Quark Confinement and Force Unification

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String theory had to adopt a bi-scale approach in order to produce the weakness of gravity. Taking a bi-scale approach to particle physics along with a spin connection produces 1) the measured proton radius, 2) a resolution of the multiplicity of measured weak angle values 3) a correct theoretical value for the Z^0 4) a reason that h is a constant and 5) a "neutral current" source. The source of the "neutral current" provides 6) an alternate solution to quark confinement, 7) produces an effective r like potential, and 8) gives a reason for the observed but unexplained Regge trajectory like $J \sim M^2$ behavior seen in quark composite particle spin families.

1 Introduction

One of the successful aspects of String Theory is its ability to produce both atomic type and gravitational type forces within the same mathematical formalism. The problem was that the resultant gravitational force magnitude was not even close.

This problem continued until the string theorists added extra dimension of about $10^{19\text{th}}$ times larger than plank scale dimensions [1, 2]. The weakness of inter-scale gravity is due to the size difference between the two scales.

But a bi-scale approach raises the question; Is there also a "strong" intra-scale gravity force at the scale that produces the other strong particle level forces?

The particle level gravity proposition (e.g. Recami [3] and Salam [4]) is revisited, as the source of the "neutral current".

Spin in the Standard Model (SM) is not viewed as physical. As shown in [5], it is not the SM mathematics, but the "standard" view of the mathematics that results in the Cosmological Constant Problem while hiding Nature's mass symmetry, a symmetry in keeping with the cosmological constant and a symmetry that results in a single mass formula for the fundamental particles ($W^{\pm}, p^{\pm}, e^{\mp}$) and electron generations.

The results of [5] could not have occurred without putting aside the SM "standard" view.

This paper proposes that the particle's components real spin is the source of a particle level gravity.

2 The spin connection

It is proposed that spin is the source of a strong particle level gravity and associated intra-scale induced curvature. A spin torsion connection to a "strong" gravity is not new [6].

An intra-scale induced curvature is different than an inter-scale induced curvature. An inter-scale force is related to the difference between scales making G a constant.

The proposed intra-scale gravity magnitude is dependent on the frequency of spin. The higher the energy the higher the frequency (e.g. like $E = h\nu$ used in the development of the Schrödinger equation). The higher the frequency the higher the resultant curvature. Thus this intra-scale gravity value is not a constant.

Given the units of strong particle level gravity (sG) are $\text{gm}^{-1}\text{cm}^3\text{sec}^{-2}$ and spin (h) are $\text{gm}^1\text{cm}^2\text{sec}^{-1}$ the first spin ½$\hbar$ particle "x" relationship one might propose is

$$\mathrm{C}\,\frac{2\,sG_x\,m_x^2}{c} = \hbar\,, \tag{1}$$

where c is the velocity of light, C is a proportionality constant and the 2 on the lhs comes from the ½ originally in front of $\hbar$.

In [5], a 4π definition of Nature's coupling constants was given for the charged particle weak angle as $\alpha_{sg} = 2\sqrt{2}\,(4\pi\varrho)^{-1}$ (~0.2344 vs 0.2312 [7]) where $\varrho = 0.959973785$.

Equating C with the α_{sg} gives

$$\alpha_{sg}\,\frac{2\,sG_x\,m_x^2}{c} = \hbar\,. \tag{2}$$

3 The proton radius

Using the traditional gravity radius relationship for proof of concept (see §12), i.e. $\mathrm{R_p} = 2\,sG_p\,m_p/c^2$ and the proton mass (m_p [8]) gives the proton radius of

$$\mathrm{R_p} = \frac{2\,sG_p\,m_p}{c^2} = \frac{\hbar}{c\,m_p\,\alpha_{sg}} = 8.96978{\times}10^{-14}\ \text{cm}\,. \tag{3}$$

From scattering data, Sick [9] gives a proton radius $\mathrm{R_p}$ of $8.95{\times}10^{-14}$cm ± 0.018 making (3) 0.221% of Sick's value and Ezhela [10] gives a proton radius $\mathrm{R_p}$ of $8.97{\times}10^{-14}$cm ± 0.02(exp) ± 0.01(norm) making (3) 0.0024% of Ezhela's value.

4 A force magnitude unification

The proposed spin frequency strong gravity connection results in the three force distance squared ratios of

$$\alpha_{cs} = 7.2973525310^{-3}\,, \tag{4}$$

$$\alpha_{cg} = 1.7109648410^{-3}\,, \tag{5}$$

$$\alpha_{sg} = 0.234463777\,. \tag{6}$$

Thus the string theory conjecture that Nature's space-time is bi-scalar and this paper's conjecture on real spin as the source of a strong particle level gravity curvature results in a unification of forces at the particle level.

5 A weak theory puzzle

One recognized puzzle is that there are three statistically different weak angle values (Salam-Weinberg mass ratio SM theoretical value 0.2227 [11], $\sin^2 \hat{\theta}_W(M_Z) = 0.2312$ [7], neutrino $s_W^2 = 0.2277$ [11]) rather than a single value as expected by the SM. Note that the conversion between these weak angle forms does not resolve this puzzle.

6 A weak theory solution

The puzzle of three different measured weak angles using the present work is no longer a puzzle.

Unlike the SM view, the theoretical definition, $\alpha_{sg} = 2\sqrt{2}(4\pi\varrho)^{-1}$, allows for at least two basic weak angle values. When $\varrho = 1$ the pure theory definition gives $\alpha_{sg(1)} = 2\sqrt{2}(4\pi\, 1)^{-1} \sim 0.2251$, close to the measured neutrino weak angle (0.2277 [11]). When using the same value of ϱ used for the fine structure constant definition [5], i.e $\varrho = 0.959973785$, the definition $\alpha_{sg} = 2\sqrt{2}(4\pi\varrho)^{-1}$ is close to the measured charge particle weak angle (~0.2344 vs 0.2312 [7]).

Thus these two different values, s_W^2 and $\sin^2 \hat{\theta}_W(M_Z)$, result from two different spin couplings ($\varrho = 1$ and $\varrho = 0.959973785$) for two different types of particles, neutrino particles and charged particles.

The resolution for the Salam-Weinberg value in part comes from the recognition that the charged particle weak angle is different from the pure theory value, and that the Salam-Weinberg mass ratio is a pure theory value. The other part comes from the expectation that a true pure theory value would use chargeless particle masses.

Using the PDG W mass (m_W [8]) and the new constant α_{cg} given in [5] to produce the W particle charge reduced mass value, $m_W(1 - S\,\alpha_{cg})$ with $S=1$, yields the pure theory Salam-Weinberg bare mass ratio equation

$$1 - \frac{(m_W(1-\alpha_{cg}))^2}{m_Z^2} = 0.2253 \simeq \alpha_{sg(1)} = 0.2251. \quad (7)$$

Note that using the pure theory approach to the Salam-Weinberg mass ratio reduces the number values for the weak angle to two. Now, as theoretically expected, the pure theory charge reduced bare Salam-Weinberg mass ratio numerically matches the pure theory weak angle value.

7 A theoretical Z^0 mass

Given the theoretical value of the W mass in [5] and rearranging to give the Z^0 theoretical mass produces the m_Z

$$m_Z = \frac{m_W(1-\alpha_{cg})}{(1-\alpha_{sg(1)})^{\frac{1}{2}}} = 91188.64 \text{ MeV}, \quad (8)$$

a value within 0.0011% of the measured PDG value of 91187.6 ± 2.1 [8].

8 Confinement and quark's existence

This particle level gravity approach also gives a reason that quarks are only seen inside of particles, but not all particles.

Noting that all quark composite particle masses are greater than the mass symmetry point ($M_{sp} \sim 21$ MeV), implies that quark particles are only stable inside the higher curvature (compacted) space-time fabric particles above the mass symmetry point and are not stable inside the low curvature (voided) space-time particles below M_{sp}.

9 Confinement, persistence and Regge trajectories

But if quarks can only exist inside high curvature particles then unstable particle decay may not occur at the quarks base mass but when the curvature is not high enough for the quarks to persist.

This means that the measured quark masses may not be their base mass but their decay point masses.

The two natural postulates, 1) that the enclosure curvature makes quarks stable and 2) that a quark decays before reaching its base mass, imply that a given quark orbital spin configuration will decay at or near some given curvature value. This means that for a specific quark particle spin family (e.g. a $S = 1/2, 3/2, 5/2$ $J(S\hbar)$ family), all members of the family would decay at or around the same curvature.

That a quark spin family all decay at the same curvature, i.e sG is a constant ($sG = C_{decay}$), means that Eq. (2) becomes

$$C' M_x^2 = J(S\hbar). \quad (9)$$

This equation is the Regge trajectory like ($J \sim M^2$) behavior seen in Chew-Fraustchi plots for unstable quark spin families (see [12] for some examples).

Thus the spin strong gravity connection that produces the correct proton radius and the correct weak angle, also gives a reason why quarks do not exist outside of particles and can produce the observed Regge trajectory like behavior.

10 The proton and quarks

As indicated by the single quantized mass formula for the electron, proton and W particle given in [5], the quantization process' spin dominates the proton and thus the (stable) proton is not a typical (unstable) quark composite particle.

Evidence that the proton is not typical also comes from B. G. Sidharth [13]. Sidharth reproduces numerous composite particle masses using the pion as the "base particle". Sidharth states, "Secondly, it may be mentioned that ... using the proton as the base particle has lead to interesting, but not such comprehensive results".

That the proton is not a quark spin dominated particle may be one of the reasons that QCD has struggled for 40 years, with numerous additions to the model to produce a good proton radius value within 5% and why "solutions", like adding the effect of the s quarks fails to be supported by experimental evidence consistent with no s quarks.

The spin connection with the strong gravity approach immediately results in a proton radius value significantly less than 1%.

11 A r potential from a $1/r$ potential force

What the data for unstable quark composite particles indicates is that there is an *effective* r like confining potential.

What the data does not say is how this r like potential *effect* occurs.

One way of creating this r potential was found by making a new force nature that requires the QCD "equivalent of the photon", the gluon, to not only mediate the force as does the photon, but also participates in it (requires glueballs to exist).

However, there is another way that does not require a new force nature nor force form nor particle nature. Note that what follows is for quark (spin dominated) composite particles, not quantization dominated fundamental particles, i.e. the proton, and is a simplification of a complex situation including the frame dragging of quarks.

For quark composite particles the real spin proposition implies that the quark orbital spin angular momentum can be a significant contribution to the strong gravity value.

The particles strong gravity value would not be a constant but fluctuate with the quarks contribution due to their radius and velocity within the strong gravity enclosure.

That is to say, the higher the internal quark real spin angular momentum value, the higher the curvature and the stronger the confinement force. Mathematically this implies a C/r potential whose "gravitational constant value" C is not constant, but also a function of constituent quark orbital spin angular momentum.

As the quark orbital spin angular momentum contribution is a function of r^2 ($C = C'r^2$) the resulting effective confining potential ($V(r)$) would be $V(r) = C/r = C'r^2/r = C'r$. Thus the quark contribution to the resultant strong gravity confining potential, i.e. *effective behavior*, can act like a r potential.

Phenomenologically/experimentally the essential requirement is that the *effective* confining behavior, not that the actual potential form, is r like. Though not rigorous, this shows the potential to produce the *effective* r like behavior.

12 The particle level gravity proposition

The particle level gravity proposition is not new. Back in the early days of the quark strong force conjecture, there also was a particle level gravity conjecture.

Nobel Prize winner Abdus Salam [4] and Recami [3], via two different particle level gravity approaches, show that both asymptotic freedom and confinement can result from this approach. Both of these two approaches lacked a source of or cause and thus were unable to produce any specific values.

As indicated by Ne'eman and Sijacki [12] "Long ago, we noted the existence of a link between Regge trajectories and what we then thought was plain gravity ... In nuclei, ... the quadrupolar nature of the SL(3,R), SU(3) and Eucl(3) sequences ... all of these features again characterize the action of a gravity like spin-2 effective gauge field. Overall the evidence for the existence of such an effective component in QCD seems overwhelming".

Note that a particle level gravity theory is a spin torsion intra-scale gravity theory that includes the curvature stress energy tensor. Thus it's properties can differ from those associated with traditional inter-scale gravity theory. For example Yilmaz's [14] attempt at inclusion of a gravity stress energy tensor term appears not to have the intra-scale "hard" event horizon associated with the inter-scale Kerr solution.

With respect to the SM, Sivaram [6] indicates that the Dirac spinor can gain mass via a strong gravity field.

Last but not least, in Sivaram's paper [6] on the potential of the strong particle level gravity approach, Sivaram states; "It is seen that the form of the universal spin-spin contact interaction ... bears a striking resemblance to that of the familiar four-fermion contact interaction of Fermi's theory of weak interactions. This suggests the possibility of identifying the coupling of spin and torsion to the vierbein strong gravitational field as the origin of the weak interaction".

Sivaram's association of Fermi's weak theory with the coupling of spin and strong gravity is in keeping with Eq. (2) and the proposition in [5] that α_{sg} is a theoretical definition of the SM charged particle weak mixing angle.

13 Why h is constant and its value source

In particle physics, h is a constant of spin. However, the Standard Model does not answer the question, "Why does particle physics have the spin constant h ?".

The answer naturally results from the real spin extent connection to strong gravity.

The spin extent is limited by the size of the particle. As real spin angular momentum energy is added to the particle, the coupling requires the particle size to contract resulting in extent contraction and resultant increase in frequency to conserve angular momentum, i.e. a spin constant. Field acceleration to a higher spin frequency results in extent contraction to match the higher spin frequency, i.e. a spin constant.

This is the observed Frequency Lorentzian nature of the photon, i.e energy dilation, (wave)length contraction and frequency dilation.

Thus the gravitational curvature constant constrains the spin constant via the coupling value of spin to strong gravity as given in Eq. (2).

14 Summary

To produce gravity's weak value, string theory requires a bi-scale approach where gravity is an inter-scale property. This leads to the conjecture that there is also an intra-scale gravity at the same scale as the other particle forces.

There is also the additional proposition that there is a real spin strong particle level gravity relationship.

If this spin particle level gravity connection is correct then one would expect that it would produce the correct proton radius and it does.

One would also expect that either the α_{sg} value or the α_{cg} value should be a value within the Standard Model.

Not only does α_{sg} match the charged particle weak angle, the pure theory $\alpha_{sg(1)}$ matches the neutrino weak angle.

These propositions resolve the problem of the NuTev [11] neutrino results being 2.5σ from the SM $\sin^2\theta_W^{(on-shell)}$ value. The true $\sin^2\theta_W^{(on-shell)}$ is the Salam-Weinberg bare mass ratio which is near the NuTev result and almost exactly $\alpha_{sg(1)}$.

As shown in [15] the FSC definition (α_{cs}) of this electro-gravitic approach matches an Einstein-Cartan FSC definition.

In keeping with [5], neither the quantization proposition nor the strong particle level gravity proposition are in conflict with the existence of quarks.

This particle level gravity approach does not require a new force form for the confinement of quarks and due to the spin strong gravity connection, can result in an *effective r* potential force for quark spin dominated unstable particles.

A strong gravity confinement source indicates that quarks can only exist inside high curvature particles thus giving a reason why quarks are not seen as free particles. The high curvature quark connection and the quark mass pattern indicates that the "measured" quark masses are not their base "invariant" mass values but decay point mass values. This proposition results in Regge trajectory like behavior.

Though the SM has had great numerical and behavioral success, its propositions (Higgs, QCD, etc.) result in fundamental problems like the Cosmological Constant Problem (10^{34+} off) and no excepted solution to the Matter Only Universe Problem, while not addressing the integration of gravity. Thus despite its numerical success, the SM has not solved the particle puzzle in all of its parts.

In [5], taking a non-standard view of the fundamental particle masses, the quantization proposition not only results in a single mass formula for the *W*, *p*, *e* and electron generations, it can solve the Cosmological Constant Problem and the Matter Only Universe Problem.

In this paper, the proposition of a real spin connection to the strong particle level gravity gives a source for the weak angle. This makes strong particle level gravity the "neutral current" and the foundation for the particle nature of particles.

These papers produce values for the $W^{\pm}$ and Z^0 mass and proton radius that are within the uncertainty in the measured values, naturally results in two weak angle values as experimentally observed, matches these values and explains why Nature has a spin angular momentum constant and thus show this approach potential. Also indicated is the potential of a bi-scalar approach to Nature which can solve the Hierarchy Problem and produce a particle scale Unification of Forces.

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