SUGRA INTERACTIONS AT THRESHOLDS OF ASYMPTOTIC FREEDOM

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Abstract. A generic, heterotic string theory is uniquely reduced to the standard model in terms of a geometry that transcends compactification. This device also extends the standard model to embrace three generations of fermions, including a left-handed strange quark that is devoid of strangeness and three right-handed neutrinos. Finally, the proposed hypothesis indicates supergravitationally mediated quark-lepton transitions that preserve baryon structure, departing from the SUSY GUT tradition that predicts proton decay.

1. A Unique Reduction to the Standard Model

The current status of high energy physics confronts two significant problems: that SUSY GUT theories predict a proton decay, which is not observed, and that heterotic string models (the only finite, physical models) of supergravity do not uniquely reduce to the standard model at SM scale. Both problems are addressed in terms of a geometry, which transcends compactification by preserving the geodesic nature of world tube coupling.

A pure supergravitational transition at string scale is envisioned as an absorption-radiation event that is encountered by a closed string of spin 3/2, as that string sweeps out a geodesic world tube in 10-spacetime. Each absorption-radiation event involves the absorption of a string of spin 2 and the simultaneous radiation of a second, generally distinct string of spin 2 through the mediation of a graviton vertex operator (GVO). The constraint of simultaneity is necessary to conserve intrinsic angular momentum along the world tube of spin 3/2. Two classes of spin-2 fields and two classes of GVOs are postulated. A Class I GVO is identified with the absorption of a Class I string of spin 2 and the radiation of a Class II string of spin 2. A Class II GVO is identified with the opposite order of absorption and radiation.

It is observed that GVOs experience "geodesic coupling" at string scale, where geodesic coupling refers to coupling in terms of a world tube that is swept out by a string of spin 3/2 (closed string analogue of a gauge field of local supersymmetry). In this context a transcendental geometry is defined as consisting of world tubes of spin 3/2 that map under compactification onto spin 3/2 geodesic couplings of GVO particle analogues (also to be known as GVOs) and of their spin 2 superpartners. Because compactification is defined in terms of an E_8 symmetry, which breaks to yield SU(5)XSU(3) (in both observable and hidden sectors), a spin 3/2 geodesic coupling is defined as one that preserves SU(5)XSU(3) as well as local supersymmetry and the spin-(3/2) nature of the gauge coupling. If SU(5) is defined so that the conserved parameters are J_3, Y, fermion number and generation, then the proposed hypothesis yields three fundamental representations of SU(5) in terms of GVOs, which correspond to three orientations of the J_3 axis about the Y axis, forming a representation of SU(3) on a plane that is orthogonal to the orientations of the SU(5) symmetries. Thus if one can constrain the spin 1 sector of each GVO
to consist exclusively of a photon, then up to constant scale factors, three generations of quarks and three generations of leptons are established. This reduction of heterotic string theory to the standard model should be compared with a reduction that was obtained from more traditional considerations [W. Buchmüller, 2005].

The coordinates and corresponding gauge particles of one orientation of the $I_3XY$ grid about the $Y$ axis are:

\begin{align*}
(1.1) & \quad I_3 = 1/2, Y = 1/3 : U_L, \nu^-_L \\
(1.2) & \quad I_3 = -1/2, Y = 1/3 : D_L, e^-_L \\
(1.3) & \quad I_3 = 0, Y = 2/3 : S_L, \mu^+_L \\
(1.4) & \quad I_3 = 1/2, Y = -2/3 : U_R, \nu^-_R \\
(1.5) & \quad I_3 = -1/2, Y = -2/3 : D_R, e^-_R.
\end{align*}

The coordinates and corresponding gauge particles of a second orientation, $2\pi/3$ from the initial orientation, are:

\begin{align*}
(1.6) & \quad I_3 = 1/2, Y = 1/3 : C_L, \nu^\mu_L \\
(1.7) & \quad I_3 = -1/2, Y = 1/3 : S_L, \mu^-_L \\
(1.8) & \quad I_3 = 0, Y = 2/3 : S_L, \mu^+_L \\
(1.9) & \quad I_3 = 1/2, Y = -2/3 : C_R, \nu^\mu_R \\
(1.10) & \quad I_3 = -1/2, Y = -2/3 : S_R, \mu^-_R.
\end{align*}

Finally, the coordinates and gauge particles of a third orientation, $4\pi/3$ from the initial orientation, are:

\begin{align*}
(1.11) & \quad I_3 = 1/2, Y = 1/3 : T_L, \nu^-_L \\
(1.12) & \quad I_3 = -1/2, Y = 1/3 : B_L, \tau^-_L \\
(1.13) & \quad I_3 = 0, Y = 2/3 : S_L, \mu^+_L \\
(1.14) & \quad I_3 = 1/2, Y = -2/3 : T_R, \nu^-_R \\
(1.15) & \quad I_3 = -1/2, Y = -2/3 : B_R, \tau^-_R.
\end{align*}

In all cases, the $Y$ coordinate of the quark and lepton are calculated in terms of the equation

\begin{align*}
Y = B + S + QHC + LHC,
\end{align*}
and the $I_3$ coordinate of the quark and lepton are calculated in terms of the equation:

$$I_3 = Q + (1/2)QHC + (1/2)LHC + (1/2)LIC - (1/2)Y,$$

where $QHC$ refers to 'quark hypercharge constant', $LHC$ refers to 'lepton hypercharge constant', $LIC$ refers to 'lepton isospin constant' and LIC+LHC refers to the sum. The values of these constant scale factors that are compatible with both symmetry and internal consistency are:

$$QHC(RH_{non-strange}quark) = -1$$

$$QHC(everythingelse) = 0$$

$$LHC(LHlepton) = 1/3,$$

$$LHC(RHlepton) = -2/3,$$

$$LIC + LHC(LHlepton) = 4/3$$

$$LIC + LHC(RHlepton) = 1/3$$

and

$$LIC + LHC(RH_{anti-lepton}) = 1/3.$$

This result should be compared with the traditional standard model and with the extension of this model that includes three fermionic generations [D. Nordstrom, 1992].

The issue of proton decay is now addressed. It is generally accepted that quarks coalesce to form triplets at about 1 TeV, and that supersymmetry is intact at scales just above 1 TeV. It is therefore argued that the supergravitational activity, which has been discussed, is indeed realized at scales below compactification scale, and specifically at scales around 1 TeV, by interactions between fields of spin 2 and valance quarks that reside within baryons of spin 3/2. These are quarks that are experiencing asymptotic freedom. It can be shown that such interactions include quark-lepton interactions that preserve baryon structure; but first the nature of the spin-2 fields that emerge from the proposed theory must be considered. The next section will describe such fields.

2. Specific Spin-2 Fields

The formulation of an appropriate spin-2 field involves a GVO

$$OP_{\epsilon_L} \equiv \gamma_L \otimes \bar{e_R}$$

and a corresponding spin-(3/2) field

$$\psi_{DL} = \bar{U}_L D_L U_L$$

where a bar indicates an anti-field and a prime indicates anti-alignment of an anti-field. If the entities 2.1 and 2.2 coalesce, then the result is clearly the spin-2 field

$$OP_{\epsilon_L} \otimes \psi_{DL} \equiv G_L^A$$
or
\[ (2.4) \quad \gamma_L \otimes \overline{e_R} \otimes U'_L D_L U_L = G_L^A \]
which describes a spin-2 resultant field that retains the color of \( D_L \), retains the
color of \( D_L \), retains the charge \( Q(D_L) + Q(e_L) = 2/3 \) and the \( I_3 \) number: \( I_3 = 0 \).

A second spin-2 field class is produced when the GVO
\[ (2.5) \quad OP_{D_L} \equiv \gamma_L \otimes \overline{D_R} \]
interacts with the same spin-(3/2) field as that described by Equation 2.2 (\( \psi_{D_L} = U'_L D_L U_L \)). In this case one obtains
\[ (2.6) \quad OP_{D_L} \otimes \psi_{D_L} = g_L^A \]
or
\[ (2.7) \quad \gamma_L \otimes \overline{D_R} \otimes U'_L D_L U_L = g_L^A. \]
The latter spin-2 field is clearly characterized by zero mass, zero charge, is colorless
and is also characterized by \( I_3 = 0 \). The spin-2 fields \( G_L \) and \( g_L \) will subsequently be known as Class I, Type A and Class II, Type A.

Let us now consider the two GVOs
\[ (2.8) \quad OP_{e_R} \equiv \gamma_R \otimes \overline{e_L} \]
and
\[ (2.9) \quad OP_{U_R} \equiv \gamma_L \otimes \overline{U_R} \]
which interact with the spin-(3/2) field
\[ (2.10) \quad \psi_{U_L} = D'_L U_L D_L \]
to respectively produce the spin-2 fields
\[ (2.11) \quad \gamma_L \otimes \overline{e_R} \otimes \overline{D'_L U_L D_L} = G_L^B \]
and
\[ (2.12) \quad \gamma_L \otimes \overline{U_R} \otimes \overline{D'_L U_L D_L} = g_L^B. \]
(Note that the quantum numbers, other than mass (which is presumably absent
in contexts where SUSY is unbroken), of \( G_R^B \) and \( g_R^B \) are the same as those that characterize \( G_R^A \) and \( g_R^A \).)

Thirdly, let us consider the two GVOs
\[ (2.13) \quad OP_{e_R} \equiv \gamma_R \otimes \overline{e_L} \]
and
\[ (2.14) \quad OP_{D_R} \equiv \gamma_R \otimes \overline{D_L} \]
that interact with the spin-(3/2) field
\[ (2.15) \quad \psi_{D_R} = D'_R D_R D_R \]
to respectively produce the spin-2 fields
\[ (2.16) \quad \gamma_R \otimes \overline{e_L} \otimes \overline{D'_R D_R D_R} = G_R^C \]
and
\[ (2.17) \quad \gamma_R \otimes \overline{D_L} \otimes \overline{D'_R D_R D_R} = g_R^C. \]
(Again, the quantum numbers of \( G^C \) and \( g^C \) are the same as those that characterize \( G^A \) and \( g^A \). As indicated above, analogues of \( G^A, G^B, G^C, g^A, g^B \) and \( g^C \) exist for all three generations [J. Towe, 2003].)

Now that spin-2 fields have been assigned specific structure, one can consider a realization of the theory of pure supergravity which impacts the standard model. Again the proposed realization occurs at approximately 1 TeV, where quarks are bound into triplets. Because supersymmetry remains intact at just above 1 TeV, it is argued that the proposed supergravitational interactions can occur between fields of spin 2 and baryons of spin 3/2. Specifically, such interactions are regarded as occurring between the proposed fields of spin-2 and valance quarks that reside within baryons of spin 3/2. These are quarks that are experiencing asymptotic freedom. Such interactions can also occur within baryons of spin 1/2 provided that mediations are complemented by theoretically provided photons (this to preserve local supersymmetry). Before considering the proposed interactions let us summarize the above described nature of the spin-2 fields and the supergravitational couplings that were prescribed by this section. Spin 2 fields occur in two classes: a class that consists of elements of charge 2/3 that are characterized by a single color and an \( I_3 \) value of zero; and a class that consists of elements that are charge-less, colorless and also characterized by \( I_3 = 0 \). There are three types of supergravitational couplings per generation: one for each pair of GVOs that share a common value of \( I_3 \) and \( Y \); i.e. one for each type of SUGRA interaction. Interaction types are designated A, B and C. Prototypes of the interactions that are proposed for the 1 TeV energy scale will now be considered.

3. SUPERGRAVITATIONALLY MEDIATED QUARK-LEPTON TRANSITIONS

An example of the Type A interaction occurs when a left-handed down quark absorbs a spin-2 anti-field of class I, Type A, also designated \( \overline{G}^A_R \) and radiates a spin-2 anti-field of class II, Type A, also designated \( \overline{g}^A_R \), producing a left-handed electron. This transition is quickly reversed so that baryon structure is preserved.

An example of a Type B interaction occurs when a left-handed up quark absorbs a spin 2 anti-field of Class I, Type B, also designated \( \overline{G}^B_R \) and radiates a spin 2 anti-field of Class II, Type B, also designated \( \overline{g}^B_R \) to produce a colorless, left-handed particle of spin 1/2 with a charge of zero; i.e. a left-handed electron’s neutrino. In both cases the baryon could be a \( \Delta^0 \). An example of a Type C interaction occurs when a right-handed strange quark absorbs a spin 2 anti-field of Class I, Type C (also designated \( \overline{G}^C_R \)), generation II, and a radiates a spin 2 anti-field of Class II, Type C (also designated \( \overline{g}^C_R \)), generation II to produce a right-handed muon: Here the baryon could be an \( \Omega \) (triplet SSS). Clearly, the proposed interactions are occurring to all generations of quarks, and are (from symmetry considerations) generation specific.

The proposed interactions can also occur within baryons of spin-(1/2) provided that a photon is absorbed and radiated together with each spin-2 anti-field to preserve local supersymmetry.

4. CONCLUSION

It was recalled that high energy physics confronts two important problems: that SUSY GUT theories predict a proton decay that is not observed and that heterotic
string models of supergravity do not uniquely reduce to the standard model at SM scale. Both problems were addressed in terms of a proposed differential geometry that transcends compactification. Specifically, it was proposed that geodesic world tubes be regarded as elements of a transcendent geometry if and only if they map under compactification onto 'geodesic couplings' of GVO particle analogues, which were subsequently referred to as GVOs. In a context where compactification was interpreted as a breaking of $E_8$ which forms $SU(5) \times SU(3)$, a geodesic coupling was defined as a coupling that preserves $SU(5) \times SU(3)$ as well as local supersymmetry and the spin-(3/2) nature of the gauge connection.

$SU(5)$ was defined so that the conserved parameters are $I_3$, $Y$, fermion number and generation. In this context the proposed hypothesis resulted in three fundamental representations of $SU(5)$ on $I_3 XY$ grids that were in terms of GVOs and symmetrically oriented about one $Y$ axis, thereby projecting onto an orthogonal plane as a representation of $SU(3)$. By constraining the spin 1 sector of the GVO to consist exclusively of a photon, three generations of quarks and three generations of leptons were established up to constant scale factors. It was concluded that the postulated transcendent geometry had reduced a generic, heterotic string theory to the standard model, and had extended the standard model to embrace three generations of fermions, including a new quark and three right-handed neutrinos. The new quark was characterized as a left-handed strange quark, which in the context of what was postulated, is characterized by a baryon number of 1/3 and a hypercharge of 1/3; i.e. by a strangeness number of zero.

Finally, the issue of proton decay was addressed. It was noted that quarks come together to form triplets at about 1 TeV, and that supersymmetry is intact at just above 1 TeV. It was therefore argued that the supergravitational activity, which had been discussed, is indeed realized at scales below compactification scale, and specifically at a scale around 1 TeV, by interactions between fields of spin 2 and valance quarks that reside within baryons of spin 3/2. It was emphasized that these quarks are experiencing asymptotic freedom. Before it could be demonstrated that such interactions produce quark-lepton transitions that preserve baryon structure, it was necessary to consider the nature of the spin-2 fields that emerge from the proposed theory.

It was observed that such fields occur in two categories: one consisting of elements of charge 2/3, a single color and an $I_3$ number of zero; and a second consisting of elements that are charge-less, colorless and also characterized by an $I_3$ number of zero. In this context the three indicated types of supergravitational interactions (per generation) were considered. These interactions were described in some detail. It was demonstrated that baryon structure is not disturbed and it was observed that the same types of interactions can occur within baryons of spin 1/2, provided that photons are absorbed and radiated together with each spin-2 anti-field—this to preserve local supersymmetry. In closing, the preservation of baryon structure by interactions with the postulated gravitational radiation field was compared with preservations of atomic structure by similar interactions with the electromagnetic radiation field of QED.

References

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