Nucleons

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The nucleons with their components and force fields are a greater challenge for quantum mechanics than the hydrogen atom that had provided deep cover to hide the defects both in quantum mechanics and relativity (Wallace and Wallace, 2024c). Once a correction to special relativity was made allowing γ to take on values less than one the hydrogen ground state could be accurately computed providing a method to deal with the nucleons. A result was to discover why the neutron and proton are stable and have similar masses.[a]

CONTENTS

I. THE DATA

Low energy nucleon properties reveal the character of the proton's and neutron's internal structure. The proton shows no electric dipole moment or induced dipole moment in very tight limits (Harrison *et al.*, 1969). The proton's spherically symmetric charge distribution is not easily perturbed implying that the proton's components maintain spherical symmetry as an intrinsic property. This basic symmetry supports the great stability of a structure of both the electrostatic field and a strong force.

The mass corrected magnetic moment of the proton compared to the electron gives a rough measure of the charge distribution's scale verses its compact core establishing its mass. The proton's charge distribution is relatively broad as compared to its more compact core. The proton's first excitation is a pion shedding the excess energy from a collision so that the proton itself remains stable. The pion's self-energy maybe close to the effective binding energy of the proton's components. Unlike the electron in electron-electron scattering there are no basic excitation of the electron, it will only shed particle and anti-particle pairs indicating no substructure to replicate. The proton's magnetic moment and the pion production indicate the proton is constructed of more basic components restricted to spherical symmetry.

The next two properties by themselves tells us little other than the weak transition preserves the long range electrostatic field. Why the mass of the proton and neutron are close in value has to be discovered?

- No Electric Dipole Moment for Proton and Neutron
- Proton verses Electron Magnetic Moment
- π Pion Mass
- Mass of the Proton and Neutron similar
- Weak Transition Preserves Long Range Fields

A consistent description of the above properties is not provided for by the Standard Model of particle physics that does not take into account that the γ of special relativity can take on values less than one when binding occurs either in an atom, or nucleus, or within a nucleon (Wallace and Wallace, 2024a).

II. THE TOOLS

Relativistic conservation of energy provides a tool to attack the problem of proton stability and neutron instability. When relativistic energy conservation is dealt with

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[a] https://vixra.org/pdf/2506.0155v1.pdf
https://www.castinganalysis.com/files/nucleons.pdf

Table I **The pion appears to represent excitation energy of the proton that cannot be contained and exceeds the energy binding the components.**

Bound Particle	Rest Mass in γ	comment
Electron bound	.9997339	atomic hydrogen
Nuclear binding	.9915	maximum
Electron bound	.88197	$Z \to \infty$
first Proton excitation	.874	pion mass added

properly it provides the mechanism to generate a private space for individual particles/fields. These private spaces are called self-reference frames that are statistically independent from the laboratory frame. This statistical independence comes with a price of lost volume in the laboratory frame that is the basis of gravity (Wallace and Wallace, 2024a).

The field solutions in the self-reference frame in three dimensions yield valid solutions for the elementary massive boson and fermion, see the Appendix for the spatial differential wave equation in the self-reference and its solutions. These solutions generate the four elementary particles and fields: electron/positron, photon, electron neutrino, and the $W^{\pm}Z^{o}$. The 8 lower dimensional components solutions along with their anti-particles are used to assemble the rest of the baryons, leptons, and mesons. These lower dimensional components can assemble only if they have a natural attraction to produce the remaining baryons, mesons, and leptons. This turns out to be a simple computation.

The notion that gauge bosons are required for binding will be shown to be unnecessary (Wallace and Wallace, 2025). Only contact interactions between individual particles and fields are required for binding. The fractional quantization of charge were found associated with the massive fermion components for the nucleons in lower dimensions (Wallace and Wallace, 2014). Conversely the electrostatic field in the nucleons is generated by the lower dimensional boson components, whereas the electron with its massive fermion field generates its negative charge distribution. This may seem contradictory except that these one and two dimensional components are not associated with a spin as that is a property of the entire nucleon in three dimensions in the laboratory frame. The self-reference frame allows some major flexibility in the components' associated properties.

III. WEAK HISTORY

Quantum mechanics' written history is one with a few solutions that are almost perfect. The early pioneers knew of problems with the subject, but failed in their repairs (Dirac, 1932) (Gamow, 1966) (Pais, 1986). Quantum mechanics suffered from a number of mathematical difficulties imposed on it by theorists: use of the continuum, validating singularities (Taylor, 2000), dealing with symmetries as starting point not an end point, using the Klein-Gordon equation as a model, and restricting analysis to a simple all encompassing vector space. This collections of mistakes ensured the Standard Model of high energy physics would be misleading (Weinberg, 1995).

The concept of the quark with a fractional charge tied to lower dimensional spaces was not a problem. What was a problem was attaching spin and color with bonding gluons making the quarks dynamically independent entities. The quarks were treated as individual fermions obeying Fermi-Dirac statistics. This was an over reach because the lower dimensional entities were not occupying the same spaces and did not require an additional set of quantum number so as not to violate Fermi-Dirac statistics. Assigning spin to quarks was a major flaw as spin only appears in the laboratory frame for entire entities not for components (Wallace and Wallace, 2019). Fermi-Dirac statistics do not apply to the individual lower dimensional components.

The method of working backwards from decay product as is the practice with the Standard Model has a fault. Many more decay channel are available when relativity is incorporated into the free particle laboratory frame wave equation. Unlike, the application of the Schrödinger or Dirac equation for scattering events where only a single channel is considered (Wallace and Wallace, 2025).

Fractional charge quantization was derived from the massive fermion wave function, $\mathbf{u}_f(r, \theta, t; \kappa, \gamma, n)$ that was dependent only on the dimension, n (Wallace and Wallace, 2014). However, the nucleon fields that generate the electrostatic field are the massless and massive boson solutions in one and two dimensions. The question is why should the charge quantization computed for the massive fermion components be valid for a collection of boson components? These lower dimensional components are not yet independent bosons or fermions. That only occurs for entire entities in the laboratory frame where spin is realized as a stabilizing force.

The massless boson collection produces the $1/r^2$ electrostatic field represented by the lower case solutions, $u_b(r, \kappa, n, \gamma)$ and the massive boson collection produces the charge density when Gauss's law is applied. The key finding was the neutron's charge distribution that is both positive and negative and cancels to zero, while being independent of any scale variations between components. The invariant net zero charge is required so the neutron can bind as its scale increases and its mass is reduced.

$$Neutron\ \mathbf{E}-field\ =\ \{u_b(r,\kappa_b,1,\gamma)u_b^*(r,\kappa_b,1,\gamma)\}^2\times$$
$$u_b(r,\kappa_b,2,\gamma)u_b^*(r,\kappa_b,2,\gamma)/r\ \sim\ \frac{1}{r^2}$$

$$Proton\ \mathbf{E}-field\ =\ u_b(r,\kappa_b,1,\gamma)u_b^*(r,\kappa_b,1,\gamma)\times$$
$$\{u_b(r,\kappa_b,2,\gamma)u_b^*(r,\kappa_b,2,\gamma)\}^2\ \sim\ \frac{1}{r^2} \quad (1)$$

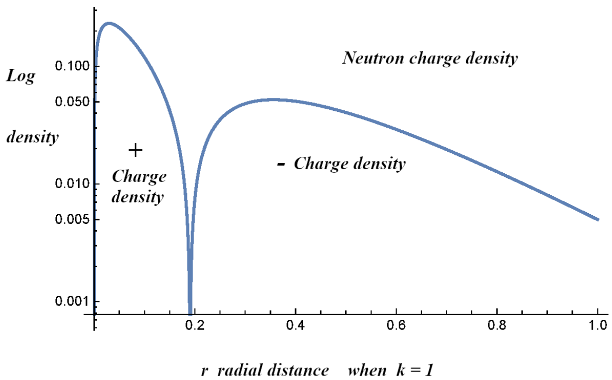

Figure 1 **Neutron charge density is computed from the divergence of the product of two one dimensional and a single two dimensional massive boson solution times their complex conjugates of equation 14.**

Where (r, θ) are the coordinates of $\mathbf{u}_f(r, \theta, t; \kappa, n, \gamma)$ on the complex plane and the detailed functions are found in the appendix. The quantization of charge $\pm\frac{1}{3}$ for dimension 1, $\pm\frac{2}{3}$ for dimension 2, and ± 1 in three dimensions was independent both of mass through the inverse scale, κ, and γ of special relativity (Wallace and Wallace, 2014). An energy change from an interaction appears as a change in γ with the particle's transverse response reflected in the rotation of angular structure on the complex plane of the particle, $\delta\theta$. The wave function, $\mathbf{u}_f(r, \theta, t; \kappa, n, \gamma)$, allows the $\partial\gamma/\partial\theta$ to be computed that is proportional to charge that is only dependent on the dimension and independent of mass (Wallace and Wallace, 2014).

A defect in the standard model was the lack of a mechanism to generate the electrostatic field. Fractional charges by themselves require that they be stably combined so no dipole momement exists or can be induced. These lower dimensional components, fermion and boson types, together generate the electrostatic fields of both the proton and neutron with a single center of spherical symmetry.

These field density solutions are not point entities as used by the Standard Model (Taylor, 2000). There are 8 lower dimensional components, half are massive and the other half massless. The lower dimensional components are not lines and surfaces rather density functions that are defined in a lower dimensional space and only when they combine are they realized as three dimensional entities. It is the details of their combinations that generate the baryons, leptons, and mesons (Wallace and Wallace, 2017).

IV. BINDING

The role special relativity plays in bound structures can be exploited to define how lower dimensional components bind to form the two principal nucleons without shuttling colored gauge bosons. For the hydrogen ground state the $|\gamma|$ of special relativity takes on a value less than one. The closed form solution of binding that satisfies relativistic conservation of energy for the ground state of the hydrogen atom requires no corrections from quantum electrodynamics if relativity is properly treated (Wallace and Wallace, 2024b). The electron gives up some self-energy, mass, to bind. The loss of mass is more obvious for nucleon binding. From the Compton relationship the scale of the individual particles, $\langle r\rangle$ increases when bound because of the loss of mass. The only requirement for binding of two or more components is that the scale increase with decreasing γ when the components overlap with the same center of symmetry. This means the components are attracting each other. It is not difficult to compute the scale where $H(r)$ is the wave function of the combined components integrated over the volume to generate the mean scale $\langle r\rangle$ that is inversely proportional to mass, see equation 2.

$$\langle r\rangle(\gamma, n, m) \ = \frac{\int H^*\ r\ U dv}{\int H^*\ H dv} \quad (2)$$

An example of two different components with dimensions, n and m, $H(r)$ is constructed as a product of these lower dimensional components with their own Jacobian scale and takes a form found in equation 3.

$$\langle r\rangle(\gamma, n, m) \ = \frac{\int u^*(r,n)u^*(r,m)r^{n+m-1}u(r,n)u(r,m)dr}{\int u^*(r,\gamma,n)u^*(r,m)r^{n+m-2}u(r,n)u(r,m)dr} \quad (3)$$

$$\begin{array}{lccc} \textbf{Binding}\ (stable) & \langle r\rangle_{|\gamma|<1} & > & \langle r\rangle_{|\gamma|=1} \\ \textbf{No Binding}\ (unstable) & \langle r\rangle_{|\gamma|<1} & < & \langle r\rangle_{|\gamma|=1} \end{array} \quad (4)$$

Only the spatial part of the wave functions will be used as the time dependent products produces a constant factor of 1 in the computation. The relative scales of the individual components will play a major part in determining which combinations will form stable structures. In the self-reference frame where these lower dimensional components are organized there are no individual dynamical contributions as found in the laboratory frame for whole three dimensional entities.

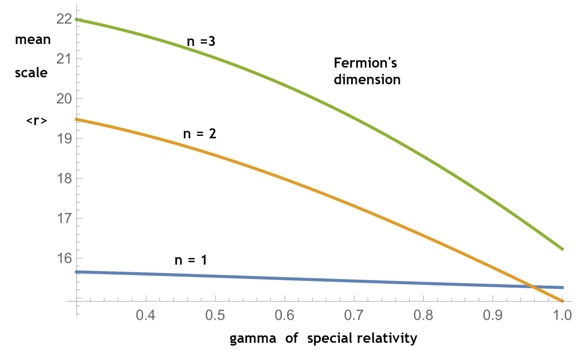

Figure 2 **As the mean scale $\langle r\rangle$ increases the particle loses mass and the energy is used in bind to another particle, using equation 2.**

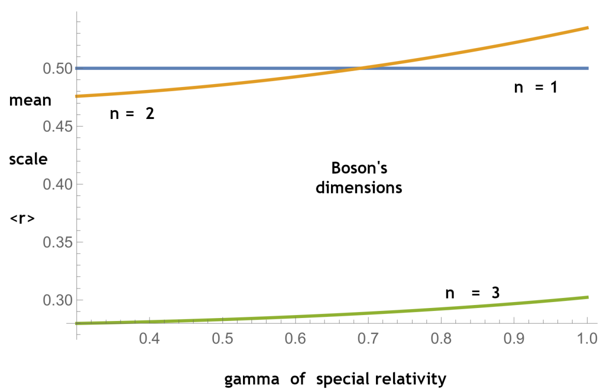

Figure 3 **The 3D boson, $W^{\pm}Z^{o}$, shows no scale increase with decreasing γ and therefore cannot be found in a bound structure because it will supply no energy to the bond.**

1. Limits to Binding

Limits to binding of electrons in atoms or between nucleons have not been a fundamental concern because the binding is relatively weak. However, the components that assemble to form the proton and neutron seem to be bound together with great strength. It was found that for a single electron ion bound to a nucleus whose atomic number is allowed to go to infinity there is a finite limit to the binding strength. This is a limit on the bond energy that can be extracted from the particle's self-energy. For a single electron ion when the nuclear charge Z is allowed to go to infinity, the binding is not infinite as the electron can only sacrifice 11.8% or a $\gamma = .892$ of its self-energy to the bond. This is a strong limit that keeps the binding process from destroying the electron. Even though the strong force potentials are not $1/r$ the nuclear components are also limited in the self-energy they can surrender to the binding process. We are guessing this limit for the nucleons is close to this 11.8% limit. There is experimental data to back this up, in that the mass of the first excitation, the neutral pion. falls close to this limit, see Table I. The proton dwelling at the maximum limit of binding eliminates the question of more stable states, all other states are considered suspect or unstable. This condition also limits the number of stable baryons.

A hint of the scaling behavior comes from the binding range required for the proton and neutron to be stable. This requirement is that the boson components scale to be greater than the massive fermion components. This produces a nucleon with a compact fermion core and a broader boson cloud. This is not analogous to atomic structure as these components are all density distributions sharing the same center of symmetry. From the disparity between the proton charge radius scale $\sim .87fm$ which is much larger than the scale of the nucleon from the Compton mass $a = \hbar/mc$ of $.21fm$ this is a ratio ~ 4. This implies that boson components are the generators of the electrostatic field and the fermion components are main the source of the nucleon's inertia. The massive boson components produce a net positive electrostatic charge for the proton and a net zero charge for the neutron where that neutrality is maintained independent of relative scale changes among the components (Wallace and Wallace, 2020). With the source for the electrostatic fields for the proton and neutron generated by the boson components the fermion composite core will be the source of the strong force.

The binding of the 1D and 2D components occurs naturally for the massive boson and fermion components if the scale of the boson components, $1/\kappa_b$, that produce the electrostatic field is greater than the scale of the fermion components, $1/\kappa_f$, in the case of the proton. In the case of a collision if the proton's charge field is compressed it becomes unstable and produces a pion. The neutron does not have this particular instability. This is a natural bonding process where the components bind without gluons and share the same center of symmetry to make up a whole baryon maintaining a zero dipole moment. The massless fermions generate the neutrinos (Wallace and Wallace, 2020). **CC** is the complex conjugated of the previous state function. To generate the anti-particle γ takes on negative values (Wallace and Wallace, 2024a).

$$\begin{aligned} Raw\ \ Field &= \Pi_i u_i(r,\kappa_i,n_i,\gamma) \times \mathbf{CC} \\ Density &= \Pi_i u_i(r,\kappa_i,n_i,\gamma) \times \mathbf{CC}\ \ r^{n_i-1} \\ Field\ in\ 3D &= \frac{\Pi_i u_i(r,\kappa_i,n_i,\gamma) \times \mathbf{CC}\ \ r^{n_i-1}}{r^2} \end{aligned} \tag{5}$$

Table II **Binding Combinations. Abbreviations: mF-massive fermion, mB-massive boson, mlB-massless bosons, and mlF-massless fermion components. Computed at $\gamma = 1$ and $\kappa = 1$. As the ratio of κ are changed so will the propensity to bind. The $\bar{1}22$ combination representing the proton only binds when the scale of the boson components is increased relative to the scale of the massive fermion components. The mF-mB-mlF combination represents the μ and τ leptons, and the mlF will generate the three neutrinos. (Wallace and Wallace, 2020)**

Dim of Components	m**F**	m**B**	m**F** m**B**	m**F** m**B** ml**B**	**Note**
$3D$	Y	N	-	-	e^-, WZ
$2D$	Y	N	-	-	
$1D$	N	-	-	-	
Combination	-	-	-	-	
$1D\bar{1}D$	Y	-			mesons
$2D\bar{2}D$	Y	N			mesons
$1D2D$	Y	N			mesons
$1D1D\bar{2}D$	Y	N	Y	Y	neutron
$\bar{1}D2D2D$	Y	N	N	Y $\frac{\kappa_b}{\kappa_f} < .75$	proton

A short hand expression for the product boson collection $H_{b11\bar{2}}(r, \kappa_b, \gamma)$ & $H_{b\bar{1}22}(r, \kappa_b, \gamma)$ and the fermion collection $H_{f11\bar{2}}(r, \kappa_f, \gamma)$ & $H_{f\bar{1}22}(r, \kappa_f, \gamma)$. These then go into equation 2 with the correct dimensional powers to compute the propensity to bind. The massive components are in bold face and the subscript defines the dimensions of the collection. There are no massless fermion components for the baryons. The massless fermion components replace the massive fermion components for the leptons allowing the weak interaction with neutrino decay products that are massless fermions.

$$\begin{aligned} H_{b11\bar{2}}(r, \kappa_b, \gamma) &= \{\mathbf{u}_b(r, \kappa_b, 1, \gamma) \times \mathbf{CC}\}^2 \times \\ &\quad \mathbf{u}_b(r, \kappa_b, 2, \gamma) \times \mathbf{CC} \times \\ &\quad \{u_b(r, \kappa_b, 1) \times CC\}^2 u_b(r, \kappa_b, 2) \times CC \end{aligned} \tag{6}$$

$$\begin{aligned} H_{f11\bar{2}}(r, \kappa_f, \gamma) &= \{\mathbf{u}_f(r, \kappa_f, 1, \gamma) \times \mathbf{CC}\}^2 \times \\ &\quad \mathbf{u}_f(r, \kappa_f, 2, \gamma) \times \mathbf{CC} \end{aligned} \tag{7}$$

$$\begin{aligned} H_{b\bar{1}22}(r, \kappa_b, \gamma) &= \mathbf{u}_b(r, \kappa_b, 1, \gamma) \times \mathbf{CC} \times \\ &\quad \{\mathbf{u}_b(r, \kappa_b, 2, \gamma) \times \mathbf{CC}\}^2 \times \\ &\quad u_b(r, \kappa_b, 1) \times CC\{u_b(r, \kappa_b, 2) \times CC\}^2 \end{aligned} \tag{8}$$

$$\begin{aligned} H_{f\bar{1}22}(r, \kappa_f, \gamma) &= \mathbf{u}_f(r, \kappa_f, 1, \gamma) \times \mathbf{CC} \times \\ &\quad \{\mathbf{u}_f(r, \kappa_f, 2, \gamma) \times \mathbf{CC}\}^2 \end{aligned} \tag{9}$$

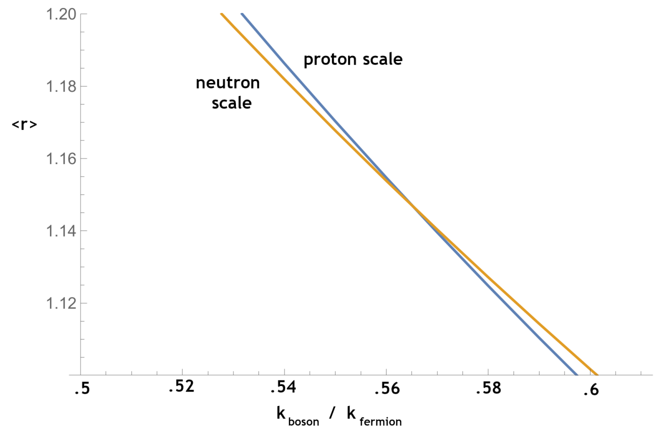

Figure 4 **Equation 10 is used to compute $\langle r \rangle$. The proton will not bind its components until the ratio $\kappa_{boson}/\kappa_{fermion} < .75$. There is no such restriction on the neutron. However, this graph is computed for a $\gamma = .88$ and only with a ratio of $\kappa_{boson}/\kappa_{fermion} < .565$ is the neutron mass greater than the proton mass. Notice how the scales closely track each other for the neutron and proton, that implies their masses will be close in value.**

For the neutron and proton the mean scale, $\langle r \rangle$ is computed as:

$$\begin{aligned} \langle r \rangle_{neu}(\gamma, \kappa_b/\kappa_f) &= \frac{\int H_{b11\bar{2}} H_{f11\bar{2}}\ r^3\ dr}{\int H_{b11\bar{2}} H_{f11\bar{2}}\ r^2\ dr} \\ \langle r \rangle_{pro}(\gamma, \kappa_b/\kappa_f) &= \frac{\int H_{b\bar{1}22} H_{f\bar{1}22}\ r^5\ dr}{\int H_{b\bar{1}22} H_{f\bar{1}22}\ r^4\ dr} \end{aligned} \tag{10}$$

The relative strength of binding is shown in Table I for the proposed neutron and proton structure. Figure 4 reveals that in order to bind the charge distribution must have greater scale than computed from the mass by the Compton relation *scale* $\sim \hbar/mc$. The static **E**-field is produced by the boson components and this gives the proton and the neutron a structure with an external charge distribution that contributes less to its mass and than the fermion core. It is the remaining massive fermion components that are compact and generate the strong force field.

V. FORCES

In the composite nucleon structure there are three sets of components. The massless boson components combine

Table III **Force sources made up from nucleon composite component assemblies in the nucleons.**

massive & massless	electrostatic	source
boson components scale $\sim .8\ fm$	neutron dim 1, 1,& 2 proton dim 1, 2, & 2	positive core outer charge is negative positive cloud

massive	strong force	range
fermion components scale $\sim .2\ fm$	neutron dim 1, 1, & 2 proton dim 1, 2, & 2	larger long range smaller short range

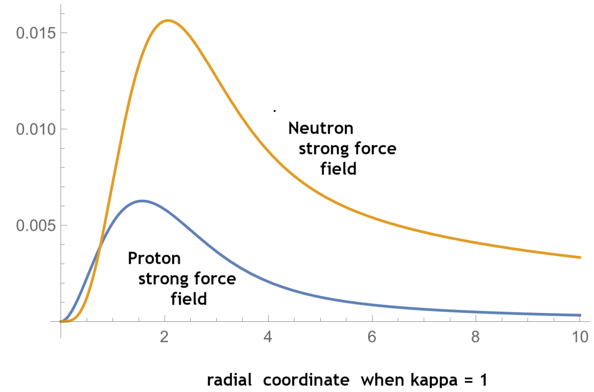

Figure 5 $\gamma = .88$, **where the product in equation 11 are over the relevant massive fermion components in one and two dimensions for the neutron** $n = 1, 1, 2$ **and proton** $n = 1, 2, 2$**. However, the sign of the field is not determined by equation 3, as the same result is produced for both the particle and anti-particle. The fields for the particle and anti-particle must have opposite signs and they are attractive. From the fact that neither proton-proton or neutron-neutron pairs are commonly found it is expected the the proton and neutron fields have an opposite sign and are attractive to each other reducing their energy.**

to establish the $1/r^2$ electrostatic field. The massive boson components define the charge density distribution via Gauss's law. Finally, the massive fermion components are used to generate the strong force field and supply the bulk of the inertial mass with its compact form. In the self-reference frame where the composite components bind and Fermi-Dirac statistics do not yet apply the boson components acquire properties of the fermion components seen in the three dimensions. In three dimensions the massive fermion solution in the self-reference frame generates both the electrostatic field and the charge density distribution for the electron and positron. That is not the case for the nucleons where the boson components, all six, are used to generate the electrostatic field and the charge distributions for the neutrons and protons. They capture the fermion's component charge quantization in order to perform this trick (Wallace and Wallace, 2014). The nucleon's fermion components then generate the strong force field.

The normalize strong force fields computed from the core fermion components are asymmetrical between the the strength of the proton and neutron fields. The neutron field is more intense and longer range as compared to the protons field as shown in Figure 6. This is consistent with having more neutrons than protons in the heavier nuclei.

$$Strong\ Force\ Field \ = \frac{\Pi_i \mathbf{u}_i^* \mathbf{u}_i^* r^{n_i - 1} \mathbf{u}_i \mathbf{u}_i}{\int \Pi_i \mathbf{u}_i^* \mathbf{u}_i^* r^{n_i - 1} \mathbf{u}_i \mathbf{u}_i dr} \qquad (11)$$

VI. NEUTRON AND PROTON MASSES

The binding computations allows testing the value of the small difference in nucleon masses. At a ratio of $\sim .2$ of the size of the massive components to the massless boson component which generates the electric field, gives the ratio of the electrostatic particle radius to the more massive components that generate the strong force. Using the electromagnetic radius of the proton as .78 femto meters with the core of the massive fermion components as .156 femto meters that produces a Compton mass $\hbar/c\langle r\rangle$ of $\sim 2 \times 10^{-27} kg$ or MeV is close to the measured mass of the proton and neutron.

The masses of the proton and neutron are in a large part determined by the strength of the binding of their low dimensional components. Its possible to get an estimate of this binding strength from the first excitation exhibited by the nucleons. For the proton that is the creation of a neutral pion, π^o, with a mass of 139 MeV, this is equivalent of a γ for the proton's components to bind of $\sim .86$. This value for γ is not far from the limiting value found for the electrostatic potential as $Z \to \infty$ of .88 (Wallace and Wallace, 2024b).

The other extreme limit is when a nucleon in driven into another nucleon and they are sitting on top of each other. The binding computation in all three cases, proton-proton, neutron-neutron, and proton-neutron can be done by using an expanded version of equation 2. Only in the case of the proton-proton is the computation non-divergent but it is also non-binding. This maybe the reason that proton-proton scattering produces such a rich array of products and jets. In the other two cases $\langle r \rangle$ is divergent and cannot be computed. In the case of the proton-neutron being collocated in a scattering experiment results in the short-range correlation explosion (Arrington *et al.*, 2011). In other words the initial components come out whole. As for the case of neutron-neutron incompatibility the stability of neutron stars is the main result. Component binding rarely shows a stable structure. None of the two component binding sets containing six total components produces a stable particle, rather they are used in describing mesons.

Having a dense massive core and larger distribution of charge makes understanding charged scattering interactions possible. The geometry of the self-reference frame restricts deformations always retaining its spherical symmetry. When the charge radius is reduced in a collision the proton can be driven into an unstable region where $\kappa_b/\kappa_f > .75$. The result for a threshold electron-proton scattering is the generation of a neutral pion that replicate components in the proton.

A. Deuterium Binding and Fusion

The simplest example of the strong force is found in deuterium where there is only one stable state with the binding driven by two nearly equal forces: strong force and the attraction of the magnetic moments. Deuterium gives us a measure of the strength of the strong force interaction as bonding vanishes if the magnetic moments are aligned. Because of deuterium's large size the electrostatic contribution is minimal.

In a set of experiments that drives D-D fusion that are typically call cold fusion Swartz found the heat production rate is enhances when the active volume is in the presence of changing magnetic field that will perturb the magnetic moments (Swartz, 2020). Cold fusion is nothing special it is normal fusion occurring in condensed matter where energy has been concentrated by one of two possible mechanisms to drive ions to fuse (Wallace and Wallace, 2025). This experiment exhibits the role the magnetic moment plays and the importance of the orientation of the nuclei in order to fuse deuteriumn in the keV region.

VII. DISCUSSION

There are innumerable nuclear models based on high energy experiments and using quantum electrodynamics as a guide. The better guide is a structural description of the nucleons that is consistent with the properties measured in the ground state rather than in the high energy spectrum. The self-reference frame solutions produce an extremely limited inventory of solutions from which to build particles. The twelve solutions are smaller than the large collection of quarks-gluons-axions along with their quantization rules that make up the standard model of particle physics. Nature is just as frugal in generating rules as it is in producing stable particles. The net result is that the self-reference frame solutions supply the stability condition for both the proton and neutron: their fields and their close values of mass. This analysis found no other stable composite massive particles.

VIII. ACKNOWLEDGMENT

There was a misconception among high energy theorist that both superconductivity and ferromagnetism were understood and could be picked over for useful ideas to apply to high energy processes (Pickering, 1984) (Pais, 1986). This was not the belief for a few solid state theorists such as Martin Gutzwiller who cautioned things were missing in our understanding about the ferromagnetic state and the origin of the basic equation of quantum mechanics in the late 1960s. In the 1990s in a long discussion outlining the low energy experimental methods and analysis used to unearth the self-reference frame with S. Weinberg we realized there was a basic problem with electro-weak theory (Wallace, 2009). Julian Noble in 2004 cautioned that both nucleon mass and nucleon magnetic moments were not handled properly by the Standard Model. John David Jackson had realized by 2008, an understanding was missing of the spin dynamics necessary to dissipate perturbations allowing ordered solid state spin system to remain stable. All of this led to discovering the particle's self-reference frame and the equations that describe its behavior.

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IX. APPENDIX

Field Solutions in Self-Reference Frame

The designation boson and fermion of the solutions are taken from the three dimensional solutions which are the only elementary true fermions and bosons. The massive fermion solution in 3D represents the electron-positron. The massless fermion solution in 3D represents the electron neutrino, ν_e $\overline{\nu_e}$. The massive 3D boson with its weak and variable charge is the $W^{\pm} - Z^o$ particle. Finally, the massless 3D boson is the photon (Wallace and Wallace, 2014) (Wallace and Wallace, 2015). These four are the only elementary three dimensional particles and fields, as all others are composite structures made up from lower dimensional components that do not become true fermions or bosons until they are realized in the laboratory frame as three dimensional entities with or without spin.

U and ${}_1F_1$ are confluent hypergeometric functions where A and B are constants to be determined, n is the dimension of the state function, γ is from special relativity, and κ is the propagation coefficient. Solutions to the Kummers equation 12 are listed for only the spatial part of the state functions (Slater, 1968) (Mathews *et al.*, 2022). The massless solutions are obtained by applying three transformations to the massive solutions: $\kappa \to i\kappa$, $\omega \to i\omega$, and $\gamma \to -i$. This transformation has its origin in how the electron neutrino is generated from the transformation of the electron's mass $m \to im$ to a complex mass and the result is the electron neutrino. The analogy is like that of taking Adams rib, where the massless field owe their existence to the massive components from which they are generated. The full derivations of equation 12 along with time dependent part of the state function are found in (Wallace and Wallace, 2014) (Wallace and Wallace, 2023).

$$\frac{\partial^2 u(r)}{\partial r^2} + (\frac{n-1}{r} - \kappa\{1 - i\gamma\})\frac{\partial u(r)}{\partial r} + i\gamma\kappa^2 u(r) = 0 \quad (12)$$

$$massive \quad fermion$$

$$\mathbf{u}(r) = Ae^{-\kappa r}{}_1F_1[\frac{n-1}{1+i\gamma}, n-1, (1+i\gamma)\kappa r]; \quad n \ > \ 1$$

$$\mathbf{u}(r) = A\{(1+i\gamma)\kappa r\}^{2-n}e^{-\kappa r}\times$$
$${}_1F_1[\frac{n-1}{1+i\gamma} + 2 - n, 3-n, (1+i\gamma)\kappa r]; \quad n < 2$$

$$massive \quad boson$$

$$\mathbf{u}(r) = Be^{-\kappa r}U[\frac{n-1}{1+i\gamma}, n-1, (1+i\gamma)\kappa r] \quad (13)$$

$$massless \quad fermion$$

$$u(r) = Ae^{-i\kappa r}{}_1F_1[\frac{n-1}{2}, n-1, 2i\kappa r]; \quad n \ > \ 1$$

$$u(r) = A\{2i\kappa r\}^{2-n}e^{-i\kappa r}{}_1F_1[\frac{3-n}{2}, 3-n, 2i\kappa r]; \quad n \ < \ 2$$

$$massless \quad boson$$

$$u(r) = Be^{-i\kappa r}U[\frac{n-1}{2}, n-1, 2i\kappa r] \quad (14)$$