SECTION 1

1.1 - Preonic Grand Unification and Quantum Gravitation: Introduction

Beyond the obvious theoretical and aesthetic motivations, there is an often overlooked experimental reason to unify the electroweak and strong interactions with quantum gravitation. In grand unification *excluding* gravitation, one ordinarily uses low energy experimental particle phenomenology and running coupling data to predict the energy-momentum transfer scale at which the three non-gravitational couplings will merge. In the more popular models, such as Georgi-Glashow SU(5)[1.1], this predicted energy transfer is on the order of $Q=M_X \approx 10^{15}$ GeV. Because there is no forseeably available method to directly observe phenomena at anywhere near this energy scale, the experimental verification of any one or another Grand Unified Theory must be based upon low energy observation of high energy "residue" phenomena, one of which is presumed to be proton decay. Unfortunately however, after more than a decade of theoretical and experimental research in this area, there have been few if any positive results, up to about 10^{15} GeV. Hence, none of the many G.U.T. models proposed to date can be considered as experimentally confirmed. If anything, the "negative (experimental) results on proton decay seem to rule out the SU(5) model, at least in its simplest form,"[1.2] and tend to suggest that the Grand Unified mass scale may even exceed 10^{15} GeV., though by how much is certainly a subject for debate.

In Grand Unification with Quantum Gravitation however, one begins on an entirely different footing. If, on the basis of some historical accident, the numerical magnitude of the Newton-Cavendish gravitational coupling constant $\sqrt{\hbar c^5/G} = \sqrt{\frac{\hbar c^5}{6.67 \times 10^{-11} \frac{met^3}{Kg\text{-}sec^2}}} = 1.22 \times 10^{19}$ GeV. was not known, and if we were for some reason precluded from performing direct gravitational experiments to measure the magnitude of this constant, then it would be necessary to predict this magnitude from low energy experimental particle data, on the basis of a Grand Unified Theory that properly includes quantum gravitation. Fortunately, because we actually do know the numerical magnitude of G, not from particle but from gravitational data, we have available a ready check on whether or not a given G.U.T. which attempts to include gravitation is in fact successful: to be correct, such a theory must be able to independently predict the already known magnitude of the gravitational coupling, consistent with and on the basis of low energy particle data, once all renormalization corrections have been properly accounted for. G.U.T. without gravitation does not share this advantage of a coupling which, a-priori, is independently known.

Specifically, in a theory which successfully includes unification with gravitation it must be possible, based upon low energy experimental measurements of running coupling data, and upon the complete particle phenomenology of the G.U.T. gauge group, to predict a G.U.T. energy transfer on the order of the gravitational mass scale $Q=M_G \approx 1.22 \times 10^{19}$ GeV., at which all four interaction couplings eventually converge. Including all higher order corrections to the renormalization group equations, the predicted magnitude of M_G must be exactly equivalent with the so-called Planck energy, and the numerical magnitude of the grand unified (squared) coupling a_G at which all of the seperate couplings (including monopole couplings) converge, must be of order one-half, ie., $a_G=\hbar c/2$, within experimental error. This is an experimentally based, model independent numerical condition which must be satisfied by any successful grand unification including gravitation.[1.3]

The central hypothesis upon which such a unification will be attempted, is that the fermions and bosons of real observable matter are themselves constructed in a mesonic fashion out of a deeper substratem of complex material particles that we shall refer to as "**preons**." These preons are very similar in nature to the complex "spinors" into which real spacetime is similarly decomposed.

In a recent set of monographs, Penrose and Rindler emphasize the fundamental importance of 2-complex dimensional spinor calculus in the deeper description of ordinary 4-real dimensional spacetime.[44] They note also what appears to be a profound link between spinors and quantum mechanics.[45] As will be established in the early discussions here, the standard Weinberg-Salam electroweak theory is easily regarded, using methods suggested by Penrose and Rindler, as a preonic theory of electroweak Bose particles. Specifically, it is simple to compose the four real bosons A^u, Z^u, W^{+u}, W^{-u} out of two complex preonic states $\Uparrow, \Downarrow$ for "isospin up" and "isospin down," which we later relabel as the "C" and "D" flavor preons. This composition takes place in quite the same manner as the composition of four real spacetime dimensions (ct,x,y,z) out of two complex spinor states $\uparrow, \downarrow$ for "spin up" and "spin down." Of course, the isospin model of weak β-decay has long been recognized. Yet even today, there does not appear to be a general recognition of the fact that "isospin up" and "isospin down" are themselves fundamental preonic states of matter, and not merely an analogy to the "spin up" and "spin down" states of spacetime. Nor does there seem to be recognition of the fact that weak β-decay, be it quarkonic or leptonic, is at bottom due to a transition between the isospin-up and isospin-down states of complex preonic matter; and that this is what accounts for the strong similarity between the quarkonic and leptonic forms of beta-decay, and hence, for the similarity between quarks and leptons.

Throughout the course of discussion it will be assumed that the fundamental observable <u>real</u> spin 1/2 fermions are the standard set of particles shown below:

	F	Qu	L	Q	R	G	B
$(u,c,t\ldots)^{R}_{L,R}$	1	1	0	2/3	1	0	0
$(u,c,t\ldots)^{G}_{L,R}$	1	1	0	2/3	0	1	0
$(u,c,t\ldots)^{B}_{L,R}$	1	1	0	2/3	0	0	1
$(d,s,b\ldots)^{R}_{L,R}$	1	1	0	-1/3	1	0	0
$(d,s,b\ldots)^{G}_{L,R}$	1	1	0	-1/3	0	1	0
$(d,s,b\ldots)^{B}_{L,R}$	1	1	0	-1/3	0	0	1
$(\nu_e,\nu_\mu,\nu_\tau\ldots)^{L}_{L,R}$	1	0	1	0	0	0	0
$(e,\mu,\tau\ldots)^{L}_{L,R}$	1	0	1	-1	0	0	0

Table 1.1: Flavor/Color/Generation Classification of the Elementary Spin-Half Fermionic Real Particles, Left-Right Symmetric Quantum Numbers Only

where u≡up, d≡down, ν≡neutrino, e≡electron with repetition of generations; superscripts R≡red, G≡green, B≡blue, L≡lepton; subscripts L,R denote left and right handed chirality states; and F≡Fermion number, Qu≡Quark number, L≡Lepton number, Q≡Electrostatic (Coulomb) charge number, (R,G,B)≡Red,Green and Blue strong color charge number. Following Pati and Salam,[1.6,1.7] we regard leptons as a fourth color of Fermion, which is the reason for the L superscript. To maintain generality and avoid any a-priori assumptions about the neutrino, it is assumed here that the neutrino has some finite, albeit very small rest mass; hence the reason for inclusion of a right handed R subscript for that particle. If one desires to consider a strictly massless neutrino, it is necessary simply to set $m_\nu=0$ in the Dirac equation for the neutrino, in which case the right handed subscript can be eliminated[1.8], leptonic Cabibbo mixing will be strictly eliminated[1.9], and the linear combination B-L (B≡Baryon number, not shown here) will be strictly conserved in all Boson-Fermion interactions.[1.10] In any case, if the neutrino were shown to have mass, and hence the right handed components were shown to exist, the above gives what would then be the appropriate quantum numbers for classifying these components. Aside from the possibility of additional fermionic generations beyond the observed three (excepting of course the "top" quark which has not yet been observed, but which is commonly anticipated), it is assumed that the above provides a complete listing of <u>all</u> the distinct flavor/color/generation and chirality combinations of <u>real</u> spin 1/2 fermions which can be observed to exist in nature. The similar classification of all conceivable scalar and vector Bosons (and presumably higher spin particles) is achieved by examining all possible combinations of transition between pairs of the above Fermions, including antiparticles.[1.11] The truly fundamental Bosons, presumably, comprise some mutually independent subset of these.

Some of the quantum numbers shown in Table 1.1 are interrelated, specifically:

$$F = Qu + L = R + G + B + L \, . \tag{1.1}$$

The reason we have chosen to examine these particular quantum numbers along with Q, and not, say Y≡Hypercharge number or I^3≡Weak Isospin number is because, so far as is known, all of the particles in nature are intrinsically left⇔right symmetric with respect to the quantum numbers in Table 1.1. This symmetry does <u>not</u> hold for certain other quantum numbers, among them, Y and I^3, as was first suggested by Lee and Yang with regard to parity violation in weak interactions. In the course of discussion here it will be assumed that the observed left⇔right symmetry of nature with respect to the particular quantum numbers shown in Table 1 actually manifests an intrinsic Lagrangian symmetry of nature, ie., that the interactions associated with these particular quantum numbers are chiral symmetric and intrinsically conserve parity. Further, we shall go so far as to utilize this assumption about left⇔right symmetry as the actual basis for gauging the chosen G.U.T. symmetry group with Quantum Gravitation. Thus for example, the left⇔right symmetry of F, Qu, L, R, G, B will be utilized as a gauge condition to ensure the intrinsic conservation of parity in strong color interactions; while the left-right symmetry of Q will be utilized as a gauge condition to ensure the intrinsic conservation of parity in electromagnetic (Coulomb) interactions, as is already done in the Weinberg-Salam flavor theory of Electroweak interactions. In Electroweak theory specifically, the electrostatic charge $Q \equiv Y + I^3$ is explicitly constructed so as to be left-right symmetric for all particles; however, Y and I^3 individually need not be and in fact are not constructed in this way, though they are constructed so as to ensure the left-right symmetry of Q. Designating explicit left and right handed components, this is to say that:

$$Q_{LR} = Q_L = Q_R = Y_L + I^3_L = Y_R + I^3_R \,, \tag{1.2)(a}$$

but that: ($\neq$ should be interpreted here to mean "not necessarily equal to")

$$Y_L \neq Y_R \;; \quad I^3_L \neq I^3_R \,, \tag{1.2)(b}$$

for any given flavor of particle.

One might anticipate in an extended theory of particle flavor, that Quark number Qu and Lepton number L, which appear in both the flavor and color groups (see 1.1)), will be constructed similarly to electrostatic charge Q. Particularly, one expects that Qu and L will also be gauged so as to be completely left-right symmetric for all particles (no axial components), but that they may be composed out of certain other flavor quantum numbers (Baryon number among them) which need not necessarily obey this same symmetry.[1.12]

This all leads to another consequence of significant importance. It should be noted, be it coincidence or otherwise, that those interactions which appear in nature to possess an intrinsic left-right symmetry, specifically the strong color and electromagnetic interactions, are precisely the same interactions for which the basic unit of charge is believed to be absolutely conserved in all natural processes. Therefore, these are also the same, and so far as we know the only interactions in nature mediated by massless vector bosons, specifically, the strong colored "gluons" $G^{\mu}_{c\bar{c}}$ and the electromagnetic "photon" A^{u}. This suggests a very tight connection between the three principles of left-right chiral symmetry and parity conservation, exact charge conservation and the masslessness of gauge bosons. This in turn suggests a gauge principle;

Specifically, based on the above, we shall wish to gauge the selected G.U.T. with quantum gravitation so as to require intrinsic parity conservation (hence left- right chiral symmetry) for all particles with respect to the strong color and electromagnetic interactions; so as to require the absolute conservation of the strong color and electromagnetic Coulomb charges; and consequently, so as to insure that the strong color and electromagnetic interactions will of necessity be mediated by massless vector bosons. These are of course, just those interactions associated with the charges shown in Table11. We make no additional assumptions about the remaining flavor quantum numbers and their interactions and gauge bosons.(ie., Y, I^3,B, etc.) This decision is left to the choice of G.U.T. gauge group and to the manner of gauge boson mixing once the underlying G.U.T. symmetry group has been properly broken according to the gauge principles outlined above.

A prototype of this approach already exists in electroweak theory. Specifically, recall that the electromagnetic current J_Q^u is related to the Coulomb charge quantum number generator Q according to: (Ψ is the Dirac wavefunction for the particular flavor of particle under consideration)

$$J_Q^u = \bar{\Psi}\gamma^\mu Q \Psi \, , \tag{1.3}$$

which means that electromagnetic currents (and currents in general) flavor transform in the same manner as their associated charge quantum number generators. Recall too that the (free) photon gauge boson for the electromagnetic interaction is given in covariant form by the field equation:

$$J_Q^u = (d^\sigma d_\sigma - m_A^2) A^u \tag{1.4)(a}$$

$$m_A = 0 \tag{1.4)(b}$$

with Lorentz and Coulomb gauge conditions:

$$A^\sigma{}_{;\sigma} = 0 \tag{1.5)(a}$$

$$A^0{}_{;0} = 0 \, , \tag{1.5)(b}$$

hence $A^k{}_{;k} = 0$. Note, for massive (free) gauge bosons, that (1.4)(b) and (1.5)(b) no longer apply, and that (1.5)(a) is then mandated by the assumed massiveness of the gauge particle.

Because equation (1.2)(a) for $Q \equiv Y + I^3$ is specifically constructed to be left-right symmetric, simultaneous enforcement of the mixing relationships:

$$\begin{pmatrix} g_Q Q \\ g_Z Z \end{pmatrix} \equiv \begin{pmatrix} g'_Y Y' \\ g'_W I^{3\prime} \end{pmatrix} = \begin{pmatrix} \mathrm{Cos}\,\theta_W & \mathrm{Sin}\,\theta_W \\ -\mathrm{Sin}\,\theta_W & \mathrm{Cos}\,\theta_W \end{pmatrix} \begin{pmatrix} g_Y Y \\ g_W I^3 \end{pmatrix} \tag{1.6)(a}$$

and

$$Q \equiv Y + I^3 \tag{1.6)(b}$$

directly yields the relationship between couplings and mixing angles:

$$\begin{pmatrix} \cos\Theta_W & \sin\Theta_W \\ -\sin\Theta_W & \cos\Theta_W \end{pmatrix} = \begin{pmatrix} g_W/g_Z & g_Y/g_Z \\ -g_Y/g_Z & g_W/g_Z \end{pmatrix} \qquad (1.7)$$

hence $\tan\Theta_W = g_Y/g_W$; along with the massive electroweak neutral current quantum number generator:

$$Z = I^3 - Q\cdot\sin^2\Theta_W \qquad (1.8)$$

and the coupling relationships:

$$1/g_Q^2 = 1/g_Y^2 + 1/g_W^2 \qquad (1.9)(a)$$

$$g_Z^2 = g_Y^2 + g_W^2 \,. \qquad (1.9)(b)$$

In the above, $\Theta_W(Q^2) \equiv$ Weinberg/Glashow electroweak mixing angle is a function of impact parameter Q^2, $Z\equiv$electroweak neutral current generator, $g_Q\equiv$electromagnetic Coulomb coupling, $g_Z\equiv$ electroweak neutral current coupling, $g_Y\equiv$hypercharge coupling and $g_W\equiv$weak isospin coupling. Further, because the (neutral current) mixing of gauge bosons and hence the creation of a massless photon and massive Z^u is given by: (see (1.7))

$$\begin{pmatrix} A^u \\ Z^u \end{pmatrix} \equiv \begin{pmatrix} B^{u'} \\ W^{3u'} \end{pmatrix} = \begin{pmatrix} g_W/g_Z & g_Y/g_Z \\ -g_Y/g_Z & g_W/g_Z \end{pmatrix} \begin{pmatrix} B^u \\ W^{3u} \end{pmatrix}, \qquad (1.10)$$

it is apparant that eq.(1.2)(a), $Q = Y + I^3$, is the pivotal "prototype" relationship used simultaneously to ensure left-right symmetry, charge conservation and masslessness of the photon, for the electromagnetic interaction. (Note that Q.E.D. Lagrangian terms of the form $\mathcal{L} = gJ^\sigma B_\sigma$ remain invariant under the above described mixing.)

Given that the flavor prototype for electrosatic Coulomb charge is given by eq. (2)(a), namely,

$$Q_{LR} = Y_L + I_L^3 = Y_R + I_R^3 \,, \qquad (1.11)$$

it will be necessary to discover similar flavor prototypes and mixing relationships for Lepton number L_{LR} and Quark number Q_{uLR}; with the further connection to color quantum numbers given by eq.(1.1). The search for these extended flavor prototypes will comprise a significant part of the discussion herein.