2.10 - Summarization of Prior Discussion, and On the Fundamental Importance of Preons in Particle Physics

All of the discussions to this point, of the Dirac equation, the chiral fifth dimension, quantized degrees of freedom, the finite C,P,T,A symmetry operators, left and right handed chiral projections, s,t,u scattering channels and the covariant polarization states of vector Bosons, have been designed with two primary objectives. First, perhaps more obviously, these discussions have been meant to provide a theoretical foundation for later dynamical discussion, developed in such a way that any later results can be directly traced back to their very simple geometric origin in the classical second-order Gaussian spacetime metric eq. (2.1), or in its first order, spin $\frac{1}{2}$ Dirac counterpart, eq. (2.10), ie., in five dimensions: (also eq. (2.7))

$$dS^2 = g_{UV} dx^U dx^V \qquad (2.242)(a)$$

$$dS = \gamma_U dx^U \qquad (2.242)(b)$$

$$g_{UV} = \frac{1}{2}(\gamma_U \gamma_V + \gamma_V \gamma_U) \quad , \qquad (2.242)(c)$$

with "chiral spacetime" 5-metric tensor (eq. (2.18)(a)):

$$g_{UV} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix} \qquad (2.242)(d)$$

in geodesic five-space coordinates. Everything else is, in one way or another, simply a more detailed quantum mechanical (or Lagrangian, see (2.120).(1)(b), (2.120).(a)) enhancement of these equations. Aside from certain specified situations, we have limited most discussion to ordinary four-dimensional spacetime. It is certainly of great interest To examine the chiral dimension X^5 in detail, and in a more direct geometric and dynamical into two complex fundamental preons, namely ⇑ and ⇓, just as spacetime is decomposed into the complex spinors ↑ and ↓.

manner, though this will not be done in the current draft.

Second, and perhaps not as obviously, this discussion was designed ultimately to lead to the discussions in Sections 2.7 and 2.8 of covariant vector Boson polarization states; and even more generally, to discussions regarding the spinor decomposition of spacetime.

no ¶ The reason we are so interested in the spinor decomposition of spacetime is because the Weinberg-Salam-Glashow Electroweak Theory, which is the singlemost important theoretical step of the past generation on the road to grand unification, involves the formal generation, via the spontaneous symmetry breakdown of a (mathematical) non-abelian gauge group, of exactly four real fundamental particles, namely, W^{+u}, W^{-u}, A^u and Z^u; and these particles in turn, as demonstrated above, are readily decomposed. The $W^{\pm}$ particles, and as the Electroweak authors also discovered, the Z^{u} particle, are all involved in mediation of the weak interactions; while the photon A^u is explicitly designed (gauged) so as to be identical with the massless, left-right symmetric mediator of electromagnetic interactions, It is primarily in this sense, whereby the four mediating Bosons of both the electromagnetic and weak interactions are generated out of a common (SU(2)xU(1)) gauge group, that one speaks of these two interactions as having been unified. A particularly simple view of the electroweak unification emerges, as demonstrated in the prior section, when the SU(2)xU(1) flavor generators (2.231) are identified directly with the two complex spinor-like states ⇑ = isospin up, ⇓ = isospin down, which we have labelled as "preons." Once this identification has been properly established, it is possible thereafter to compose the four real particles of electroweak theory out of the two complex preonic particles, isospin-up and isospin-down. This composition, or decomposition if one starts with the electroweak real particles and works backward toward the complex preonic spinor-like particles, is given in eqs. (2.234),

$$\begin{cases} W^{+u} = B^{u}(-\overline{\Downarrow}\Uparrow) = \left|I=1,\ I^{3}=1,\ Y=0,\ Q=1,\ Z=\mathrm{Cos}^{2}\theta_{W}\right\rangle & (2.243)(a) \\ A^{u} = B^{u}(\overline{\Uparrow}\Downarrow) = \left|I=1,\ I^{3}=0,\ Y=0,\ Q=0,\ Z=0\right\rangle & (2.243)(b) \\ W^{-u} = B^{u}(\overline{\Uparrow}\Uparrow) = \left|I=1,\ I^{3}=-1,\ Y=0,\ Q=-1,\ Z=-\mathrm{Cos}^{2}\theta_{W}\right\rangle & (2.243)(c) \end{cases}$$

$$\begin{aligned} Z^{u} &= B^{u}(\overline{\Uparrow}\Uparrow(\tfrac{1}{2}-\mathrm{Sin}^{2}{}_{W})-\tfrac{1}{2}\overline{\Downarrow}\Downarrow) \\ &= \left|I=\mathrm{Cos}^{2}\theta_{W},\ I^{3}=0,\ Y=0,\ Q=0,\ Z=0\right\rangle \quad . \end{aligned} \qquad (2.243)(d)$$

Aside from an expanded set of (interrelated, by (2.233)) flavor quantum numbers, and certain differences in the "neutral" $I^3, S^3=0$ sector, this preonic decomposition is virtually identical to the four covariant vector boson polarization states: (see (2.227)-(2.229))

$$\begin{cases} B^{u}_{(1,1)} = B^{u}(-\overline{\downarrow}\uparrow) = \left|S=1,\ S^{3}=1\right\rangle & (2.244)(a) \\ B^{u}_{(1,0)} = B^{u}(\ \tfrac{1}{2}(\overline{\uparrow}\uparrow-\overline{\downarrow}\downarrow)\ ) = \left|S=1,\ S^{3}=0\right\rangle & (2.244)(b) \\ B^{u}_{(1,-1)} = B^{u}(\overline{\uparrow}\downarrow\ ) = \left|S=1,\ S^{3}=-1\right\rangle & (2.244)(c) \end{cases}$$

$$B^{u}_{(0,0)} = B^{u}(\ \tfrac{1}{2}(\overline{\uparrow}\uparrow+\overline{\downarrow}\downarrow)\ ) = \left|S=0,\ S^{3}=0\right\rangle, \qquad (2.244)(d)$$

which are readily decomposed as shown into the two complex spinor states $\uparrow$=spin up, $\downarrow$=spin down. Of course, the polarization states (2.244) arise by the quantum mechanical consideration of <u>spacetime</u> symmetry, which is to say that the origin of these states can be traced back to the quantum mechanical formulation of the metric equations (2.242); and particularly to the spin "degree of freedom" contained in (2.242)(b). Aside from the development of the theoretical foundation for later dynamical discussion, this is the major point of the entire set of discussions of the Dirac equation, to this point. In contrast to spacetime symmetry, the "iso-"polarization states in (2.243) are associated with flavor symmetry, though they look very much like the vector Boson polarization states of (2.244), in covariant spacetime formulation. One inevitably concludes therefore, that the isospin-up and isospin-down "iso-"spinors, which have been named "preons," are just as important to a full understanding of particle flavor symmetry, as are the better known spin-up and spin-down spinors to the fuller understanding of spacetime. Herein lies the fundamental importance of the weak isospin model of beta-decay, and the primary reason for the particular interest taken here in the covariant polarization states of vector Bosons, and in the spinor decomposition of spacetime emphasized so heavily by Penrose and Rindler.[2.7]

From here, aside from some concluding discussion in a future draft regarding the chiral dimension of spacetime, attention will be focused directly on grand unification. The formal development of a unified gauge field theory of the Electroweak, Strong and Quantum Gravitational interactions, out of basic Lagrangian principles, will be the primary topic in Section 3 of a future draft. At this juncture, we shall attempt to provide an overview introduction to this theory, to outline some of the physical motivations toward the particular gauge theory to be presented, and to demonstrate the remarkable power and simplicity of the preonic approach to grand unification.