Geometric reduction of the string landscape

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Abstract: The string background AdS 7XS 4 and dual CFT are adopted, and symmetric, multi-dimensional objects are identified as elements of the 7-dimensional vacuum that complements 4-spacetime in the proposed, 11-dimensional theory. Increments of the proposed, multi-dimensional elements with respect to increments of linear scale are (assuming a vacuum density) interpreted as creation operators or Higgs events that break SU(7). Each creation operator (each symmetry breaking event) and resulting mass is identified as a gauge transformation that preserves SUGRA gauge. If appropriately calibrated, the proposed model approximates the masses of the fermionic spectrum and predicts a new lepto-quark state of mass \( \frac{M}{\sqrt{3}} \) GeV/c². Because the proposed model derives quantization from gauge invariance (as proposed by F. London in 1927), this model can be implemented as a large scale quantization which results in a galactic hierarchy of states that maximize Riemannian symmetry. If the number of such states is equal to the range of the quantum number which, in the micro-scale model, generates the approximate lepto-quark masses, then the large scale model generates a theoretical number of galaxies that approximates the number indicated by observation.

I. The spontaneous breaking of SU(7)

Based upon AdS/CFT correspondence [1], the string background AdS 7XS 4 [2] and dual CFT are adopted. Thus a Type IIB theory of super-strings is regarded as equivalent to a maximally supersymmetric SU(N) Yang-Mills theory in a Minkowski 4-spacetime [3]. In this context, it is postulated that symmetric, (M+1)-dimensional classes of elements: \( l^{M+1} \): \( M = 0, 1, 2, \ldots, 6 \) collectively constitute the 7-dimensional vacuum that complements 4-spacetime in the proposed 11-dimensional theory. It is assumed that all such elements share the ground state energy or vacuum energy of this 7-dimensional domain and that the seven postulated classes of multi-dimensional elements constitute a fundamental representation of the group SU(N): N=7.

A second postulate recalls that conformal symmetries preserve angles and admit increments of scale. In this context increments \( d^M \) of the proposed (M+1)-dimensional magnitudes \( l^{M+1} \): \( M = 0, 1, 2, \ldots, 6 \) with respect to increments, \( dl \), of linear scale are identified as creation operators:

\[
d^M (l^{M+1}) = (M + 1)! dl \cdots \leftarrow M \rightarrow \cdots dl : \tag{1}
\]

\( M = 1, 2, \ldots, 6 \) that enhance the vacuum energy (divided by c²) which is, according to hypothesis, shared by the postulated multi-dimensional objects \( l^{M+1} \). Consequently, the factors \( (M+1)! \) which are generated by the proposed creation operators are regarded as the factors by which mass is enhanced. The resulting masses are collectively identified as constituting a fundamental representation of broken SU(7).
The resulting masses will also be identified as the masses of known lepto-quark states plus the mass of a predicted state. Specifically, because the proposed model is calibrated by averaging two of the elements that constitute the broken fundamental representation, the symmetry that will be applied consists of only six elements. Thus the applied symmetry can be represented in terms of a projection that distinguishes lepto-quark states in terms of only two quantum numbers: isotopic spin \(I_3\) and generation. Each vertex of the consequent hexagon can be identified with a specific lepto-quark state and with a specific creation operator provided that the proposed hexagon is divided into three levels, that each level is associated with a value of \(I_3\) and that increments of mass are associated with clockwise rotations about the center of symmetry of the hexagon.

This model is calibrated by association of the bottom base with \(I_3=0\), by association of the middle level with \(I_3=+1/2\) and by association of the top level with \(I_3 = -1/2\). A second aspect of the proposed calibration associates the vertex at the right side of the bottom base with the charmed quark state characterized by \(I_3=0\) and with the creation operator \(d^{M=1}\): \(M=1\) of (1). A second clockwise increment of rotation associates the vertex at the left side of the middle level with the lepto-quark state that is characterized by the charm quark and with the creation operator \(d^{M=2}\): \(M=2\) of (1). A third clockwise increment of rotation associates the vertex on the right side of the top level with the lepto-quark state that is characterized by the bottom quark and with the creation operator \(d^{M=3}\): \(M=3\) of (1). A fourth clockwise increment associates the vertex at the right side of the top level with a currently unknown lepto-quark state that is predicted and with the creation operator \(d^{M=4}\): \(M=4\) of (1) and finally a fifth clockwise increment associates the vertex which lies on the right side of the middle level with the lepto-quark state that is characterized by the top quark and by the creation operator \(d^{M=5}\): \(M=5\) of (1). To fully implement this model it is necessary to discuss details regarding observed values.

2. Comparison with observation

Since it is indicated that the proposed geometric process for the introduction of mass may approximate the masses of the fundamental fermions, it is important to discuss the observational data with which theoretical numbers are to be compared. The masses of leptons are well known, but there is some controversy regarding the masses of the quarks. The concept of quark mass is clarified however, if the constituent picture is prescribed for mesons and baryons that are made of quarks that are more massive than the up and down quarks. It is implicitly argued that the masses which emerge from the constituent quark model (where the sum of the constituent masses of valence quarks is roughly equal to the mass of a baryon or meson) are more relevant than those emerging from the Sine-Gordon Soliton model and the Chiral-Lagrange model. Based upon this argument, the masses of lepto-quark states will, in this discussion, refer to the constituent masses of quarks. These quark masses are approximately: charmed: \(1.5\) GeV/c\(^2\); strange: \(0.50\) GeV/c\(^2\); bottom: \(4.3\) GeV/c\(^2\). The mass of the top quark is \(176\) GeV/c\(^2\) (according to SLAC), but if this number is rounded to two significant digits, as are the other values, then the mass of the top quark is approximately \(180\) GeV/c\(^2\) [4], [5].

The second consideration that must be clarified if theoretical and experimentally established numbers are to be compared is the aforementioned calibration of the micro-scale. Since the masses of the up and down quarks are nearly the same, the initial condition, in terms of which calibration is done involves a mean of the masses of these quarks. An average or mean of the masses of the up and down quarks will be determined from three sources. The heaviest value will be indicated by the rho vector...
meson; the best known moderate value will be indicated by the proton and the lightest value will be indicated by the pion. If these means are averaged, the result is approximately 0.25 GeV/c^2. This number will be assigned to the fundamental vacuum energy (divided by c^2) that was introduced in the previous section. Adopting the notation “f” for this vacuum “mass” which is postulated as common to the elements \( l^{M+1} \) of the proposed 7-dimensional vacuum, it will now be demonstrated that the proposed hypothesis (embodied in expression (1)) prescribes an array of lepto-quark states that includes observed particles, plus a new lepto-quark state that is not currently recognized.

If \( N=1 \), then \( [(M + 1)!] f \) becomes

\[
(2)(0.25)\text{GeV} / c^2 = (0.5)\text{GeV} / c^2
\]

which approximates the observationally determined mass of the strange quark plus the relatively negligible mass of the \( \mu^- \).

If \( N=2 \), then \( [(M + 1)!] f \) becomes

\[
(3)(2)(0.25)\text{GeV} / c^2 = (1.5)\text{GeV} / c^2
\]

which approximates the observationally determined mass of the charmed quark plus the relatively negligible mass of the \( \nu^\mu \).

If \( N=3 \), then \( [(M + 1)!] f \) becomes

\[
(4)(3)(2)(0.25)\text{GeV} / c^2 = (6.0)\text{GeV} / c^2,
\]

which approximates the observationally determined mass of the bottom quark plus that of the \( \tau^- \) (the former of about 4.3 GeV/c^2 and the latter of about 1.7 GeV/c^2).

If \( N=4 \), then \( [(M + 1)!] f \) becomes

\[
(5)(4)(3)(2)(0.25)\text{GeV} / c^2 = (30.0)\text{GeV} / c^2,
\]

which corresponds to the mass of a lepto-quark state that is not currently recognized. This new state constitutes a prediction by which the proposed model lends itself to confirmation.

If \( N=5 \), then \( [(M + 1)!] f \) becomes

\[
(6)(5)(4)(3)(2)(0.25)\text{GeV} / c^2 = (180.0)\text{GeV} / c^2,
\]

which approximates the observationally determined mass of the top quark plus the relatively negligible mass of the tauon’s neutrino.

### 3. Lepto-quark states as stationary super-gravitational states

A fourth postulate associates the events that break the super-conformal symmetry with gauge transformations in a theory of pure super-gravity and identifies the individual mass classes that constitute the fundamental representation of the broken SU(7) symmetry as resulting from gauge transformations that preserve SUGRA gauge. To discuss SUGRA interactions and the gauge transformations that occur to the SUGRA connections it is necessary to briefly digress. The theory of 11-dimensional super-gravity is based upon an Osp(1/4)-symmetric Lagrangian:
\[ \mathcal{L} = \sqrt{-g} R + g^{\mu \nu} \gamma^5 \nabla_\mu \psi \gamma^\rho \psi_{,\rho} \epsilon^{\mu \nu \rho \sigma}, \]  

which is based upon the super-Poincare algebra

\[ [M_A, M_B] = f^{C \lambda} A_B M_C, \]  

where the components of diagonal generators \( M_A \) are

\[ M_A = \{ P_a, -iM_{ab}, Q_a \}. \]  

The \( P_a \) generate the translation group, the \(-iM_{ab}\) constitute the adjoint representation of the Lorentz group and the \( Q_a \) are components of the SUSY generator.

If the \( \omega^A \) describe all connection fields:

\[ \omega^A \mu = (e^a_\mu, \omega^{ab}_\mu, \bar{\xi}^a_\mu), \]  

and if the \( \omega^A \mu \) transform under Osp(1/4) as

\[ \delta \omega^A \mu = f^{A \lambda} B e^B e^C \omega^C \mu, \]  

then the Osp(1/4) covariant derivative is

\[ \nabla_\mu = \partial_\mu + M_A \omega^A \mu = \partial_\mu + e^a_\mu P_a - i\omega^{ab}_\mu + \bar{\xi}^a_\mu Q_a \]  

and the Riemannian curvature tensor is

\[ [\nabla_\mu, \nabla_\nu] = R^{A \mu \nu} M_A, \]  

where

\[ R^{A \mu \nu} = \partial_\mu \omega^A_\nu - \partial_\nu \omega^A_\mu + \omega^B_\nu \omega^C_\mu f^{A \lambda} B. \]  

[6]. In this context the interaction Hamiltonian for pure SUGRA interactions is

\[ -i(\alpha) \bar{\psi} \gamma^a \gamma^5 M_A \omega^A \mu \psi_{,\mu} \epsilon^{\mu \nu \rho \sigma}. \]  

In this context it is assumed that each lepto-quark state that constitutes an element of the fundamental representation of the broken SU(7) symmetry is individually preserved by a characterizing class of super-gravitational interactions. Accordingly, the transitions among these super-gravitational states are associated with gauge transformations (on the SUGRA connections) that preserve SUGRA gauge:

\[ \exp(i) \delta \omega^A = \exp(i) f^{A \lambda} B e^B e^C \omega^C = \exp[2i\pi M]. \]
An example of a SUGRA GUT interaction (a quark-lepton transition that is super-gravitationally mediated) is as follows:

![Diagram of a SUGRA GUT interaction](image)

**Figure 1  A First Order SUGRA Interaction**

Clearly this interaction is mediated by the SUGRA pair consisting of $e^+ \psi_L D_L$ and $D_L D_L D_L$. A pure SUGRA interaction that would involve a quark-lepton transition can be mediated by super-gravitational partners

$$\omega^\mu_A = (e^- \epsilon^+ \epsilon^- L)^A_{\mu} \quad \text{and} \quad (\psi^\mu)_L = (e^+ \psi_L D_L)_{\mu}$$

(17)

Each of the seven elements of the postulated fundamental representation of broken SU(7) is preserved by a characteristic SUGRA interaction; e.g. by an interaction that is mediated by an analogue of the SUGRA pair that is described by equation 17 (or depicted by Figure 1). Thus the 14 generators and connections of the Osp(1/4) theory are exhaustively implemented and each lepto-quark class is preserved by a characterizing super-gravitational interaction. It will now be argued that the stationary SUGRA states in terms of which the small scale is modeled can also be applied to the astrophysical scale.

4. Large scale SUGRA states

As just observed, the connection coefficients $\omega^\mu_A$ of local super-symmetry lend themselves to gauge transformations:

$$\exp(i\beta) \delta \omega^\mu = \exp(i\beta) f^A_{\ BC} \omega^\mu dx^\mu$$

(18)

under the local SUSY group Osp(1/4), where $\beta$ represents a scale factor. The large scale model that was introduced in 2008 [7] identifies inflation events with the gauge transformations that are intrinsic to local super-symmetry. Moreover, this model imposes gauge invariance, which restricts gauge transformations to those that preserve maximal Riemannian symmetry:

$$\exp(i\beta) f^A_{\ BC} \epsilon^B \omega^C = \exp[2i\pi N]$$

(19)
N=0,1,2,… Since this model is applied to the large scale it is calibrated in terms of a large scale boundary condition that is established by observation: It is observed that galaxies are typically separated by distances that are about ten times the diameter of the typical galaxy; that galactic clusters are typically separated by distances that are about ten times the diameter of the typical cluster etc. Based upon this boundary condition, the constant $\beta$ of expression (19) is chosen as

$$\beta \equiv 0.434294482\ldots,$$

so that the equation (19) reduces to

$$\exp[A^b_c B^b C^c] = 10^N;$$

N=0,1,2,…

If the range of the integral values N in expression (21) is the same as the final range of the quantum number M in Section 2 (since two values of M were incorporated into a single initial condition in that discussion, the proposed range of values was reduced from 0,1,2,…,6 to 0,1,2,…,5), then the large scale model that is associated with (21) describes a galactic hierarchy that parallels observation. Specifically, observations of local conditions reveal that the typical galaxy is about $c_0 t_0=10^5$ light years in diameter and that five galaxies populate the typical basic cluster. Based upon these boundary conditions and upon an assumption of homogeneity (up to very large scales), one can roughly associate the expression $(4/3)\pi R_1^3$, which will be regarded as approximately describing the volume of a typical basic cluster (in terms of galaxies) with the number ‘5.00.’ Thus, rounding to three digits it is concluded that typically, the radius of the cluster which associates with $N=1$ is about $R_1 \approx 1.06$. Now utilizing this value of $R_1$ and citing the boundary condition that corresponds to the equation (21), one determines the approximate ‘radius’ of the $N=2$ state (recall that clusters are typically separated by a distance about ten times the diameter of the typical cluster): $(2)(10)(1.06)=21.2$, which is interpreted as the approximate ‘radius’ of a super-cluster. Now proceeding similarly, one can determine the ‘radius’ of the $N=3$ state: $(2)(10)(21.2)=424$; of the $N=4$ state: $(2)(10)(424)=8480$ and of the $N=5$ state: $(2)(10)(8480)=169600$.

Since gauge invariance associates with maximal Riemannian symmetry, it is inferred that the initial phase transition on a SUGRA gauge connection (referring to expression (21) where $N=1$) produces a spherically symmetric wave front and that the phase transitions on this radially symmetric wave are also isotropically distributed. Specifically it is argued that the second of the phase transitions that is prescribed by (21) (that corresponding to $N=2$) emerges from each point of the initial wave just as this wave is initially propagated. It is argued that, due to inflation, the points of propagation become instantaneously separated so that the second wave appears as an isotropic distribution of semi-spherical, secondary wavelets that are mirror images of each other about the center of radial symmetry of the expansion. Analogously it is argued that the third of the phase transitions that is prescribed by (21) (that corresponding to $N=3$) emerges from each point of the secondary waves (just as the primary and secondary waves are simultaneously propagated). Again, due to inflation, these points become instantaneously separated so that the second wave appears as an isotropic distribution of semi-spherical, tertiary wavelets that are mirror images of each other about the center of radial symmetry of the initial expansion etc.

This sequence of phase transitions produces a Huygens pattern along the shock front of global expansion. The predicted empty “bubbles” of instantaneous expansion are observed by radio surveys of the regions near the event horizon [8]. The distributions of galactic clusters that are, according to observation, distributed along the boundaries of the bubbles probably result from the instantaneous expansions of the bubbles, which leave the more slowly expanding distributions of mass-energy at the interstices.
It is currently argued that the observable evidence of the big bang that exists today will ultimately disappear [9]. In this vein it is argued that the event horizon, which includes the Huygens pattern that is described above will ultimately disappear beyond the event horizon. It is argued that in this limit, the galaxies that initially constitute the interstices of inflationary bubbles will approach a distribution in which they approximate the surface of a large sphere. In this limit the radius of the N=5 configuration is implemented to determine the approximate surface area of this spherical idealization as a number of galaxies. This calculation produces about $4\pi R_5^2 \approx 3.63 \times 10^{11}$, which is approximately the number of galaxies that is indicated by observation.

**Conclusion**

Based upon AdS/CFT correspondence, the string background AdS$\times$S$^4$ and its dual CFT are adopted. Thus a Type IIB theory of super-strings is regarded as equivalent to a maximally super-symmetric SU(N) Yang-Mills theory in a Minkowski 4-spacetime. In this context, it is postulated that symmetric, (M+1)-dimensional classes of elements: $T^{M+1}$: $M=1,2,...,6$ collectively constitute the 7-dimensional vacuum that complements 4-spacetime in the proposed 11-dimensional theory. It is postulated that these symmetric, multi-dimensional elements share the energy of the vacuum and constitute a fundamental representation of super-conformal SU(7). Secondly it is postulated that increments of the proposed, multi-dimensional objects with respect to increments of linear scale act as creation operators that enhance the vacuum energy (divided by $c^2$) which is by hypothesis shared by the postulated multi-dimensional objects, thereby breaking the super-conformal symmetry of the vacuum. Calibration of this model approximates the masses of known lepto-quark states and predicts a new lepto-quark state of approximate mass $\frac{302}{c^2}$ GeV.

It is argued that the elements which constitute the fundamental representation of the broken SU(7) are individually preserved by characterizing SUGRA interactions. Specifically, it is observed that mediating SUGRA connections are susceptible to gauge transformations under the local SUSY group, but it is argued that if such gauge transformations are restricted to those that preserve SUGRA gauge, then the elements of broken SU(7) that are individually preserved by characterizing SUGRA interactions are distinguished in that they preserve maximal Riemannian symmetry and thereby select small values of the cosmological constant (as opposed to the large values that seem to associate with large scale chaos).

Since quantization is derived in this model from gauge invariance, as proposed by F. London in 1927, this model is implemented as a large scale quantization, which results in a galactic hierarchy of states (each preserving maximal Riemannian symmetry). If the range of the relevant large scale quantum number is equal to the range of the quantum number which, in the micro-scale model approximates the lepto-quark spectrum, then the large scale model produces a theoretical number of galaxies that approximates the number indicated by observation.

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