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Stationary String States as Theoretical Fermions

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Abstract

Excited states of the early vacuum are modeled as analogues of Weyl curvature states and corresponding gauge transformations which by hypothesis occur when closed, spin-2 strings sweep out closed world tubes. Admissible curvature states are restricted to those that preserve the implicitly indicated gauge. Calibration of this model establishes a theoretical sequence of masses that approximates the lepto-quark spectrum. Moreover, a new quark of mass $M \cong 30$ GeV/c^2 is predicted.

Keywords: string theory, conformal field theory, quarks, super-gravity

1. Analogue of Weyl Curvature

The discussion to follow recalls the geometry of Hermann Weyl in which the parallel displacement of a vector around a closed curve generally admits an increment of vector magnitude and a consequent gauge transformation:

$$\exp\oint\frac{dl}{l} = \exp\oint\phi_\mu dx^\mu \tag{1}$$

[9]. The Weyl geometry motivates a new string model in which vectors are replaced by closed strings. Specifically the parallel displacement of a vector around a closed curve is replaced by the transport of a closed, spin-2 string of length S that sweeps out a closed world tube. In this context the curvature that corresponds to an increment of vector magnitude in the Weyl model is

replaced by a curvature

$$W = \oint \frac{dS}{S} \tag{2}$$

that corresponds to an increment of string length. The curvature (2) is regarded as an analogue of Weyl curvature and will subsequently be referred to as "W-curvature."

Secondly it is observed that the outer circumference of a closed world tube can itself sweep out a closed world tube. If each of the two world tubes that together constitute this composite preserves gauge in the sense that $\exp[W^n/n!] = \exp[2\pi in]$: n=1,2, then the composite and corresponding W-curvature are admissible and the W-curvature is given by

$$\int_0^W \int_0^W dW dW = \frac{W^2}{2!} \tag{3}$$

[5]. The admissible composites that are characterized by the curvature (3) constitute a class of composites and a curvature class. Accordingly it is argued that a generalization of the process which produces this curvature class will produce m curvature classes; i.e. will produce m classes of composites, each class corresponding to a W-curvature

$$\text{W-curvature} = W^n/n! \quad n=1,2,3,\ldots,m. \tag{4}$$

For admissibility however, each class must preserve gauge in the sense

$$\exp(\frac{W^n}{n!}) = \exp[2\pi(i)n] \quad W = \oint \frac{dS}{S}: \tag{5}$$

W>0, n=1,2,3,…,m. Each world tube composite is interpreted as a stationary string state.

2. AdS/CFT Correspondence

Osp(1/4)-pure super-gravity on M_4 :

$$\mathcal{L} = \sqrt{-g}R + e\overline{\psi}_\mu \gamma_\nu \gamma^5 \nabla_\sigma \psi_\rho \varepsilon^{\mu\nu\rho\sigma} \tag{6}$$

is regarded as dual to the string background AdS_7XS^4 [3], [1]. The Lagrangian density (6) is based upon the super-Poincare algebra

$$[M_A, M_B\} = f^C{}_{AB} M_C \, , \tag{7}$$

where the components of M_A are

$$M_A = (P_a, -iM_{ab}, Q_\alpha) \, . \tag{8}$$

The P_α represent the translation group, the $-iM_{ab}$ constitute the adjoint representation of the Lorentz group and the Q_α are components of the SUSY generator. The $\omega^A{}_\mu$ describe all connection fields:

$$\omega^A{}_\mu = (e^a{}_\mu, \omega^{ab}{}_\mu, \bar{\xi}^\alpha{}_\mu) \tag{9}$$

and transform under Osp(1/4) as

$$\delta\omega^A{}_\mu = f^A{}_{BC} \varepsilon^B \omega^C{}_\mu \tag{10}$$

[4]. Finally then, the Osp(1/4)-covariant derivative is

$$\nabla_\mu = \partial_\mu + M_A \omega_\mu{}^A = \partial_\mu + e^a{}_\mu P_a - i\omega^{ab}{}_\mu M_{ab} + \bar{\xi}_\mu{}^\alpha Q_\alpha \tag{11}$$

and the Riemann curvature tensor is

$$R^A{}_{\mu\nu} = \partial_\nu \omega^A{}_\mu - \partial_\mu \omega^A{}_\nu + f^A{}_{BC} \omega^B{}_\mu \omega^C{}_\nu \, . \tag{12}$$

3. Calibration and Quantitative Results

The proposed model is calibrated by associating each element of the composite W-curvature class

$$\int_0^W \cdots (\int_0^W dW) \cdots dW = \frac{W^6}{6!} \tag{13}$$

with the mass of the heavy, spin-2 composite $T_L\psi_L\nu_R^{\tau^+}$, where T_L represents an LH top quark, where ψ_L represents a mass-less, LH, spin-2 field and where $\nu_R^{\tau^+}$ represents an RH anti-tauon's neutrino (the top quark and the tauon's neutrino are regarded as I_3=+1/2 partners in the heavy fermion generation). Thus the proposed hypothesis parallels Wheeler's ideal which attributes mass to curvature [10]. Specifically the proposed calibration assumes that

$$W=[180(\mathrm{GeV/c^2})]^{1/6}, \tag{14}$$

or that

$$\frac{W^6}{6!}=\frac{(180)GeV/c^2}{6!}=(0.25)GeV/c^2 \tag{15}$$

or

$$(6!)(0.25)GeV/c^2=(180)GeV/c^2 \tag{16}$$

[8].

It will now be argued that the context of this calibration and the structure of the proposed model combine to model additional mass classes. Specifically, an expression that is algebraically equivalent to (16) is obtained if both sides of (16) are divided by "6" to produce

$$(5)(4)(3)(2)(0.25)GeV/c^2=(30)GeV/c^2. \tag{17}$$

Interpretation of this unfamiliar mass will be deferred until after the massive states described by expressions (18), (19), (20) and (21) have been interpreted. Continuing then, both sides of (17) are divided by "5" to produce

$$(4)(3)(2)(0.25)GeV/c^2=(6)GeV/c^2. \tag{18}$$

The mass represented by expression (18) motivates the association of (18) with the composite $B_L\psi_L\tau_R^+$ or $\overline{B}_R\psi_L\tau_L^-$, where B_L is an LH bottom quark (a mass of about

4.3 GeV/c^2), where $\overline{B}_R$ is an RH anti-bottom quark, where τ_L^- is an LH tauon and where τ_R^+ is an RH anti-tauon (a mass of about 1.7 GeV/c^2). The bottom quark and the tauon are regarded as I_3= -1/2 partners in the heavy generation.

To observe a fourth state, both sides of (18) are divided by "4" to produce

$$(3)(2)(0.25)\text{GeV/c}^2=(1.5)\text{GeV/c}^2\,. \qquad (19)$$

The mass of expression (19) motivates the association of (19) with the composite spin-2 field $C_L\psi_L\nu_R^{\mu^+}$ or $\overline{C}_R\psi_L\nu_L^{\mu^-}$, where C_L and $\overline{C}_R$ respectively represent the LH charmed quark and the RH anti-charmed; and where $\nu_L^{\mu^-}$ and $\nu_R^{\mu^+}$ respectively represent the LH muon's neutrino and the RH anti-muon's neutrino. The charmed quark and the muon's neutrino are regarded as I_3=+1/2 partners in the moderately heavy generation.

To observe a fifth state, both sides of (19) are divided by "3" to produce

$$(2)(0.25)\text{GeV/c}^2=(0.5)\text{GeV/c}^2\,. \qquad (20)$$

The mass of expression (20) motivates the association of (20) with the composite, spin-2 field $S_R\psi_L e_L^+$ or $\overline{S}_L\psi_L e_R^-$, where S_R and $\overline{S}_L$ respectively represent the RH strange quark and the LH anti-strange, and where e_R^- and e_L^+ respectively represent the RH electron and the LH anti-electron. The strange quark and the right-handed electron are regarded as I_3 partners in the light generation. (In the proposed model S_R and e^-_R are classified by hypothesis as elements of a light quark-lepton generation.)

Finally, to observe a sixth state, both sides of (20) are divided by "2" to produce

$$\frac{(0.5)GeV/c^2}{2}=(0.25)GeV/c^2\,. \qquad (21)$$

The mass of expression (21) motivates the association of (21) with the average mass of the two spin-2 states: $U_L\Psi_L\nu_R^{e+}$ and $D_L\Psi_L e^+_R$, where U_L and D_L respectively represent the LH up quark and LH down quark, where Ψ_L represents a mass-less LH spin-2 field and where $\nu_L^{e^-}$ and e_L^- respectively represent the LH electron's neutrino and the LH electron. The up quark and the LH electron's neutrino are regarded as I_3=+1/2 partners in the light generation, and the down quark and LH electron are regarded as I_3= -1/2 partners in the light generation. Note that the I_3 value of the averaged states is I_3=0. The masses that are indicated by expressions (18), (19)

(20) and (21) are approximately equal to those determined by observation [2], [6].

To interpret the mass that is described by expression (17), it is first observed that the LH muon μ^-_L is not included in the foregoing discussion. Accordingly, the mass that is described by (17) is interpreted as the spin-2 composite $7_L \psi_L \mu_R^+$ or $\overline{7}_R \psi_L \mu_L^-$. Paralleling the earlier discussion, these composites are interpreted as lepto-quark states, the constituents of which share an I_3 classification and a generational classification. Thus the 7_L is interpreted as an unobserved LH quark that is characterized by $I_3 = -½$ and is regarded as a member of the moderately heavy generation. Finally, since the mass of the μ_L^- is relatively negligible, the mass of the newly predicted quark that is associated with expression (17) will be designated as approximately 30 GeV/c^2.

Conclusion

The spin-2 elements (16) through (21) cumulatively constitute a fundamental representation of a partially broken SU(3) symmetry (partially broken because masses are unequal):

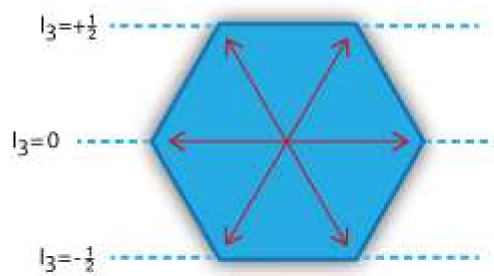

Figure 1
Three Generations of I_3 Generators

Specifically the proposed representation assumes the form

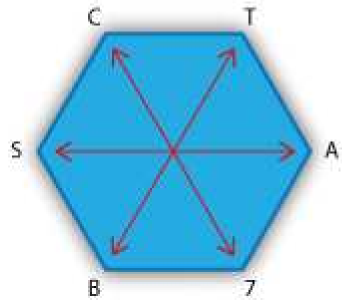

Figure 2
Fundamental Representation

where T represents the lepto-quark state (16), where 7 represents the state (17), where B represents (18), where C represents (19), where S represents (20) and where A represents (21) (the state A specifically representing the average of the masses and I_3 numbers of the up quark and its I_3 partner and the down quark and its I_3 partner).

In the proposed high energy model, spin-2 composites such as $T_L \psi_L \nu_R^{\tau^+}$ have essentially been treated as fundamental particles. However, the proposed model implicitly distinguishes leptons from quarks through what will be called super-gravitational conjugation. First order SUGRA GUT interactions that preserve I_3 and generation. appear to be admitted by the proposed model:

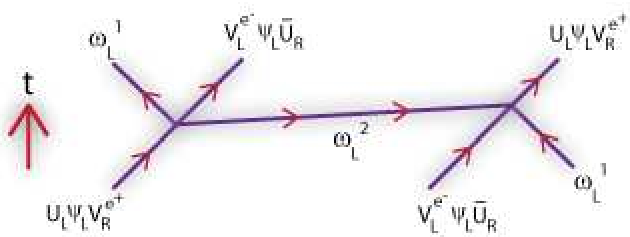

Figure 3
SUGRA Interactions

In Figure 3 the ω_L are components of the spin-(3/2) SUGRA connection (Equation 9). Specifically, $\omega_L^{\ 1}$ is regarded as equivalent to the composite $\nu_R^{\ e^+} \nu_R^{\ e^+} \overline{U}_R$ and $\omega_L^{\ 2}$ is regarded as equivalent to the composite $U_L U_L U_L$.

The proposed model of the micro-scale is supported by a feasibility argument that is based upon super-gravity. Specifically, a super-partner that is selected from the spin-(3/2) SUGRA connections (Equation 9) is assigned to each closed string of spin-2 that sweeps out an admissible world tube composite of curvature $W^n/n!$: n=1,2,3,... Moreover there is, by hypothesis, a 1-1 correspondence between the proposed classes of gauge preserving phase transformations on closed, spin-2 strings and the admissible classes of phase transformations on spin-(3/2) super-partners. The latter classes of phase transformations are interpreted as constituting inflation events, so that the proposed micro-scale model is implicitly related to a large scale model. Fortuitously, the latter model is equivalent to a model that was discussed by this author in 2008 [7]. The proposed large scale model demonstrates that if gauge transformations on SUGRA connections are restricted by gauge invariance, then the large scale structure is reduced to a hierarchy of maximally symmetric Riemannian states. If the number of theoretical inflation events is six (paralleling the six classes of curvature states by which the micro-scale is modeled above), then calibration of the proposed large scale construction in terms of a well-established boundary condition indicates a theoretical number of galaxies (about 3.6×10^{11}) that is approximately equal to the number indicated by observation.

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