \partial^\mu\left[G^\nu, G^\sigma\right] + \partial^\nu\left[G^\sigma, G^\mu\right]\right)$ **with fermion wavefunctions and an inverse mass 1/m².**

<u>THE RESULT OF DOING SO IS THAT MAXWELL'S TWO EQUATIONS MAY BE COMBINED INTO "ONE EQUATION" AND SIMULTANEOUSLY MERGED WITH DIRAC THEORY.</u>

<u>MORE PREVIEW</u>: THE DERIVATION IS SOMEWHAT DETAILED, BUT AT THE END OF THE DAY, WE CAN TURN THE NON-ZERO MAGNETIC MONOPOLE OF COMMUTING GAUGE FIELDS FROM

$$P^{\sigma\mu\nu} = \mathbf{0} - i\left(\partial^\sigma\left[G^\mu, G^\nu\right] + \partial^\mu\left[G^\nu, G^\sigma\right] + \partial^\nu\left[G^\sigma, G^\mu\right]\right)$$

INTO ($\sigma^{\mu\nu} = \frac{i}{2}\left[\gamma^\mu, \gamma^\nu\right]$; Tr = Trace (sum of diagonal elements)**)**

$$\boxed{\mathrm{Tr}\, P^{\sigma\mu\nu} = \mathbf{0} + 2\left(\partial^\sigma \frac{\bar{\psi}_R \sigma^{\mu\nu}\psi_R}{m_R} + \partial^\mu \frac{\bar{\psi}_G \sigma^{\nu\sigma}\psi_G}{m_G} + \partial^\nu \frac{\bar{\psi}_B \sigma^{\sigma\mu}\psi_B}{m_B}\right)}$$

1) The R, G, B represent three colors of quark.

2) <u>Protons and neutrons</u> come from Maxwell's magnetic monopole equation for non-commuting gauge fields, with (R,G,B)→(d,u,u) or (u,d,d).

3) The magnetic monopoles are <u>populated with quarks</u> via Maxwell's inverted electric charge equation combined with Dirac's $J_\nu = \bar{\psi}\gamma_\nu\psi$ for charge conservation, and then "injected" into the three terms in the monopoles by applying the "Exclusion Principal" of Fermi-Dirac-Pauli via $SU(3)_{COLOR}$.

4) Finally, <u>confinement</u> is <u>enforced by spacetime geometry</u> via the "0" of dd=0.

ALL FOUR OF MAXWELL'S EQUATIONS ARE MERGED IN THE ABOVE INTO <u>ONE</u> EQUATION AND COMBINED WITH DIRAC THEORY AND THE EXCLUSION PRINCIPLE. <u>THIS IS THE THEORETICAL FOUNDATION OF NUCLEAR PHYSICS.</u>

IS THERE PRECEDENT FOR COMBINING MAXWELL'S TWO EQUATIONS INTO ONE?

A. Einstein, *Relativistic Theory of the Non-Symmetric Field*, in *The Meaning of Relativity*, December 1954 (Final paper), page 139: "It is surprising that the gravitational equations for empty space determine their field just as strongly as do Maxwell's equations in the case of the electromagnetic field." What he meant is that:

$$R_{\mu\nu} = 0 \Rightarrow z_1 = 12$$

$$\left\{ \begin{array}{c} \partial_{\sigma} F^{\mu\nu} = 0 \\ \partial^{\sigma} F^{\mu\nu} + \partial^{\mu} F^{\nu\sigma} + \partial^{\nu} F^{\sigma\mu} = 0 \end{array} \right\} \Rightarrow z_1 = 12$$

This is what first caused me to ask, in 1983-1984: <u>"what would be the result of combining both of Maxwell's equations into one equation?"</u> At the time, I proved (unpublished) the above <u>are</u> physically-equivalent equations, but only when we forego $F^{\mu\nu} = \partial^{\mu} G^{\nu} - \partial^{\nu} G^{\mu}$ to allow <u>non-zero magnetic</u> sources. This caused me to closely study magnetic monopoles.

EXPERIMENTAL PHYSICS

In 1919: Ernest Rutherford Discovers the Proton

In 1932: His Disciple James Chadwick Discovers the Neutron

In 1934: the Muon (second generation electron) is Discovered. Isidor Rabi Quips: "Who Ordered That?

"WHO ORDERED THAT?" Remains a pertinent question to this date, not only for the three "generations" of spin ½ "Fermions," but for many particles, <u>including the proton and the neutron</u>

PART II – THEORY: PROTONS AND NEUTRONS ARE THE MAGNETIC MONPOLES OF NON-COMMUTING GAUGE FIELDS

"NOVEL COMBINATION / SYNTHESIS OF KNOWN (AND WELL-ESTABLISHED, THOUROUGHLY-TESTED, UNQUESTIONABLE) ELEMENTS"

PUTTING TOGETHER THEORY AND EXPERIMENT

Two Questions:

1. Channeling Rabi: Who ordered the Proton and Neutron? (A Theoretical question about an Experimental Observation)

2. Do the Magnetic Monopoles for Non-Commuting Fields,

$$*****\Rightarrow P^{\sigma\mu\nu}=\mathbf{0}-i\left(\partial^{\sigma}\left[G^{\mu},G^{\nu}\right]+\partial^{\mu}\left[G^{\nu},G^{\sigma}\right]+\partial^{\nu}\left[G^{\sigma},G^{\mu}\right]\right)\neq 0\Leftarrow *****$$

exist anywhere in the Material Universe, and if so, in what way do we observe them? (An Experimental Question about a Theoretical Observation)

If you believe in Maxwell and believe in non-commuting gauge fields, and if you take Einstein's $z_1=12$ finding to be more than just "surprising," then they <u>must</u> exist somewhere in some form!

THE THEORIZED ANSWER

1. The Protons and Neutrons which form the vast preponderance of directly observed matter in the universe, are the Magnetic Monopoles of Non-Commuting Fields. (They were ordered by Maxwell and Yang & Mills and Hamilton and Dirac. Also by Dirac (again) and Fermi and Pauli via Exclusion as will shortly be discussed.)

2. Conversely, Magnetic Monopoles, long pursued since the time of Maxwell, DO EXIST (they are not unicorns), and have always been hiding in plain sight, in Yang-Mills (non-commuting field) incarnation, as Protons and Neutrons, which exist <u>everywhere</u> in the Universe where there is matter!

DEDUCING MAXWELL'S "ONE EQUATION"
(I will name this the "Maxwell-Dirac Equation")

As previewed above, we combine all four (or both as of 1915) of Maxwell's equation into one equation together with Dirac theory together with Fermi-Dirac-Pauli Exclusion, using the non-zero magnetic monopoles of non-commuting gauge fields. The result is (the "$_\vee$ " and "quoted denominators are my own compact notation which expand to show chiral behaviors; $\sigma^{\mu\nu} = \tfrac{i}{2}\left[\gamma^\mu, \gamma^\nu\right]$):

$$\boxed{\mathrm{Tr}\, P^{\sigma\mu\nu} = -2\left(\partial^\sigma \frac{\bar{\psi}_R \sigma^{\mu_\vee \nu} \psi_R}{"\not{p}_R - m_R"} + \partial^\mu \frac{\bar{\psi}_G \sigma^{\nu_\vee \sigma} \psi_G}{"\not{p}_G - m_G"} + \partial^\nu \frac{\bar{\psi}_B \sigma^{\sigma_\vee \mu} \psi_B}{"\not{p}_B - m_B"}\right) \underset{\text{interaction}}{\overset{\text{Point}}{\Rightarrow}} 2\left(\partial^\sigma \frac{\bar{\psi}_R \sigma^{\mu\nu} \psi_R}{m_R} + \partial^\mu \frac{\bar{\psi}_G \sigma^{\nu\sigma} \psi_G}{m_G} + \partial^\nu \frac{\bar{\psi}_B \sigma^{\sigma\mu} \psi_B}{m_B}\right)}$$

<u>THIS IS WHAT WE OBTAIN AFTER WE MERGE BOTH OF MAXWELL'S EQUATIONS INTO ONE EQUATION USING NON-COMMUTING GAUGE FIELDS (COURTESY OF YANG & MILLS AND ROOTED IN HAMILTON), THEN AND APPLY DIRAC THEORY AND FERMI-DIRAC-PAULI EXCLUSION!</u>

<u>First</u>, this gives us exactly 3 colors of quark! (Not known before why 3 rather than another number, nor known why protons and neutron are composite entities in the first place)

<u>Second</u>, the "colors" Red, Green, Blue, associated with the widely-accepted theory of strong interactions "Quantum Chromodynamics" (QCD) appear above in the form:

$$\sigma\mu\nu + \mu\nu\sigma + \nu\sigma\mu - \sigma\nu\mu - \mu\sigma\nu - \nu\mu\sigma \sim RGB + GBR + BRG - RBG - GRB - BGR$$

This is <u>exactly</u> what the colors of protons and neutrons are supposed to look like.

THE ANTISYMMETRIC CHARACTER OF MAGNETIC MONOPOLES AND THEIR HAVING THREE SPACETIME INDEXES, IN REPTROSPECT, IS THE BEST TIP OFF THAT MAGNETIC MONOPOLES MAKE GOOD PROTONS AND NEUTRONS

<u>Third</u> (in differential forms language), when we apply Stokes' Theorem to "Maxwell's one equation" (the "Maxwell-Dirac equation") we obtain:

$$\iiint \mathrm{Tr}P = \oiint \mathrm{Tr}F = 2\oiint\left[\mathbf{0}+\left(\frac{\overline{\psi}_R\sigma^{\mu\nu}\psi_R}{m_R}+\frac{\overline{\psi}_G\sigma^{\mu\nu}\psi_G}{m_G}+\frac{\overline{\psi}_B\sigma^{\mu\nu}\psi_B}{m_B}\right)\right]dx_\mu dx_\nu$$

This is what flows across closed surfaces of these magnetic monopoles. By inspection, the color singlet wavefunction is:

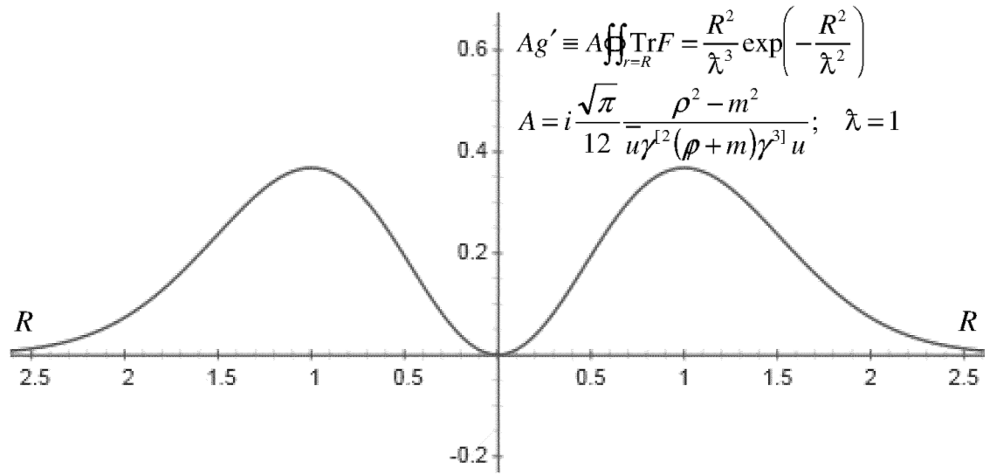
$$\overline{R}R+\overline{G}G+\overline{B}B$$

This is <u>exactly</u> what the mesons (the only particles that do flow in and out of protons and neutrons) are supposed to look like.

<u>Fourth</u>, the "0" in Stokes' Theorem applied above, which is really equation $\oiint dG = 0$ courtesy of dd=0 and the First Bianchi Identity $R_\tau{}^{\nu\sigma\mu}+R_\tau{}^{\sigma\mu\nu}+R_\tau{}^{\mu\nu\sigma}=\mathbf{0}$, means that <u>nothing else</u> flows in and out of protons and neutrons.

THIS SOLVES CONFINEMENT THEORETICALLY, AND SHOWS THAT <u>SPACETIME GEOMETRY CONFINES QUARKS IN NON-COMMUTING GAUGE THEORY IN THE EXACT SAME WAY THAT IT BARS MAGNETIC MONOPOLES FROM MAXWELL'S COMMUTING THEORY</u>. WE NOW SHOW HOW CONFINMENT IS PROVED BY EXPERIMENTAL NUCLEAR BINDING ENERGIES.

<u>Fifth</u>, finally, we also derive a field for the magnetic monopole which is <u>short-ranged, not inverse-square</u>. The figure below shows the <u>total</u> magnetic monopole flux $g'(R) = \oiint_{r=R} \mathrm{Tr}F$ **over a closed surface as a function of radial distance R from the magnetic monopole (proton or neutron) "center."**



The peak flux occurs at about $R_{\text{Peak}} \sim .63F$ **. with a standard deviation** $\sigma = \frac{1}{\sqrt{2}}R_{\text{Peak}} \sim .45F$ **, the nuclear interaction virtually ceases to be effective at about** $4\sigma \approx 3R_{\text{Peak}} \sim 2F$ **.**

THIS IS PRECISELY THE TYPE AND SCALE OF THE SHORT-RANGED BEHAVIOR EXPECTED FROM NUCLEAR INTERACTIONS.

PART III – EXPERIMENTAL EVIDENCE TO PARTS-PER-MILLION, IN SUPPORT OF THE THEORY THAT PROTONS AND NEUTRONS ARE MAGNETTIC MONOPOLES

“NO LESS THAN WHAT GALILEO WOULD DEMAND”

GALILEO WOULD ASK: HOW DO WE PROVE THIS TO BE TRUE WITH EMPIRICAL DATA?

If we really think magnetic monopoles are protons and neutrons, then their energies must make some sense in relation to the energies we observe in association with protons and neutrons. So the first step should be to actually calculate predicted energies of these magnetic monopoles.

Energy calculations always start with a Lagrangian density. Here, from t'Hooft monopole theory, we start with (Φ represents the vacuum):

$$\mathfrak{L} = -\tfrac{1}{2}\,\mathrm{Tr}\left(F_{\mu\nu}F^{\mu\nu}\right) - \mathrm{Tr}\left(D_\mu\Phi D^\mu\Phi\right) - \mu^2\,\mathrm{Tr}\left(\Phi\Phi\right) - \tfrac{1}{2}\lambda\left(\mathrm{Tr}\left(\Phi\Phi\right)\right)^2$$

$$\left(D_\mu\Phi\right)_{AB} = \partial_\mu\Phi_{AB} - i\left(\left[G_\mu, \Phi\right]\right)_{AB}$$

In a first pass (Part III), we ignore vacuum terms and only use $\mathfrak{L} = -\tfrac{1}{2}\,\mathrm{Tr}\left(F_{\mu\nu}F^{\mu\nu}\right)$. This contains an "inner product" of pure gauge fields with commutators $\left[G_\mu, G_\nu\right]$. As we shall now see, this leads us to the binding energies of the proton and neutron. In a second pass (Part IV), we don't ignore the vacuum terms. From the commutator $\left[G_\mu, \Phi\right]$, we note that these vacuum terms are half gauge field and half vacuum. This leads us to the proton and neutron masses (my 43 year quest).

COMMENT ON TIMING

IT IS ESPECIALLY IMPORTANT TO CONVEY A THOROUGH UNDERSTANDING OF THE FIRST PASS ENERGY CALCULATION IN PART III, WHICH LEADS TO NUCLEAR BINDING ENERGIES.

IF THERE IS ENOUGH TIME REMAINING, I WILL REVIEW PART IV FOR PROTON AND NEUTRON MASSES AS WELL. IF THERE IS NOT, I WILL SIMPLY SHOW YOU THE PROTON AND NEUTRON MASSES RESULT, GIVE MY OVERALL CONCLUSION, AND THEN OPEN THE Q&A PERIOD.

IN THAT EVENT, IF SOMEONE IN Q&A ASKS FOR A FULLER EXPLANATION OF THE PROTON AND NEUTRON MASS CALCULATION, I WILL PROVIDE THAT AT THE TIME.

THE FIRST PASS ENERGY CALCULATION

The first pass energy calculation, familiar to most any physicist, employs the equation (<u>the 0 signifies turning off the vacuum terms in $\mathfrak{L}$</u>).

$$E = -\iiint \mathfrak{L}_{\text{gauge}} d^3x = \tfrac{1}{2}\operatorname{Tr}\iiint F_{\mu\nu}F^{\mu\nu} d^3x + \mathbf{0}$$

Here, we use a magnetic monopole field strength (with p=$d_R u_G u_B$ and n=$u_R d_G d_B$) reconstituted from the "Maxwell-Dirac equation" via Stokes' theorem:

$$\operatorname{Tr}F^{\mu\nu} = 2\left(\frac{\overline{\psi}_R \sigma^{\mu\nu}\psi_R}{m_R} + \frac{\overline{\psi}_G \sigma^{\mu\nu}\psi_G}{m_G} + \frac{\overline{\psi}_B \sigma^{\mu\nu}\psi_B}{m_B}\right).$$

In a slight variation, however, we prefer to calculate the energy from the "outer product" $E = \tfrac{1}{2}\iiint \operatorname{Tr}F_{\mu\nu}\operatorname{Tr}F^{\mu\nu} d^3x$ because the inner product is simply a special case of the outer product.

We also <u>treat ψ as a Gaussian</u>, which means the quarks are regarded as <u>free</u> fermions. We can do this, because confinement is geometrically mandated, and so the quarks are simply following geometric geodesics in the Einsteinian sense and are not held in place by any "force" in the Newtonian sense. This enables fully-analytical calculations. The resulting binding energies validate this use of Gaussian wavefunctions.

The expression $\mathrm{Tr}F^{\mu\nu}$ in the last slide and other expressions we have shown so far all contain a trace. You should see at least once, what the 3x3 field strength tensor looks like before the trace is taken. It is:

$$F^{\mu\nu} = 2\begin{pmatrix} \dfrac{\overline{\psi}_R \sigma^{\mu\nu} \psi_R}{m_R} & 0 & 0 \\ 0 & \dfrac{\overline{\psi}_G \sigma^{\mu\nu} \psi_G}{m_G} & 0 \\ 0 & 0 & \dfrac{\overline{\psi}_B \sigma^{\mu\nu} \psi_B}{m_B} \end{pmatrix}$$

The trace, then, is clearly:

$$\mathrm{Tr}F^{\mu\nu} = 2\left(\frac{\overline{\psi}_R \sigma^{\mu\nu} \psi_R}{m_R} + \frac{\overline{\psi}_G \sigma^{\mu\nu} \psi_G}{m_G} + \frac{\overline{\psi}_B \sigma^{\mu\nu} \psi_B}{m_B} \right)$$

The Energies we obtain actually involve 3x3x3x3 matrices that originate in the commutators $\left[G_\mu, G_\nu\right]$ and look like this: (The $(2\pi)^{\frac{3}{2}}$ factor is from Gaussian integration over three space dimensions.)

$$E_{P\,AB\,CD} = \tfrac{1}{2}\iiint F_{P\,AB}\cdot F_{P\,CD}\,d^3x = \frac{1}{(2\pi)^{\frac{3}{2}}}\begin{pmatrix} \sqrt{m_d} & 0 & 0 \\ 0 & \sqrt{m_u} & 0 \\ 0 & 0 & \sqrt{m_u} \end{pmatrix} \otimes \begin{pmatrix} \sqrt{m_d} & 0 & 0 \\ 0 & \sqrt{m_u} & 0 \\ 0 & 0 & \sqrt{m_u} \end{pmatrix}$$

– and –

$$E_{N\,AB\,CD} = \tfrac{1}{2}\iiint F_{N\,AB}\cdot F_{N\,CD}\,d^3x = \frac{1}{(2\pi)^{\frac{3}{2}}}\begin{pmatrix} \sqrt{m_u} & 0 & 0 \\ 0 & \sqrt{m_d} & 0 \\ 0 & 0 & \sqrt{m_d} \end{pmatrix} \otimes \begin{pmatrix} \sqrt{m_u} & 0 & 0 \\ 0 & \sqrt{m_d} & 0 \\ 0 & 0 & \sqrt{m_d} \end{pmatrix}$$

These matrices look very similar to matrices that can be used for the <u>Koide relationships</u> involving the charged Leptons. These will eventually help deliver the complete proton and neutron masses.

<u>For step 1</u>, we focus on the <u>predicted difference</u> ΔE between the neutron and proton mass. This turns out to be (the $(2\pi)^{\frac{3}{2}}$ emerges from a Gaussian integration in three space dimensions that is used in the energy calculation):

$$\Delta E = E_N - E_P = 3(m_d - m_u)/(2\pi)^{\frac{3}{2}}$$

Given that $m_d = 4.8^{+.7}_{-.3}\, MeV$ and $m_u = 2.3^{+.7}_{-.5}\, MeV$ **the calculated** ΔE **fits the electron rest mass, using the mean values of the up and down quark mass, to about 3%. This is despite a 20% spread in the down mass and a more than 50% spread in the up mass experimental errors. It also makes sense that a "bare" neutron mass would exceed the "bare" proton mass (vacuum turned off) by the rest mass of the electron which differentiates them. So we <u>postulate</u> that** $m_e \equiv \Delta E$**, that is:**

$$m_e = 0.510998928\, MeV \equiv \Delta E = 3(m_d - m_u)/(2\pi)^{\frac{3}{2}}$$

<u>IF</u> THIS RELATIONSHIP TURNS OUT TO BE VALID, WE NOW KNOW THE <u>DIFFERENCE</u> BETWEEN THE UP AND DOWN MASSES WITH VERY HIGH PRECISION. QUERY: CAN WE NAIL EITHER THE UP OR DOWN MASS WITH SIMILAR PRECISION? YES!

<u>For step 2</u>, we note that the <u>observed</u> deuteron binding energy is:

$$B_{H^2} = 2.224566\, MeV$$

Given that $m_u = 2.3^{+.7}_{-.5}\, MeV$, these two energies are the same, <u>within experimental errors</u>.

So, we introduce the <u>postulate</u> that the up quark mass is either identical with, or very close to, the deuteron binding energy, that is:

$$m_u \equiv B_{H^2} = \mathbf{2.224566\ MeV}$$

(We will explain the physical basis for this postulate momentarily.)

We then use this postulate to <u>deduce the down quark mass with equally high-precision</u> <u>within experimental errors</u> ($m_d = 4.8^{+.7}_{-.3}\, MeV$) by:

$$m_d = \frac{(2\pi)^{\frac{3}{2}}}{3} m_e + m_u = \mathbf{4.907244\ MeV}$$

These postulated up and down masses provide a lot of "rope for hanging," as these empirical masses are more precisely determined over time.

ON WHAT PHYSICAL BASIS DO WE JUSTIFY THE POSTULATE IDENTIFYING THE ^{2}H DEUTERON BINDING ENERGY WITH THE UP QUARK MASS?

I will gloss over this to save time and come back later.

- **We know that nuclear binding energies are <u>discrete</u> numbers, and that each nuclide type has its own discreet binding energy. Something must be responsible for determining those energy numbers. What is that something?**
- **Think about the early Bohr-Sommerfield model of electron orbitals, or fitting wavelengths into a cavity.**
- **The up quark mass is continued twice in a proton (duu) and once in a neutron (udd), and is the smaller of the quark masses.**
- **Perhaps the masses of the quarks themselves, contained inside the proton and neutron, are what determine the energies released when they bind.**
- **The ^{2}H deuteron is the simplest compound nuclide, so its binding energy is the lowest possible energy based on quark masses, namely, the up mass itself.**
- **If this is so, then we can confirm this by showing that other nuclides, such as ^{3}H, ^{3}He and ^{4}He, also have binding energies which are clear functions of the up and down quark masses.**
- **And if this is so, that means that fusion and fission binding energies simply reflect <u>resonant frequencies</u> that originate in and are reflective of the quark masses. These binding energies are "signals" amidst nuclear "noise."**

<u>For step 3</u>, we now can use these masses based on the foregoing <u>postulates</u> to <u>predict</u> the following "outer product" energies for the proton and the neutron (via up and down quark masses):

$$E_{\mathrm{P}} = \left(m_d + 4\sqrt{m_u m_d} + 4m_u\right) / \left(2\pi\right)^{\frac{3}{2}} = 1.715697 \text{ MeV}$$

$$E_{\mathrm{N}} = \left(m_u + 4\sqrt{m_u m_d} + 4m_d\right) / \left(2\pi\right)^{\frac{3}{2}} = 2.226696 \text{ MeV}$$

(Note per earlier that $E_N - E_P = 3\left(m_d - m_u\right) / \left(2\pi\right)^{\frac{3}{2}} = m_e = 0.510998928\, MeV)$ **)**

At first these seem odd, because the observed energies are

E_P=938.272046(21) MeV and E_N=939.565379(21) MeV.

But, let's keep in mind that we have calculated these without considering vacuum energies and without considering perturbation, so we do not expect these numbers to be the same yet. We expect these energies to be "bare" proton and neutron masses. The real question is: what do these numbers actually mean, if anything?

WHAT ARE THESE NUMBERS SAYING TO US?

The real puzzle (and tremendous opportunity) in these numbers is that if we add up only the three quark masses inside of the proton and neutron, we expect to find the “inner product” sum of quark masses:

$$E_{\mathrm{P}} = 2m_u + m_d = 9.356376 \text{ MeV and } E_{\mathrm{N}} = 2m_d + m_u = 12.039054 \text{ MeV}$$

So the real mystery is this: <u>How can we put about 9.36 MeV worth of quarks into a proton and only get out about 1.72 MeV? And how we can put about 12.04 MeV worth of quarks into a proton and only get out about 2.23 MeV?</u>

But we know in atomic binding theory (courtesy of Langmuir and others) that when the energy of the whole is <u>less than</u> the energy of its parts, we are dealing with <u>binding energies</u>.

SO LET'S CALCULATE THE BINDING ENERGIES B:

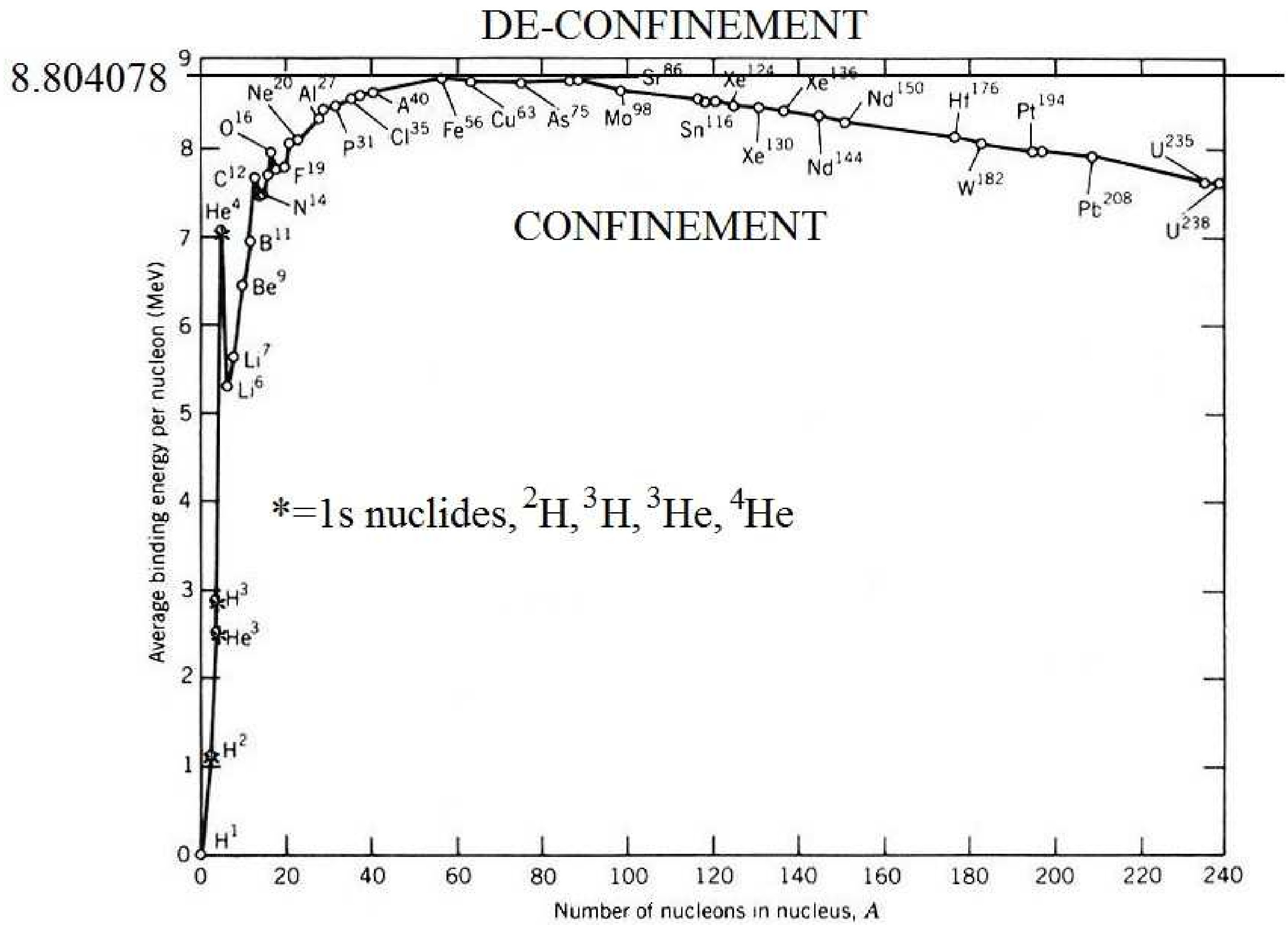
For the proton and neutron respectively, we calculate that these "missing energies" are simply:

$$B_P = 9.356376 \text{ MeV} - 1.715697 \text{ MeV} = 7.640679 \text{ MeV}$$
$$B_N = 12.039054 \text{ MeV} - 2.226696 \text{ MeV} = 9.812358 \text{ MeV}$$

Now, we know that atomic nuclei have roughly the same number of protons and neutrons (which together are called "nucleons"). So for a ballpark estimation, we can say that for a nucleus with an equal number of protons and neutrons, the <u>average</u> binding energy per nucleon (the average of the two numbers above) is 8.726519 MeV

So, what do we actually know about nuclear binding energies observed in nature in the laboratory?

LET'S LOOK AT EMPIRCAL DATA; IT'S ANYWHERE ONLINE, OR IN ANY BOOK ABOUT NUCLEAR PHYSICS



THE EAGLE HAS LANDED!!!

FIRST, LOOK AT IRON-56 (Z=26 PROTONS, N=30 NEUTRONS)

^{56}Fe has a very high per-nucleon binding energy, and is a good case study and something of a "North Star." Using the numbers above, we <u>predict</u> that the ^{56}Fe binding energy is:

$$B\left(\mathrm{Fe}^{56}\right) = 26\times 7.640679\ \mathrm{MeV} + 30\times 9.812358\ \mathrm{MeV} = \mathbf{493.028394\ MeV}$$

$$\mathbf{/56\ Nucleons = 8.804078 MeV / Nucleon}$$

What is its actual, <u>observed, experimental</u> binding energy?

<u>492.253892 MeV</u>! (8.790248 MeV / Nucleon)

So, exactly 99.8429093% of the binding energy *predicted* by this model of nucleons as Yang-Mills magnetic monopoles is <u>used to bind</u> together the ^{56}Fe nucleus, with a small 0.1570907% balance <u>unused</u>. We can calculate similarly for other nuclides also:

CONFINEMENT BY THE NUMBERS: THE 99 PERCENT ISOTOPES

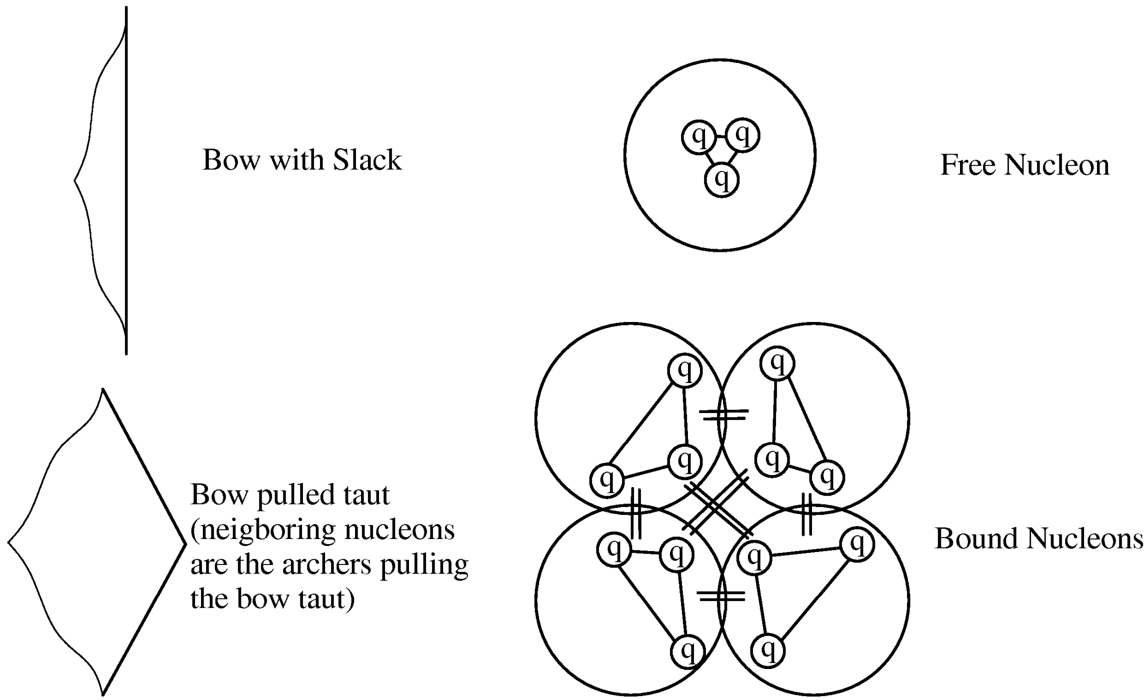
$$\%\ \text{Used} = \text{Experimental Binding Energy} \,/\, \left(Z \times 7.640679\ \text{MeV} + N \times 9.812358\ \text{MeV}\right)$$

Atomic Mass Numbers

N (Neutrons) \ Z (Protons):	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	
		50	51	52	53	54	55	56
26	~~99.213630~~	98.695901	98.660226	97.373740	96.608556	94.998548	93.787438	57
27	**99.107777**	98.882545	98.876859	98.197433	97.594407	96.175619	94.989209	58
28	~~[illegible]~~	**99.387334**	~~99.653418~~	99.123303	99.039692	97.655043	96.626595	59
29	99.220808	99.216274	**99.554050**	99.195979	99.146310	98.216443	97.318495	60
30	99.217298	99.317462	~~[illegible]~~	**99.524080**	~~99.635860~~	98.822929	98.358595	61
31	98.501628	98.817671*	99.416076	*99.290450	**99.485827**	98.891655	98.466836	62
32	98.216088	98.610158	~~99.472554~~	99.427134	~~99.793784~~	99.266439	99.062451	63
33	97.363710	97.991856	98.863981	98.999991	99.427081	99.109647	98.952644	64
34	96.944196	97.615885	98.698444	98.927109	~~99.580555~~	~~99.342859~~	~~99.335053~~	65
35	95.920916	96.903397	97.941521	98.362641	99.054253	[illegible]	**99.026345**	66
36	95.412418	96.341537	97.658944	98.153283	99.043404	99.023538	~~99.256807~~	

Most importantly: None of these exceed 100%. This shows quark confinement! Now, how do we account for the <1% unused balances?

THEORY OF NUCLEAR BINDING AND QUARK CONFINEMENT – FIRST, LET'S HAVE A VISUAL PICTURE OF THIS: SLACK VERSUS TAUT NUCLEAR SEE SAW – THE ARCHER'S BOW



This also explains the "First EMC Effect" which to date has not been explained by QCD, wherein quarks are observed to be less-localized in heavier nuclides versus free nucleons.

- **In general, we envision a nuclear "slack" versus "taut" "see saw" between energies *released* to facilitate nuclear binding and *reserved* to ensure quark confinement. *Confinement bends, but never breaks.***

- **For ^{56}Fe, confinement is maximally bent. For ^{56}Fe, 99.8429093% of the energy available for nuclear binding is released for nuclear binding. But the remaining 0.1570907% does not get released. It is reserved for confining quarks within each nucleon.**

- **At 99.8429093%, Iron-56, utilizes higher percentage of its *available* binding energy than any other nuclide. Confinement never breaks.**

- **Nickel-62 has a higher per-nucleon biding energy than ^{56}Fe, but uses a lower percentage because the neutron carries more binding energy than the proton by a factor of (AMU not MeV, 1 u = 931.494061(21) MeV/c^2):**

$$\frac{B(n)}{B(p)} = \frac{{}^{1}_{0}B}{{}^{1}_{1}B} = \frac{0.01053400062 2\ u}{0.00820260733 2\ u} = 1.28422588032 5$$

- **For heavier nuclides, because neutrons carry an energy *available* for binding about 28.42% larger than that of the proton, neutrons will in general find it easier to bind into heavy nuclei by a factor of 28.42%. Simply put: neutrons bring more available binding energy to the table than protons, so are more welcome at the table. <u>THIS IS WHY STABLE HEAVY NUCLEI ARE NEUTRON RICH</u>, NOT PROTON RICH.**

- **But for the lightest nuclides, the extra binding energy of the neutron is not needed. If we adopt the principle that "Quarks Just Want to be Free," then <u>THIS IS WHY STABLE LIGHT NUCLEI ARE PROTON RICH</u>. Specifically: free protons are stable as opposed to free neutron, and ^{3}He (extra proton) is stable versus ^{3}H.**

- **<u>The alpha particle ^{4}He is a "fulcrum" between proton-rich and neutron-rich</u>. To get energies needed to create shells beyond 1s, nature needs the extra 28.42% binding energy that is provided by a neutron over a proton.**

- **For ^{2}H (deuteron), the lightest composite nuclide, we <u>postulated earlier</u> the up quark mass to be equal to the deuteron binding energy (We later show that they differ by less than 1 ppm). As noted, this is well within experimental errors.**

- **This postulate that $m_u \equiv B_{H^2} = \mathbf{2.224566\ MeV}$ merely states that for this very lightest compound nuclide with one proton and one neutron, <u>the resonant binding energy of the deuteron is simply equal to the up mass, which is the very lightest energy, found twice in the proton and once in the neutron</u>.**

- **This postulate is generalized to a hypothesis wherein we regard nucleons and nuclides as "<u>resonant cavities</u>" which are prone to bind at energies which are directly reflective (functions) of the masses of the up and down quarks they contain.**

- **The foregoing for the deuteron provides preliminary validation of this postulate.**

- **The key question: what determines how much of this <u>available</u> binding energy is actually <u>used</u> for <u>any particular nuclide</u>? (Again, whatever is not used for binding is reserved for quark confinement.)**

- **<u>The new task ahead: can we validate this postulate into a confirmed theory using binding energies of nuclides other than the deuteron?</u>**

THE RESONANT CAVITY POSTULATE WORKS FOR THE DEUTERON, BUT DOES IT WORK FOR OTHER BINDING ENERGIES? YES! (in AMU, 1 u = 931.494061(21) MeV)

Helium-4 (Alpha particle) "Energy Retained for Confinement" (81.06% to bind):

$$
{}_{2}^{4}B_{0\,\text{Predicted}} = 2\cdot\left(2m_u + m_d - \frac{m_d + 4\sqrt{m_u m_d} + 4m_u}{(2\pi)^{\frac{3}{2}}}\right) + 2\cdot\left(2m_d + m_u - \frac{m_u + 4\sqrt{m_u m_d} + 4m_d}{(2\pi)^{\frac{3}{2}}}\right)
$$

$$
-2\sqrt{m_u m_d} = \mathbf{0.030373002032\ u}
$$

$$
{}_{2}^{4}B_{0\,\text{Observed}} = \mathbf{0.030376586499\ u}
$$

Difference: $\mathbf{-\,3.584467\times10^{-6}}\ u$

Helium-3 (Helion) "Energy Released for Binding" (30.76% to bind):

$$
{}_{2}^{3}B_{0\,\text{Predicted}} \cong 2m_u + \sqrt{m_u m_d} = \sqrt{m_\mu}\left(2\sqrt{m_\mu} + \sqrt{m_d}\right) = \mathbf{0.008320783890\ u}
$$

$$
{}_{2}^{3}B_{0\,\text{Observed}} = \mathbf{0.008285602824\ u}
$$

Difference: $\mathbf{3.5181066\times10^{-5}\ u}$

Hydrogen-3 (Triton) "Energy Released for Binding" (31.11% used to bind) (Deduced with "Mass Excess" rather than "Binding Energy" calculation.)

$${}_1^3B_{0\,\mathrm{Predicted}} = 4m_u - 2\sqrt{m_\mu m_d}\,/\left(2\pi\right)^{\frac{3}{2}} = \mathbf{0.009099047078\,u}$$

$${}_1^3B_{0\,\mathrm{Observed}} = \mathbf{0.009105585412\,u}$$

$$\text{Difference:} \quad \mathbf{-6.538334\times 10^{-6}\,u}$$

Hydrogen-2 (Deuteron – Original Postulate) "Energy Released for Binding" (12.75% released to bind)

$${}_1^2B_{0\,\mathrm{Predicted}} = m_u = \mathbf{0.002387339327\,u}$$

$${}_1^2B_{0\,\mathrm{Observed}} = \mathbf{0.002388170100\,u}$$

$$\text{Difference:} \quad \mathbf{-8.30773\times 10^{-7}\,u}$$

In tensor language, the stable alpha is a "diagonal" component of an internal symmetry tensor, and the helion, triton and deuteron are "off-diagonal" tensor components.

“Mass Excess” Results used to derive the Triton Binding Energy (and the Neutron minus Proton mass difference to be momentarily reviewed)

Proton + Proton → Deuteron

$${}^{1}_{1}H + {}^{1}_{1}H \to {}^{2}_{1}H + e^{+} + \nu + \text{Energy:}$$

$$\text{Energy}_{\text{Observed}} = \mathbf{0.000451141003\ u}$$

$$\cong 2\sqrt{m_{\mu} m_{d}} \,/\, (2\pi)^{\frac{3}{2}} = \mathbf{0.000450424092\ u}$$

Difference: $\mathbf{7.16911 \times 10^{-7}\ u}$

Proton + Deuteron → Triton

$${}^{1}_{1}H + {}^{2}_{1}H \to {}^{3}_{1}H + e^{+} + \nu + \text{Energy:}$$

$$\text{Energy}_{\text{Observed}} = \mathbf{0.004780386215\ u}$$

$$\cong 2m_{u} = \mathbf{0.004776340200\ u}$$

Difference: $\mathbf{4.046015 \times 10^{-6}\ u}$

SOLAR FUSION CYCLE (these individual mass terms become nuclear fusion resonances):

$$\text{Energy}\left(4\cdot {}^1_1H+2e^- \rightarrow {}^4_2He+\gamma(12.79MeV)+2\gamma(5.52MeV)+2\gamma(.42MeV)+4\gamma(e)+2\nu\right)$$

$$=\left(2m_u+6m_d-4\sqrt{m_u m_d}-\frac{10m_d+10m_u+16\sqrt{m_u m_d}}{(2\pi)^{\frac{3}{2}}}\right)+2\left(m_u+\sqrt{m_u m_d}\right)+2\left(2\frac{\sqrt{m_\mu m_d}}{(2\pi)^{\frac{3}{2}}}\right)+4\left(m_e\right)+2\left(m_\nu\right)$$

$$=4m_u+6m_d-2\sqrt{m_u m_d}+\frac{2m_d-22m_u-12\sqrt{m_u m_d}}{(2\pi)^{\frac{3}{2}}}=26.733389\,MeV$$

What of some of the Harmonic Resonances we can Use to Catalyze <u>"Sun in a Box" Nuclear Fusion</u>?

$6m_d = 29.44MeV = 6.69F$

$m_u = 2.22MeV = 88.56F$

$2m_u(\text{harmonic}) = 4.45MeV = 44.28F$

$4m_u(\text{harmonic}) = 8.90MeV = 22.14F$

$\sqrt{m_u m_d} = 3.30MeV = 59.62F$

$2\sqrt{m_u m_d}(\text{harmonic}) = 6.61MeV = 29.81F$

$4\sqrt{m_u m_d}(\text{harmonic}) = 13.22MeV = 14.91F$

$2m_d/(2\pi)^{\frac{3}{2}} = 0.62MeV = 316.15F$

$10m_d/(2\pi)^{\frac{3}{2}} = 3.12MeV = 63.23F$

$10m_u/(2\pi)^{\frac{3}{2}} = 1.41MeV = 139.47F$

$22m_u/(2\pi)^{\frac{3}{2}} = 3.10MeV = 63.40F$

$2\sqrt{m_u m_d}/(2\pi)^{\frac{3}{2}} = 0.42MeV = 469.53F$

$4\sqrt{m_u m_d}/(2\pi)^{\frac{3}{2}}(\text{harmonic}) = .84MeV = 234.77F$

$12\sqrt{m_u m_d}/(2\pi)^{\frac{3}{2}}(\text{harmonic}) = 2.52MeV = 78.26F$

$16\sqrt{m_u m_d}/(2\pi)^{\frac{3}{2}}(\text{harmonic}) = 3.36MeV = 58.69F$

<u>Quark Masses</u>: Calibrated to M_N-M_P (<u>Nine Orders of Magnitude More Precise</u> than Current Known Data $m_u = 2.3^{+.7}_{-.5}\ MeV = 0.00247^{+0.00075}_{-0.00054}u$ and $m_d = 4.8^{+.7}_{-.3}\ MeV = 0.00515^{+0.00075}_{-0.00032}$), using the Neutron Minus Proton Mass Difference below. Lots of "rope" for experimental confirmation in the future.

$$m_u = 0.0023873393\ \ 27\ u\ ;\ m_d = 0.0052673125\ \ 26\ u$$

<u>Neutron Minus Proton Mass Difference Found via Mass Excess to 8 PARTS IN 10 MILLION!!! (Very Important Relationship!)</u> (Exact by Postulated Definition, all else <u>Recalibrated</u>.)

$$\boxed{\left[M_N - M_P\right]_{\text{Observed}} = \mathbf{0.001388449188\ u} \equiv m_u - \left(3m_d + 2\sqrt{m_\mu m_d} - 3m_u\right)/\left(2\pi\right)^{\frac{3}{2}} = \left[M_N - M_P\right]_{\text{Predicted}}}$$

PRIORITY PROJECT: Because we now know $M_N - M_P$, we can deduce the Proton and Neutron Masses via an algebraic solution of two equations for two unknowns if we can find a way to ferret out $M_N + M_P$. SO THE NEW MISSION: FIND $M_N + M_P$!!!

PART IV – FINAL ASSAULT ON THE PROTON AND NEUTRON MASSES

"AFTER 43 YEARS…"

THE TARGETS

E_P=938.272046(21) MeV and E_N=939.565379(21) MeV.

THE HYPOTHESIS

The full proton and neutron masses should emerge when we put the heretofore neglected vacuum terms with $v_F = 246.219651\, GeV$ (Fermi vev) **back into the Lagrangian. Because the key commutator is now** $\left[G_\mu, \Phi\right]$ **versus the earlier** $\left[G_\mu, G_\nu\right]$**, quark masses should become square roots of quark masses and the Fermi vev should become the square root of the Fermi vev.**

THE CLUE

$$\sqrt{v_F \cdot \sqrt{m_u m_d}} = 901.835259\,\text{MeV}$$

(versus the earlier term $\sqrt{m_u m_d}$)

<u>In the ballpark to about 3%, but we need the right coefficients to be exact.</u>

Where do we obtain such coefficients? <u>From a Grand Unified Theory (GUT)!</u>

SU(8) GRAND UNIFIED THEORY WITH THREE FERMION GENRATIONS (The answer to Rabi!)

	Linearly Independent Degrees of Freedom						Linear Combinations			
	λ^{63}	$\lambda^{48},\lambda^{35}$	I_L^3	$B-L$	λ'^{8}	λ'^{3}	Y_L	Q	Y_R	I_R^3
ν	$\frac{1}{2\sqrt{28}}\cdot 7$	$\therefore$	$\frac{1}{2}$	–1	0	0	–1	0	0	0
u_R	$-\frac{1}{2\sqrt{28}}$	$\therefore$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{\sqrt{3}}$	0	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{4}{3}$	0
d_G	$-\frac{1}{2\sqrt{28}}$	$\therefore$	$-\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{2\sqrt{3}}$	$\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{2}{3}$	0
d_B	$-\frac{1}{2\sqrt{28}}$	$\therefore$	$-\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{2\sqrt{3}}$	$-\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{2}{3}$	0
e	$-\frac{1}{2\sqrt{28}}$	$\therefore$	$-\frac{1}{2}$	–1	0	0	–1	–1	–2	0
d_R	$-\frac{1}{2\sqrt{28}}$	$\therefore$	$-\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{\sqrt{3}}$	0	$\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{2}{3}$	0
u_G	$-\frac{1}{2\sqrt{28}}$	$\therefore$	$\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{2\sqrt{3}}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{4}{3}$	0
u_B	$-\frac{1}{2\sqrt{28}}$	$\therefore$	$\frac{1}{2}$	$\frac{1}{3}$	$-\frac{1}{2\sqrt{3}}$	$-\frac{1}{2}$	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{4}{3}$	0

Fermions and Generators of SU(8), with Generation Replication, following $SU(8)\rightarrow SU(6)\times SU(2)$ Symmetry Breaking ~10^{15} GeV

FINALLY, AFTER 43 YEARS OF PERSONAL PURSUIT: THE PROTON AND NEUTRON MASSES THEMSELVES!!!

1) The GUT gives us an electroweak vacuum which is (the vacuum for each fermion comes "equipped" with the charge for each fermion):

$$\mathrm{diag}\left(\Phi_F\right)=\mathrm{diag}\left(T^i\varphi_{iF}\right)\equiv v_F\left(0,\left(\tfrac{2}{3},-\tfrac{1}{3},-\tfrac{1}{3}\right),-1,\left(-\tfrac{1}{3},\tfrac{2}{3},\tfrac{2}{3}\right)\right)=v_F\mathrm{diag}Q$$

$$\text{for }\left(\nu,\left(u_R,d_G,d_B\right),e,\left(d_R,u_G,u_B\right)\right),\text{ respectively}$$

2) We use this to form, with mass dimension ½:

$$\left(-\tfrac{1}{3}v_F,\tfrac{2}{3}v_F,\tfrac{2}{3}v_F\right)\rightarrow\left(i^{.5}\sqrt[4]{\tfrac{1}{3}v_F m_d},\sqrt[4]{\tfrac{2}{3}v_F m_u},\sqrt[4]{\tfrac{2}{3}v_F m_u}\right)***$$

and

$$\left(\tfrac{2}{3}v_F,-\tfrac{1}{3}v_F,-\tfrac{1}{3}v_F\right)\rightarrow\left(\sqrt[4]{\tfrac{2}{3}v_F m_u},i^{.5}\sqrt[4]{\tfrac{1}{3}v_F m_d},i^{.5}\sqrt[4]{\tfrac{1}{3}v_F m_d}\right)***$$

for each of the proton and neutron, respectively.

***Footnote: $\sqrt[4]{-1}=i^{.5}=\left(1+i\right)/\sqrt{2}=\exp\left(i\delta\right)$ for $\delta=\pi/4$

3) Note that 2) above is analogous the earlier matrices

$$\text{sqrt}\begin{pmatrix} \sqrt{m_d} & 0 & 0 \\ 0 & \sqrt{m_u} & 0 \\ 0 & 0 & \sqrt{m_u} \end{pmatrix} \textbf{ and } \text{sqrt}\begin{pmatrix} \sqrt{m_u} & 0 & 0 \\ 0 & \sqrt{m_d} & 0 \\ 0 & 0 & \sqrt{m_d} \end{pmatrix}$$

which also have mass dimension ½, but also incorporates the clue

$$\sqrt{v_F \cdot \sqrt{m_u m_d}} = 901.835259 \text{ MeV}$$

4) After some development, we reach the <u>Actual Solution</u>

$$\boxed{M_N + M_P = 3\left(\sqrt{v_F \sqrt{\tfrac{2}{3} m_u \tfrac{1}{3} m_d}} \exp(i\delta) + \cos\theta_1 (m_u + m_d)\right)}$$

When we solve simultaneously with $M_N - M_P$**, the separate masses are**

$$M_N = \tfrac{1}{2}\left(3\left(\sqrt{v_F \sqrt{\tfrac{2}{3} m_u \tfrac{1}{3} m_d}} \exp(i\delta) + \cos\theta_1 (m_u + m_d)\right) + m_u - \left(3m_d + 2\sqrt{m_\mu m_d} - 3m_u\right) / (2\pi)^{\frac{3}{2}}\right)$$

$$M_P = \tfrac{1}{2}\left(3\left(\sqrt{v_F \sqrt{\tfrac{2}{3} m_u \tfrac{1}{3} m_d}} \exp(i\delta) + \cos\theta_1 (m_u + m_d)\right) - m_u + \left(3m_d + 2\sqrt{m_\mu m_d} - 3m_u\right) / (2\pi)^{\frac{3}{2}}\right)$$

***Footnote again: $\sqrt[4]{-1} = \sqrt{i} = (1+i)/\sqrt{2} = \exp(i\delta)$ for $\delta = \pi/4$

5) It is convenient to define "vacuum-enhanced" masses *M_u*, *M_d*

$$\left(M_u \equiv \sqrt{\tfrac{2}{3} v_F m_u} = 604.1751345 MeV; \quad M_d \equiv \sqrt{\tfrac{1}{3} v_F m_d} = 634.5784463 MeV\right)$$

Then we can write the neutron plus proton mass sum as:

$$M_N + M_P = 3\left(\sqrt{M_u M_d}\exp(i\delta) + m_u \cos\theta_1 + m_d \cos\theta_1\right)$$

6) In 4), we have used the empirical masses E_P=938.272046(21) MeV and E_N=939.565379(21) MeV to *deduce*

$$\delta = 0$$

(implies CP conservation – antiprotons and neutrons have the same masses as protons and neutrons, <u>this is what is observed</u>)

– and –

$$\cos\theta_1 = \mathbf{0.9474541242}$$

SO WE NOW HAVE A THEORETICAL FORMULATION FOR THE OBSERVED PROTON AND NEUTRON MASSES. BUT, THESE STILL CONTAIN <u>ONE EMPIRICAL PARAMETER</u>, NAMELY, COS θ_1=0.9474541242.

CAN WE RELATE COS θ_1 TO QUARK MIXING ANGLES?
The experimental data (Particle Data Group) says that:

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 0.97427 \pm 0.00015 & 0.22534 \pm 0.00065 & 0.00351^{+0.00015}_{-0.00014} \\ -0.22520 \pm 0.00065 & 0.97344 \pm 0.00016 & 0.0412^{+0.0011}_{-0.0005} \\ -0.00867^{+0.00029}_{-0.00031} & -0.0404^{+0.0011}_{-0.0005} & 0.999146^{+0.000021}_{-0.000046} \end{pmatrix}$$

The "major determinant" is:

$$|V|_+ = V_{ud}V_{cs}V_{tb} + V_{us}V_{cb}V_{td} + V_{ub}V_{cd}V_{ts} = \mathbf{0.947535^{+0.000400}_{-0.000262}}$$

So <u>within experimental, errors</u>

$$|V|_+ = \cos\theta_{1\,-0.000262}^{\;\,+0.000400} = \mathbf{0.947454^{+0.000400}_{-0.000262}}$$

This means that the proton and neutron masses are a <u>purely theoretical function only of known physics parameters</u>, with *nothing new* introduced!

THE PROBLEM I'VE PURSUED FOR 43 YEARS IS SOLVED!

Bonus: we derive a "Master Mass and Mixing Matrix." (A new "toy" for nuclear and particle physicists to play with.)

$$\Theta = 27\begin{pmatrix} \begin{matrix} -m_u\sqrt{m_s m_c}\sqrt{m_b m_t}\,\mathrm{c}_1\,\mathrm{s}_2\,\mathrm{s}_3 \\ +\sqrt{M_u M_d}\,m_s m_b\,\mathrm{c}_2\,\mathrm{c}_3\,\mathrm{e}^{i\delta} \end{matrix} & \begin{matrix} m_u\sqrt{m_s m_c}\,m_t\,\mathrm{c}_1\,\mathrm{s}_2\,\mathrm{c}_3 \\ +\sqrt{M_u M_d}\,m_s\sqrt{m_b m_t}\,\mathrm{c}_2\,\mathrm{s}_3\,\mathrm{e}^{i\delta} \end{matrix} & \sqrt{m_u m_d}\sqrt{m_s m_c}\sqrt{M_t M_b}\,\mathrm{s}_1\,\mathrm{s}_2 \\ \begin{matrix} -m_u m_c\sqrt{m_b m_t}\,\mathrm{c}_1\,\mathrm{c}_2\,\mathrm{s}_3 \\ -\sqrt{M_u M_d}\sqrt{m_s m_c}\,m_b\,\mathrm{s}_2\,\mathrm{c}_3\,\mathrm{e}^{i\delta} \end{matrix} & \begin{matrix} m_u m_c m_t\,\mathrm{c}_1\,\mathrm{c}_2\,\mathrm{c}_3 \\ -\sqrt{M_u M_d}\sqrt{m_s m_c}\sqrt{m_b m_t}\,\mathrm{s}_2\,\mathrm{s}_3\,\mathrm{e}^{i\delta} \end{matrix} & \sqrt{m_u m_d}\,m_c\sqrt{M_t M_b}\,\mathrm{s}_1\,\mathrm{c}_2 \\ \sqrt{m_u m_d}\sqrt{M_c M_s}\sqrt{m_b m_t}\,\mathrm{s}_1\,\mathrm{s}_3 & -\sqrt{m_u m_d}\sqrt{M_c M_s}\,m_t\,\mathrm{s}_1\,\mathrm{c}_3 & m_d\sqrt{M_c M_s}\sqrt{M_t M_b}\,\mathrm{c}_1 \end{pmatrix}$$

The vacuum-enhanced masses $M_{u,c,t} \equiv \sqrt{\tfrac{2}{3} v_F m_{u,c,t}}; \quad M_{d,s,b} \equiv \sqrt{\tfrac{1}{3} v_F m_{d,s,b}}$ **.**

In the circumstance where $s_2 = 0$**,** $s_3 = 0$**, and all of the second and third generation masses are set to 1, this becomes:**

$$\Theta = 27\begin{pmatrix} \sqrt{M_u M_d}\,\mathrm{e}^{i\delta} & 0 & 0 \\ 0 & m_u\cos\theta_1 & \sqrt{m_u m_d}\sin\theta_1 \\ 0 & -\sqrt{m_u m_d}\sin\theta_1 & m_d\cos\theta_1 \end{pmatrix};\ \text{i.e.:}$$

$$\tfrac{1}{9}\mathrm{Tr}\Theta = 3\left(\sqrt{M_u M_d}\exp(i\delta) + m_u\cos\theta_1 + m_d\cos\theta_1\right) = M_N + M_P$$

Consequently, one expects we can use Θ **to gain substantial new insights into fermion and baryon masses generally, e.g.,** $\Lambda_0(uds) = 1115.683 MeV$ **and** $\Omega_-(sss) = 1672.45 MeV$ **.**

CONCLUSION

- **Magnetic Monopoles – pursued since the time of Maxwell – do exist, hiding in plain sight, wherever matter exists. Proton and Neutrons are indeed the Magnetic Monopoles of <u>non-commuting</u> gauge fields.**

- **Fusion and Fission Energies directly reflect the masses of the up and down quarks contained with these magnetic monopoles. They are "signals" about internal workings of the protons and neutrons.**

- **If we wish to <u>catalyze fusion energy release</u>, <u>perhaps</u> we can do so by <u>bathing hydrogen in ultra-high-frequency gamma radiation</u> at the frequencies that are found in the solar fusion cycle. (I don't own a fusion lab, I will need help to test this through to practice. I have filed a patent pending for this <u>resonant-assisted nuclear fusion</u>.)**

- **Quarks are confined in <u>non-commuting</u> gauge theories for the exact same theoretical reasons that magnetic monopoles do not exist at all in Maxwell's (commuting field electrodynamics), because of the geometric identity dd=0 based on the first Bianchi identity.**

- **Because nucleons are now understood to be magnetic monopoles, this also means that atoms themselves comprise core *magnetic* charges (nucleons) paired with orbital *electric* charges (electrons and elusive neutrinos), with <u>the periodic table itself thereby revealing an electric/magnetic symmetry of Maxwell's equations</u> which has often been pondered, but has heretofore gone unrecognized in the 140 years since Maxwell first published his Treatise on Electricity and Magnetism.**

- **We have now solved at least 2/3 of the "Yang-Mills Mass Gap Problem" by fully explaining confinement and validating this with empirical nuclear data, and by deriving the appropriate short range for nuclear interactions. (The chiral characteristics of vector and axial mesons are also embedded in the "Maxwell-Dirac equation.")**

- **Nuclear physics appears to be governed by simply <u>combining Maxwell's two classical equations into one equation</u> (the "Maxwell-Dirac equation") using non-commuting gauge fields in view of Dirac theory and Fermi-Dirac Exclusion for fermions.**

- **Finally, if unifying Maxwell's two equations, with sources, into one equation, is equivalent to the "gravitational equations for empty space," (per A. Einstein's comment about "strength of equations") then while the <u>electrodynamic</u> formulation of this $z_1 = 12$ combination is the "Maxwell-Dirac equation":**

$$\operatorname{Tr} P^{\sigma\mu\nu} = \mathbf{0} + 2\left(\partial^\sigma \frac{\overline{\psi}_R \sigma^{\mu\nu} \psi_R}{m_R} + \partial^\mu \frac{\overline{\psi}_G \sigma^{\nu\sigma} \psi_G}{m_G} + \partial^\nu \frac{\overline{\psi}_B \sigma^{\sigma\mu} \psi_B}{m_B} \right)$$

the equivalent <u>gravitational</u> formulation of this $z_1 = 12$ combination is simply the Einstein equation *in vacuo*:

$$R_{\mu\nu} = 0 \quad .$$

Consequently, nuclear physics and the QCD theory of quarks emerge as the natural unification of classical electrodynamics and pure gravitational geometry.

THANK YOU!

IF YOU WOULD LIKE TO COMMMUNICATE FURTHER OR RECEIVE A COPY OF THIS PRESENTATION, PLEASE CONTACT ME AT:

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