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Superon-quintet and graviton model for supersymmetric spacetime and matter

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Abstract. By using the irreducible representation of $N = 10$ extended Super-Poincaré algebra, an attempt to interpret the quarks, the leptons and the gauge bosons except the graviton as the composites of more fundamental objects with spin 1/2, *superon quintet*, is presented. All the local gauge interactions of GUTs are investigated systematically by using the superon diagrams. The stability of the proton and the suppression of the flavour changing neutral currents are understood naturally in the superon pictures of GUTs. The fundamental action of the model is proposed and the uniqueness of the model is pointed out.

1 Introduction

The (local) supersymmetry (SUSY) [1] is the most promising notion for explaining the rationale of beings of all elementary particles including the graviton. However, as shown by Gell-Mann [2], SO(8) maximally extended supergravity theory (SUGRA) is too small to accommodate all observed particles as elementary fields within the framework of the local field theory. On the contrary, at the risk of the local field theory at the moment, it is interesting from the viewpoints of simplicity and beauty of nature to attempt the accomodation of all observed elementary particles in a single irreducible representation of a certain group (algebra). In the previous paper [3], by identifying the graviton as the Clifford vacuum state (not necessarily the lowest energy state) of SO(N) extended super-Poincaré algebra (SPA) we have studied the irreducible representations of SO(N) SPA for the massless case. By only the group theoretical arguments we have shown [3] that SPA with $N = 10$, 11 and 12 may be relevant to the unified description of matters and forces, where the graviton is identified with the Clifford vacuum state of SO(N) extended SPA. And we found that $N = 10$ stands out among them for the assignment of quantum numbers adopted in [3] to supercharges Q^N $(N = 1, 2, \ldots, 10)$ of SO(10) SPA is unique in order to realize minimally all observed quarks, leptons and gauge bosons as the low energy massless states of the representations. So far, our arguments were pure mathematical and lacked the physical (field theoretical) interpretations of the results.

In this article, after the quick review of the results of [3] for the self-contained arguments, we will show that we can interpret the results from the viewpoints of the internal structure of the quarks, the leptons and the gauge bosons except the graviton. We see that at (above) the Planck energy scale the ground state of nature (spacetime and matter) may possess SO(10) super-Poincaré symmetric structure and that the structure of the tower of the massless irreducible representations of SO(10) SPA reveal the structure of the relativistic composite states counted upon the Clifford (mathematical) vacuum. Our discussions are focused to $N = 10$ and the uniqueness of the model is pointed out. We write down the fundamental Lagrangian of the model, which may describe the dynamics of the fundamental constituents at the Planck scale.

2 SO(10) SPA

In [3], by noting that generators Q^N $(N = 1, 2, \ldots, 10)$ of SO(10) SPA are the fundamental represemtations of SO(10) internal symmetry and that $SO(10) \supset SU(5) \supset SU(3) \times SU(2) \times U(1)$ we have decomposed 10 generators Q^N of SO(10) SPA as follows with respect to SO(10) internal symmetry

$$\begin{aligned} \underline{10} &= \underline{5}(Q^N; N = 1, 2 \ldots 5) + \underline{5}^*(Q^N; N = 6, 7, \ldots 10) \\ &= \left\{ \left(\underline{3}, \underline{1}; -\frac{1}{3}, -\frac{1}{3}, -\frac{1}{3} \right) + (\underline{1}, \underline{2}; 1, 0) \right\} \\ &\quad + \left\{ \left(\underline{3}^*, \underline{1}; \frac{1}{3}, \frac{1}{3}, \frac{1}{3} \right) + (\underline{1}, \underline{2}^*; -1, 0) \right\} , \end{aligned} \qquad (1)$$

where we have written (SU(3), SU(2); electric charges).

In order to see easily the helicity contents of the irreducible representation for the massless case $(P_\mu P^\mu = 0)$ we go to the little algebra of SO(10) SPA, where we can always choose the light-like frame $P_\mu = \epsilon(1, 0, 0, 1)$. In terms of two-component Weyl spinors, the little algebra for the supercharges in this frame now becomes after suitable rescaling

$$\{Q^M_\alpha, Q^N_\beta\} = \{\bar{Q}^M_{\dot{\alpha}}, \bar{Q}^N_{\dot{\beta}}\} = 0 \quad \{Q^M_\alpha, \bar{Q}^N_{\dot{\beta}}\} = \delta_{\alpha 1}\delta_{\dot{\beta}\dot{1}}\delta^{MN} , \qquad (2)$$

where $\alpha, \beta = 1, 2$ and $M, N = 1, 2, \ldots 10$. As a cosequence of (1) the spinor charges Q_{1}^{M}, $\bar{Q}_{\dot{1}}^{M}$ satisfy the algebra, of annihilation and creation operators respectively and can be used to construct a, 4-dimensional Fock space with positive metric. For the massless case, the Clifford vacuum $|\Omega(\lambda)\rangle$ is a representation of the little group E_2 of a light-like vector, i.e. a massless state of a given helicity $\pm\lambda$, if space inversion is considered. We identify the graviton with the Clifford vacuum $|\Omega(\lambda)\rangle$ (not necessarily the lowest energy state), which satisfies

$$Q_{\alpha}^{M}|\Omega(\lambda)\rangle = 0 \tag{3}$$

and build up a new state with helicity $(2 - \frac{n}{2})$ by

$$\bar{Q}_{\dot{1}}^{M_1}\bar{Q}_{\dot{1}}^{M_2}\ldots\bar{Q}_{\dot{1}}^{M_n}|\Omega(\lambda)\rangle \,. \tag{4}$$

(Note that the helicities of such states are determined by the SO(10) SPA.) These states given by the Clifford vacuum $|\Omega\rangle$ and all states of (3) obtained from $|\Omega\rangle$ by multiplying with every possible product of the creation operators $Q_{\dot{1}}^{M}$ span an irreducible $2 \cdot 2^{10}$ dimensional representation of the little algebra (1) of SO(10) SPA. It contains helicities up to ± 3, if parity is included. For a reference we show in the following explicitly all states of SO(10) SPA and specify them by SO(10) dimension $\underline{d}$ and the helicity λ, as $\underline{d}(\lambda)$:

$$\Big[\underline{1}(+2), \underline{10}\left(+\frac{3}{2}\right), \underline{45}(+1), \underline{120}\left(+\frac{1}{2}\right), \underline{210}(0), \underline{252}\left(-\frac{1}{2}\right), \underline{210}(-1), \underline{120}\left(-\frac{3}{2}\right), \underline{45}(-2), \underline{10}\left(-\frac{5}{2}\right), 1), \underline{1}(-3)\Big] + [\text{CPT-conjugate}] \tag{5}$$

By noting that the helicity of every such state as (3) and (4) is automatically determined by SO(10) SPA and that Q_{1}^{M} and $\bar{Q}_{\dot{1}}^{M}$ satisfy the algebra of the annihilation and the creation operators for the spin $\frac{1}{2}$ particle, we speculate that these states (3) and (4) are the relativistic (gravitational) massless composite states spanned upon the mathematical (not the physical vacuum with the lowest energy) Clifford vacuum and are composed of the fundamental object Q^N *superon* with spin $\frac{1}{2}$. Therefore we regard (1) as a *quintet of superons* and a *quintet of antisuperons*. The identification of the generators of SO(10) SPA with the fundamental objects (particles) is strange so far especially from the viewpoint of the familiar local gauge field theory. We will consider these problems later and show (a possibility of) a fundamental (local) field theory of the superons.

Now we envisage the Planck scale physics as follows: At (above) the Planck energy scale, the ground state of spacetime and matter have the structure described by SO(10) SPA, where the gravity dominates and creates the pairs of the superon-quintet and the antisuperon-quintet from the vacuum in such a way as superon-composites (massless) states span the irreducible (massless) representations of SO(10) SPA upon the (Clifford) vacuum.

3 Superon quintet model (SQM)

3.1 Quarks, leptons and gauge bosons in SQM

From the viewpoints of the superon hypothesis we can investigate more concretely the physical meaning of the results obtained in [3]. For simplicity we use the following notations for superons Q^N $(N = 1, 2, \ldots 10)$.

For the superon quintet $\underline{5}$: $[(\underline{3}, \underline{1}; -\frac{1}{3}, -\frac{1}{3}, -\frac{1}{3}), (\underline{1}, \underline{2}; +1, 0)]$, we use

$$\Big[(Q_a, Q_b, Q_c), (Q_m, Q_n); a, b, c = 1, 2, 3; m, n = 4, 5\Big] \tag{6}$$

and for the antisuperon-quintet $\underline{5}^*$: $[(\underline{3}^*, \underline{1}; +\frac{1}{3}, +\frac{1}{3}, +\frac{1}{3}), (\underline{1}, \underline{2}^*; -1, 0)]$, we use

$$\Big[(Q_a^*, Q_b^*, Q_c^*), (Q_m^*, Q_n^*); a, b, c = 1, 2, 3; m, n = 4, 5\Big] \,. \tag{7}$$

Accordingly we can specify explicitly all the the states corresponding to observed quarks, leptons and massless gauge bosons of the standard model (SM) [4] presented in [3] as follows. The multiplicity of the fermionic states specified by the quantum numbers of (SU(3), SU(2); electric charges) is counted in the two-component Weyl spinor unit. (SO(10) normalization factor is neglected.)

$(\nu_e, e)_L$ *type leptons:* Four generations from $\underline{120}$; $(Q_m \epsilon_{ln} Q_l^* Q_n)$, $(Q_a Q_a^* Q_m)$ and conjugate states. Four generations from $\underline{252}$; $\epsilon_{abc} Q_b Q_c \epsilon_{ade} Q_d^* Q_e^* Q_m$, $Q_a Q_a^* \epsilon_{lm} Q_l^* Q_m^* Q_n$, and conjugate states.

$(\nu_e)_R$ *type leptons:* Two generations from $\underline{252}$; $\epsilon_{abc} Q_a Q_b Q_c \epsilon_{mn} Q_m Q_n$ and conjugate states.

$(e)_R$ *type leptons:* Two generations from $\underline{120}$; $\epsilon_{abc} Q_a Q_b Q_c$ conjugate states. Two generations from $\underline{252}$; $\epsilon_{abc} Q_a Q_b Q_c Q_m Q_m^*$ and conjugate states.

$(u, d)_L$ *type quarks:* Two generations from $\underline{120}$; $\epsilon_{abc} Q_b^* Q_c^* Q_m^*$ and conjugate states. Four generations from $\underline{252}$; $\epsilon_{abc} Q_a^* Q_b^* Q_c^* Q_d Q_m^*$, $\epsilon_{abc} Q_b^* Q_c^* Q_l \epsilon_{mn} Q_m^* Q_n^*$ and conjugate states.

$(u)_R$ *type quarks:* Two generations from $\underline{120}$; $Q_a \epsilon_{mn} Q_m Q_n$ and conjugate states. Two generations from $\underline{252}$; $\epsilon_{abc} Q_b Q_c Q_a^* \epsilon_{mn} Q_m Q_n$ and conjugate states.

$(d)_R$ *type quarks:* Four generations from $\underline{120}$; $Q_a^* \epsilon_{abc} Q_b Q_c$, $Q_a Q_m Q_m^*$ and their conjugate states. Six generations from $\underline{252}$; $\epsilon_{abc} Q_a Q_b Q_c \epsilon_{def} Q_e^* Q_f^*$, $\epsilon_{abc} Q_b Q_c Q_a^* Q_m Q_m^*$, $Q_a \epsilon_{kl} Q_k Q_l \epsilon_{mn} Q_m^* Q_n^*$, and conjugate states.

SU(2) × U(1) gauge bosons: One singlet state from $\underline{45}$; $\frac{1}{\sqrt{2}}(Q_4 Q_4^* - Q_5 Q_5^*)$. One triplet state from $\underline{45}$; $\{-Q_4 Q_5^*, \frac{1}{\sqrt{2}}(Q_4 Q_4^* + Q_5 Q_5^*), Q_5 Q_4^*\}$.

SU(3) gluons: One octet state from $\underline{45}$; $\{Q_1 Q_3^*, Q_2 Q_3^*, +Q_1 Q_{2*}, \frac{1}{\sqrt{2}}(Q_1 Q_1^* - Q_2 Q_2^*), Q_2 Q_1^*, \frac{-1}{\sqrt{6}}(2Q_3 Q_3^* - Q_2 Q_2^* - Q_1 Q_1^*), +Q_3 Q_2^*, Q_3 Q_1^*\}$.

SU(2) Higgs Boson: One doublet state from $\underline{210}$; $\epsilon_{abc} Q_a Q_b Q_c Q_m$ and conjugate states.

(X, Y) *leptoquark bosons* in GUTs(SU(5), SO(10)): From $\underline{45}$ we obtain: $Q_a^* Q_m$ and a conjugate states.

The specifications of SU(5) leptoquark states are interesting concerning the proton decay, for the symmetry breaking via SU(5) invariance may be worthwhile to consider. For the gauge bosons we have considered only the adjoint representation of SO(10) SPA. Although the mass generation mechanism, i.e. the mechanism of the symmetry breaking, [SO(10) massless SPA upon the Clifford vacuum]
$\longrightarrow$ [...]
$\longrightarrow$ [$SU(3) \times SU(2) \times U(1)$]
$\longrightarrow$ [$SU(3) \times U(1)$] is yet to be examined and discussed later, we dare to pe form $SU(3) \times SU(2) \times U(1)$ invariant recombinations of the helicity states of the massless irreducible representation of the little algebra of SO(10) SPA in order to see the possible contents of $SU(3) \times SU(2) \times U(1)$ invariant massive states of the irreducible representation of the little algebra of PA. Through the recombination, many of the lower helicity $(\pm\frac{3}{2}, \pm 1, \pm\frac{1}{2}, 0)$ states of SO(10) SPA are converted to the longitudinal components of the higher spin massive states of PA and others remain massless. In [3] we have carried out the recombination among $2 \cdot 2^{10}$ helicity states and found surprisingly all massless states necessary and sufficient for the SM with three generations of quarks and leptons appear in the surviving massless states. A few characteristic (i.e. independent on the intermediate symmetry breaking pattern) predictions which can be tested by the high energy particle experiment are presented in [3].

Now superons may be for quarks, leptons, gauge bosons except the graviton, and Higgs bosons what quarks are for baryons and mesons. Then it is interesting to perform the similar analysis used in the quark model for the hadron physics [7], which may give phenomenologically the superon dynamics at the Planck scale.

3.2 SQM and superon diagram

To see concretely the physical (phenomenological) implications of the superons for the unified gauge models (SM and GUTs) it is very important to understand all the gauge couplings of the unified gauge models in terms of the superon pictures. Now we consider the assignments of observed quarks and leptons to the massless representation of SO(10) SPA. For simplicity we neglect the mixing between the states. By using naively the conjugate representations we take the following left-right symmetric assignment for quarks and leptons, i.e. $(\nu_l, l^-)_R = (\bar{\nu}_l, l^+)_L$, etc. For $[(\nu_e, e), (\nu_\mu, \mu), (\nu_\tau, \tau)]$, we take

$$[Q_m \epsilon_{ln} Q_l^* Q_n^*,\ Q_a Q_a^* Q_m^*,\ Q_a Q_a^* Q_b Q_b^* Q_m^*] \tag{8}$$

and the conjugate states respectively.

For $[(u, d), (c, s), (t, b)]$ we take

$$\Big[\epsilon_{abc} Q_b^* Q_c^* Q_m^*,\ \epsilon_{abc} Q_b^* Q_c^* Q_l \epsilon_{mn} Q_m^* Q_n^*, \\ \epsilon_{abc} Q_a^* Q_b^* Q_c^* Q_d Q_m^* \Big] \ . \tag{9}$$

and the conjugate states respectively.

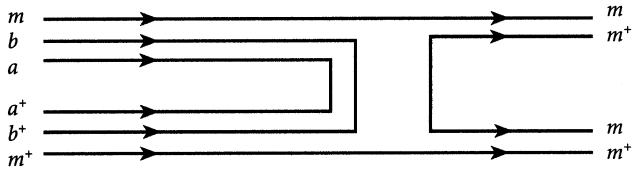

Fig. 1. Superon diagrams for π^0 decay. Superons are labeled by the indices used in (6) and (7). $\pi^0 \to 2\gamma$

The superon line Feynmann diagram is obtained by replacing the single line in the Feynmann diagram of the gauge models by the corresponding multiple superon lines. We discuss as a few examples the following typical processes, i.e.

(i) β decay: $n^0 \to p^+ + e^- + \bar{\nu}_e$, (ii) $\pi^0 \to 2\gamma$, (iii) the proton decay: $p^+ \to e^+ + \pi^0$, (iv) a flavor changing neutral current process (FCNC): $K^+ \to \pi^+ + \nu_e + \bar{\nu}_e$ and (v) an advocated typical process of the (non-gauged) compositeness: $\mu \to e + \gamma$.

To translate the vertex of the Feynmann diagram of the unified gauge model into that of the superons, we assume that the superon-antisuperon pair creations and pair annihilations within a single state for a quark, a lepton and a (gauge) boson (i.e. within a single SO(10) SPA state) are forbidden. This rule seems natural because every state is the irreducible representation of SO(10) SPA and is prohibitted from the decay without any remnants, i.e. without the interaction between the superons contained in the different states. Now it is straightforward to translate uniquely the Feynmann diagram of the unified gauge models into that of the superon model.

For the processes (i) and (ii) we can draw the corresponding similar tree-like, superon line diagrams easily, where for (ii) the triangle-like superon diagram does not appear. For the process (iii) we consider the Feynmann diagrams for the proton decay of GUTs and find that the corresponding superon line diagrams do not exist due to the mismatch of the superons contained in the quarks (u and d) and the gauge bosons (X and Y) at the gauge coupling vertices. This means that irrespective of the masses of the gauge bosons the proton is stable, at least against $p^+ \to e^+ + \pi^0$. For FCNC process (iv) the penguin-type and the box-type superon line diagrams are to be studied corresponding to the penguin- and box-Feynmann diagrams for $K^+ \to \pi^+ + \nu_e + \bar{\nu}_e$ of GUTs. Remarkablely the superon line diagrams which have only the up-quark for the internal quark line exist. This is the indication of the strong suppression of the FCNC process, at least for the process $K^+ \to \pi^+ + \nu_e + \bar{\nu}_e$. The similar simple mechanism seems valid for other FCNC processes. For the process (v) the corresponding tree-like superon line diagram does not exist due to the mismatch at the gauge cuopling vertex, i.e. $\mu \to e + \gamma$ decay mode is absent at the tree-level in the superon (composite) model. The process $\tau \to e(\mu) + \gamma$ is suppressed similarly. As a few examples of the superon line diagrams we show in Fig. 1 and Fig. 2 the superon diagrams for the process (ii) and one of the penguin Feynmann diagrams for the process (iv), respectively.

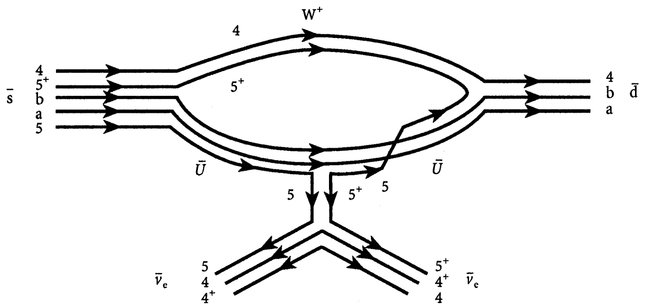

Fig. 2. Superon diagrams for one of the penguin diagrams of K^+ decay. Superons are labeled by the indices used in (6) and (7). $K^+ \to \pi^+ + \nu_e + \bar{\nu}_e$

3.3 Uniqueness of SQM

Before closing this section we comment on the uniqueness of SQM. As mentioned in the introduction of this article, we showed in [3] that $N = 11$ and 12 were also promising. However by counting the number of the charged states of each helicity of SO(N) SPA we can show that SQM is unique within the framework of N-extended SPA if we assume the following; (i) N-extended SPA realizes SO(N) symmetry, (ii) the massless electrically charged high-spin particles are absent in nature and (iii) nature is minimal and simple. $N = 12$ SPA is excluded due to (ii) and (iii), i.e. it would contain many massless charged vector particles in the low energy. $N = 11$ is so far excluded due to (iii). In these analyses the eleventh and the twelfth generators are regarded simply as the neutral superons and the others are unchanged.

4 Field theory for SQM

4.1 Action for SQM

Now we consider the fundamental field theory which describes the superon dynamics. In [8], we have investigated the nonlinear representation of $N = 1$ SUSY [9] in two dimensional spacetime. We have shown that by using Noether procedure we can construct the supercharge Q explicitly and carry out the canonical quantization for the fundamental (Goldstone) spinor field $\psi(x)$ so that the super-Poincaré algebra can be satisfied at the quantized level. In two dimensional spacetime the spinor supercurrent density giving the supercharge Q has been written as follows

$$J^\mu(x) = \frac{1}{i}\sigma^\mu \psi(x) - \kappa\{\text{the higher orders of } \psi(x)\} , \quad (\mu = 1, 2) \tag{10}$$

where κ is an arbitrary constant with the second power of length and σ^μ are Pauli matrices, $\sigma^0 = 1$. This is a nice indication for our asumption that the generator (supercharge) Q^N of SO(10) SPA represents the fundamental particle *superon with spin* $\frac{1}{2}$, which obeys the Fermionic quantum statistics. Equation (10) is the current-field identity with spin $\frac{1}{2}$ including, as shown by the term proportional to κ, the higher order components of the currents induced by the nonlinear dynamics of superons. Therefore we speculate that the fundamental theory of the superon quintet model of spacetime and matter at (above) the Planck scale is SO(10) nonliner supersymmetry (NL SUSY) in the curved spacetime corresponding to the superonless Clifford vacuum. Now the Clifford vacuum state becomes dynamical field and all the helicity-states including the observed quarks, leptons and gauge bosons except the graviton are the relativistic (gravitational) composite states composed of Goldstone fermions, *superons* upon the physical vacuum. Interestingly the relevance of NL SUSY and the interpretation of quarks and leptons as Nambu-Coldstone fermions has been persued some time ago [10].

From these speculations and by considering the systematic arguments of the conversions between the linear-SUSY and the nonlinear-SUSY representations [11,12], we propose the following Lagrangian as the fundamental theory of SO(10) superon model of spacetime and matter.

$$L = -\frac{c^3}{16\pi G}\, e(R + \Lambda)|W| , \tag{11}$$

$$|W| = \det W^\nu_\mu = \det(\delta^\nu_\mu + \kappa T^\nu_\mu) , \tag{12}$$

$$T^\nu_\mu = \frac{1}{2i}\sum_{i,\,j=1}^{10} (\bar{s}^i O_{ij}\gamma_\mu D^\nu s^j - D^\nu \bar{s}^i \gamma_\mu O_{ij} s^j) , \tag{13}$$

where κ is yet an arbitrary constant with the dimension of the fourth power of length, $e = \det e^a_\mu$, $D_\mu = \partial_\mu + \frac{1}{2}\omega^{ab}_\mu \sigma_{ab}$ and R and Λ are the scalar curvature and the yet arbitrary cosmological constant, respectively. O_{ij} is a 10×10 unitary matrix representing the quantum mechanical mixing among the superon quintet states, which may be probable but unpleasant from the elementary nature of the superon. The cosmological constant Λ and κ are connected by the supersymmetry breaking scale. The states with helicity ± 3, $\pm\frac{5}{2}$ and ± 2 (except the graviton) necessary for completing the irreducible representation of SO(10) SPA appear after specifying the contorsion in the spin conection $\omega^\mu_{ab}(e^\mu_a, s^i)$ [13], for these states are at least 10-, 9- and 8-superon states respectively and are hidden in (11). Equation (11) is manifestly invariant under at least the general coordinate transformation and global SO(10). And it is reduced to SO(10) NL SUSY a la Volkov-Akulov [9] by taking only $R \to 0$ limit and to Einstein action (i.e. Clifford vacuum action) by taking the superonless limit $s^i \to 0$. Furthermore in the similar sense of [11] and [12], the invariance of (11) under the global SO(10) NL SUSY may be anticipated, which may be included in the scope of [11] and [12]. The fundamental Lagrangian (11) can be rewritten in the following simple form $L = -\frac{c^3}{16\pi G} n(R + \Lambda)$, where $n = \det n^a_\mu = \det(e^a_\nu W^\nu_\mu)$.

4.2 Symmetry breaking for SQM

As for the (spontaneous) symmetry breaking mentioned before it is urgent to study the structure of the true vacuum of (11). SUSY(SPA) would be broken (spontaneously) in the true vacuum of (11) and the characteristic dimensionful constant κ and NL SUSY Goldstone fermions are generated. To see clearly the (low energy) mass spectrum of the particles spanned upon the true vacuum, we should convert the SO(10) NL SUSY Lagrangian of the fundamental action (11) into the equivalent linear broken SUSY SO(10) Lagrangian. We expect that SUSY is broken spontaneously at the tree level and by the conversions to the linear representation the bosonic and the fermionic high-spin massless states turn out to be massive states satisfying the broken SUSY mass relation

$$\sum_j (-1)^{2j}(2j+1)M_j^2 = 0 \;, \qquad (14)$$

for spin j. This detour may be the way to circumvent the difficulty for the high-spin massless gauge field in the curved spacetime and to accomodate naturally the high-spin massive fields in the unified gauge field theory. The low-energy structure of the linearized broken SUSY Lagrangian should involve GUTs, at least the SM with three generations. The manifest SUSY in the low energy is not necessary in SQM, for the unification is automatic and the stability of the proton and the suppression of the FCNC is understood by the topologies of the superon diagrams. For carrying through these complicated scenario it is encouraging to note that the linearlization of such a nonlinear fermionic system was already carried out explicitly [11, 12]. They investigated in detail the conversions between $N = 1$ NL SUSY (Volkov-Akulov) model and the equivalent linear (broken) $N = 1$ SUSY Lagrangian. The generic and the systematic arguments by using the superspace [12] may be useful for the linerization of the $N = 10$ superon model. It is very interesting if we can regard the yet hypothetical SO(10) superon model may be for the unified gauge models (SM and GUTs) what the BCS theory is for the Landau-Ginzburg theory of the superconductivity.

For understanding directly the superon nonlinear dynamics (i.e. the structure of the spacetime) at the Planck scale without the linearization, the algebraic analysis [7] of the currents obtained from the commutators of the supercharges,

$$\{Q_\alpha^M, \bar{Q}_{\dot\beta}^N\} = 2\delta^{MN} \sum_{\mu=0}^{3} (\sigma_\mu)_{\alpha\dot\beta} P^\mu \;, \qquad (15)$$

may be useful. As a qualitative test of the superon model it is interesting to fit all the decay data of low lying hadrons in terms of the superon line diagram amplitudes.

5 Conclusions

We have shown that among all (group) theoretical models for spacetime and matter based upon SO(N) super-Poincaré symmetry, SO(10) (superon-quintet and graviton) model may be the (almost) unique viable model. The superon-quintet hypothesis as a universal fundamental constituents except the graviton may explain qualitatively the physical meanings of the various mixing angles and the Higgs mechanism in the unified gauge models.

Besides those interesting aspects of superon-quintet and graviton model mentioned above, much more open questions are left.

However we regard that the beautiful complimentality between the gauge unified models (SM and GUT) and the superon model, i.e. the former is strengthened or revived by taking account of the topology of the latter superon diagram, while drawing the superon diagram of the latter is guided by the Feynmann diagram for the gauge interaction of the former, may be an evidence of SO(10) SPA structure of spacetime and matter behind the gauge models (SM GUT), i.e. an evidence of the superon quintet hypothesis. The experimental search for a predicted new spin $\frac{3}{2}$ lepton doublet (ν_Γ, Γ^-) with the mass of the electroweak scale [3] is important. The clear signals of the new particles may be similar to the top-quark pair production event without the jet production.

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