Preonic Grand Unification and Quantum Gravitation: Capsule Outline and Summary

Through the decomposition of real Fermions and vector Bosons into complex "preons," in much the same way that real spacetime is decomposed using spinor calculus into complex spinors, one is able to arrive at a greatly simplified classification of the elementary real particles, including both left and right handed chiral projections. The theory proposed accounts for all of the electromagnetic, weak, strong and quantum gravitational interactions, along with all of the flavor, color and "horizontal" generation gauge groups, at all energy scales up to and including the gravitational Planck energy. Also reviewed is the Q.E.D. Dirac equation and its various finite symmetry groups C, P, T and the chiral operator γ^5, and arguments are presented to establish that chirality, from a geometrodynamic viewpoint, is most naturally regarded as a fifth spacetime dimension.

Section 1.1 is a general introduction, establishing the broad scope of constraints and assumptions upon which the remaining development is based. Section 1.2 is an expanded outline and summary, and covers in greater depth the same material being summarized herein in capsule form.

Sections 2.1 - 2.8, by and large, contain a fairly standard review of the Dirac equation, with particular emphasis placed upon the classical spacetime origin of this equation in the metric equation $ds^2 = g_{uv}dx^u dx^v$, and upon the "spin" degree of quantum mechanical freedom embodied within the Dirac equation. This discussion is intended to provide the geometric and kinematic basis for later discussion of preonic grand unification. Particular emphasis is placed in this discussion upon particle spin, because the "spin" degree of freedom as developed in "spacetime" is largely copied into electroweak theory in the form of the "isospin" degree of "flavor" freedom. As a consequence of this similarity between spin and isospin, it is shown in the later discussion of Sections 2.9-2.10 how it is possible to decompose the four <u>real</u> vector Bosons A^u, W^{+u}, W^{-u}, $Z^u (\equiv W^{0u})$ of electroweak theory into two <u>complex</u> "isospinors," "isopsin-up" and "isospin-down," (these are called "preons") in much the same way that it is possible to decompose the four <u>real</u> dimensions ct, x, y, z of spacetime into two <u>complex</u> "spinors," "spin-up" and "spin-down." This in turn, provides the basis for the subsequent progressive extension of the preonic approach, to encompass additional particles, symmetries and interactions.

While Sections 2.1 - 2.8 are therefore intended primarily as a review of the Dirac equation, and as an entree into the later discussions of preonic grand unification, there is one significant area in which these sections introduce new material of a fundamental character, and this relates to the "chiral" Dirac matrix $\gamma^5 \equiv i\gamma^0\gamma^1\gamma^2\gamma^3$. In particular it is shown, beginning in section 2.1, that the simplest and most natural treatment of chirality, is as a fifth covariant dimension of spacetime. The five-dimensional metric has signature diag $(g_{UV}) = (\gamma^0\gamma^0, \gamma^1\gamma^1, \gamma^2\gamma^2, \gamma^3\gamma^3, \gamma^5\gamma^5) = (1, -1, -1, -1, 1)$, $U, V = 0, 1, 2, 3, 5$, and so is not unlike the early five-dimensional "cylinder" models of Kaluza-Klein. By regarding chirality as a fifth dimension of spacetime, fully on a par with the usual four dimensions ct, x, y, z, many aspects of modern particle physics which in four dimensions may seem somewhat ad-hoc or obscure, are seen in a five dimensional approach to indeed be quite clear and natural. In fact, once the five-dimensional viewpoint is adopted, it becomes clear very quickly that the seperate consideration of chirality and spacetime is significantly more cumbersome and unnatural than is their combined consideration; just as the combined covariant consideration of space and time in ordinary geometrodynamics is significantly simpler than the seperate, pre-relativistic treatment of space and time according to Newtonian physics. Those sections which explicitly address changes to the conventional spacetime analysis of the Dirac equation, as a consequence of the fifth chiral dimension, include Sections 1.2, 2.1, 2.4 and 2.5.

Preonic grand unification with quantum gravitation per se, is developed in the remaining Sections 2.9 - 2.14. In Section 2.9, it is shown how the four real vector Bosons A^u, W^{+u}, W^{-u}, Z^u of electroweak theory may be decomposed into two complex preons, in the same manner that the four real spacetime dimensions ct, x, y, z are readily decomposed into two complex spinors, utilizing methods suggested by Penrose and Rindler in their recent set of monographs on Spinors and Spacetime. The fundamental importance of preons in elementary particle theory, which parallels the importance of spinors in the study of spacetime, is explicitly emphasized in Section 2.10.

As we begin to see in Section 2.11, the utility of spinor-like preons is not confined to electroweak theory and its associated real particles. Whereas electroweak theory requires two preons, represented by the eigenstate solutions of an SU(2)xU(1) gauge group, it is now shown that with four preons, and an associated SU(4) gauge group, that it then becomes possible to compose all left-handed chiral flavor projections of both Fermion and Boson (spin $\frac{1}{2}$ and spin 1), and to account not only for electroweak theory,(which is embodied in the explicit SU(2) subgroup of SU(4)) but also for a colorless strong interaction. The limitations at this point however include the facts that 1) right-handed chiral projections are not yet accounted for, 2) quantum gravitation is not yet accounted for, 3) strong interaction Q.C.D. color is not yet accounted for and 4) the replication of Fermion generations is not yet accounted for.

In Section 2.12, we attempt to account now for right, as well as left-handed chiral projections. However, in order to simultaneously account for chiral asymmetry in weak interactions (as first suggested by Yang and Lee with respect to weak interaction parity non-conservation) and chiral symmetry in strong and electromagnetic interactions, one is forced unavoidably to supplement the prior SU(4) subgroup with a U(1) factor, ie., one is forced to extend the four preon flavor group to SU(4)xU(1). Because the new U(1) subroup is an ultra high energy abelian subgroup, it appears that the most natural path, to avoid the introduction of yet a fifth fundamental interaction in nature, is to associate this new U(1) subgroup with quantum gravitation. In short, this is to say that the gauge group of quantum gravitation must be introduced, in order to account simultaneously for weak interaction parity non-conservation, and electromagnetic and strong interaction parity conservation. The irony here is that quantum gravitation turns out to resemble the weak interaction, insfar as it does not conserve parity either.

At this point, the preonic flavor theory has been fully developed. However, the color and generation gauge symmetries have not yet been accounted for. Section 2.13 is concerned directly with the introduction of color into what is up until this point essentially a colorless strong interaction. This section also includes a detailed discussion of both electroweak and strong/hyperweak neutral current phenomena, which are closely connected with intergenerational Cabibbo mixing, discussed in depth in the subsequent section.

Section 2.14, which is the final section, deals in depth for the first time, with the replication of fermion generations. Among other things, it is established in this section that the bi-colored gluons of the strong interaction, which are ordinarily associated strictly with strong interaction color decays, are also bi-generational, and that these gluons therefore serve a dual role as the mediators of both color and intergenerational interaction decay. In conjunction with the $W^{\pm u}$ of standard electroweak theory, it is the intermediate production of these bi-colored and bi-generational gluons which is directly responsible for the Cabibbo type mixing of fermions across generational boundaries. The reason that Cabibbo mixing is observed for quarks, but is not observed for leptons, is due quite simply to the fact that gluons couple to quarks, but not to leptons. At ultra-high energies of grand unification, leptonic Cabibbo mixing is in fact predicted. However, this mixing takes place via a super-massive strong interaction neutral current, rather than through the ordinary low energy gluons, and it is not expected that this form of mixing could be observed with present technology. Further, while ordinary gluons do indeed remain massless insofar as color symmetry is concerned (because color SU(3) continues to remain unbroken at low energies) they do <u>not</u> retain their massless character once their dual role as mediators of the generation interaction is considered. This is because one expects that the generation symmetry is quite badly broken at low energies, as is deduced for example by considering the extreme differences in the masses of the various fermions, from one generation to the next. The fact that Cabibbo beta-decay within a given generation is far more likely to occur than is the Cabibbo decay of Fermions accross generations, has its physical origin in the fact that the gluons which mediate <u>inter</u>generational decay are considerably more massive than those which mediate <u>intra</u>-generational decay. This leads to a definitive set of predictions which, if correct, should quite probably be observable with present experimental technology.

If the strong interaction gluons are both bi-colored and bi-generational, and are therefore involved in mediating not only color, but also intergenerational decays, then these gluons, which from their role as mediators of the generational interactions are presumed now to have non-zero mass, should be directly observable among the intermediate vector decay products of Cabibbo type reactions such as $u \rightarrow s$, ie., these should be observable during the decay of the $K^+ \equiv \bar{s}u$ and similar mesons. In fact, if $G^u_{\bar{u}e}$ is used to designate the particular bi-generational gluon produced during quark decay from the e to the u generation, then the intermediate decay products of the K^+, prior to subsequent decay into a final configuration, are specified by the reaction $K^+ \longrightarrow G^u_{\bar{u}e} + W^{+u}$. The observation of the $W^{\pm u}$ and Z^u Bosons at CERN has properly been hailed as perhaps the leading advance of the decade in experimental physics. In all Cabibbo beta-decays which cross generational boundaries however, one also expects the additional production of a massive bi-generational gluon. Assuming a long enough lifetime, it appears to be quite likely that such gluons could be observed also, along with the $W^{\pm u}$ and Z^u, among the intermediate vector bosons produced during intergenerational beta decay. Further, one would anticipate that the relative masses of the various bi-generational gluons will be closely related to the relative amplitudes for occurrence of the various forms of Cabibbo transition, and this in turn, is directly connected with the various components of what is, for three generations, known as the Kobayashi-Maskawa mixing matrix. As such, the bi-generational properties of the strong interaction gluons may serve to provide a clear physical basis for understanding the Cabibbo mixing of quarks, and may in fact be directly observable in experiments similar to those first used to establish the actual physical reality of the $W^{\pm u}$ and Z^{u} vector Bosons of electroweak theory.