Nonlinear-Supersymmetric General Relativity Theory(NLSGR)

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1. Motivations

@ The success of GR and SM(GWS) model,
still many unsolved fundamental problems are left, e.g.,

- **Unification of two SMs,**
- **Space-time dimension *four*,**
- **Three-generations structure of quarks and leptons,**
- **C-asymmetry of nature**
- **Tiny Neutrino mass M_ν, proton stability in GUT**
- **Dark Matter, Dark Enegy; $\rho_{D.E.} \sim (M_\nu)^4 \Leftrightarrow \Lambda CDM$, Inflation**

$\Longrightarrow$ **SUSY, SUGRA,**

- **Origin of SUSY breaking ?, $\cdots$ etc.**

@ As for the three-generations structure

among SO(N) LSUSY sP, only $N = 10$ gives SM with just 3 generations:,
where
- The decomposition of 10 supercharges $Q^I, (I = 1, 2, \cdots .10)$ are:

$$\underline{\mathbf{10}}_{SO(10)} = \underline{\mathbf{5}}_{SU(5)} + \underline{\mathbf{5}}^*{}_{SU(5)}$$

$$\underline{\mathbf{5}}_{SU(5)} = [\{\underline{\mathbf{3}}^{*c}, \underline{\mathbf{1}}^{ew}, (\tfrac{e}{3}, \tfrac{e}{3}, \tfrac{e}{3}) : Q_a (a = 1, 2, 3)\},\ \{\underline{\mathbf{1}}^{c}, \underline{\mathbf{2}}^{ew}, (0, -e) : Q_m (m = 4, 5)\}].$$

$\Leftrightarrow$ **Supercharge** $\underline{5}_{SU(5)}$ has the same quantum numbers as $\underline{5}$ of SU(5) GUT.

• Massless helicity states of gravity supermultiplet of SO(10) sP with CPT conjugation are specified by the helicity $h = (2 - \frac{n}{2})$ and the dimension $\underline{d}_{[n]} = \frac{10!}{n!(10-n)!}$:

$$|h>= Q^n Q^{n-1} \cdots Q^2 Q^1 |2>,\ Q^n\ (n = a, m, a^*, m^*)\text{: supercharge}$$

$\lvert h\rvert$	3	$\frac{5}{2}$	2	$\frac{3}{2}$	1	$\frac{1}{2}$	0
$\underline{d}_{[n]}$	$\underline{1}_{[10]}$	$\underline{10}_{[9]}$	$\underline{1}_{[0]}$ $\underline{45}_{[8]}$	$\underline{10}_{[1]}$ $\underline{120}_{[7]}$	$\underline{45}_{[2]}$ $\underline{210}_{[6]}$	$\underline{120}_{[3]}$ $\underline{252}_{[5]}$	$\underline{210}_{[4]}$ $\underline{210}_{[4]}$

• Wishful assumption of a maximal symmetry breaking (superHiggs-like mechanism, i. e., the maximal number of higher helicity-states become massive by absobing the lower-helicity states in $\underline{SU(3) \times U(1)\ \text{invariant way}}$ as many as possible,
.

@ Dirac particle survivors after *tentative* superHiggs-like mechanism

$SU(3)$	Q_e	$SU(2) \otimes U(1)$
$\underline{\mathbf{1}}$	0 -1 -2	$\begin{pmatrix} \nu_e \\ e \end{pmatrix}$ $\begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix}$ $\begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix}$ (N) (E)
$\underline{\mathbf{3}}$	$5/3$ $2/3$ $-1/3$ $-4/3$	$\begin{pmatrix} u \\ d \end{pmatrix}$ $\begin{pmatrix} c \\ s \end{pmatrix}$ $\begin{pmatrix} t \\ b \end{pmatrix}$ $\begin{pmatrix} h \\ o \end{pmatrix}$ $\begin{pmatrix} a \\ f \end{pmatrix}$ $\begin{pmatrix} g \\ m \end{pmatrix}$ $\begin{pmatrix} r \\ i \\ n \end{pmatrix}$
$\underline{\mathbf{6}}$	$4/3$ $1/3$ $-2/3$	$\begin{pmatrix} P \\ Q \\ R \end{pmatrix}$ $\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$
$\underline{\mathbf{8}}$	0 -1	$\begin{pmatrix} N_1 \\ E_1 \end{pmatrix}$ $\begin{pmatrix} N_2 \\ E_2 \end{pmatrix}$

- New color-singlet states: N^0 and $E^{\pm 2}$

@ How to construct N=10 SUSY with gravity
despite the No-Go theorem for $N > 8$ by the S-matrix argument.

- **To circumvent the No-Go theorem the degeneracy of space-time is essential.**

A quick review of NLSUSY:

- **Take (flat) space-time specified by x^a for SO(1,3) and ψ_α for SL(2,C).**
- **Consider one form $\omega^a = dx^a + \frac{\kappa^2}{2i}(\bar{\psi}\gamma^a d\psi - d\bar{\psi}\gamma^a\psi)$,**

κ is an arbitrary constant with the dimension l^{+2}.

- **$\delta\omega^a = 0$ under $\delta x^a = \frac{i\kappa^2}{2}(\bar{\zeta}\gamma^a\psi - \bar{\psi}\gamma^a\zeta)$ and $\delta\psi = \zeta$**

with a global spinor parameter ζ.

- **An invariant action($\sim$ invariant volume) is obtained:**

$S = -\frac{1}{2\kappa^2}\int \omega^0 \wedge \omega^1 \wedge \omega^2 \wedge \omega^3 = \int d^4x L_{VA}$,

L_{VA} is N=1 Volkov-Akulov model of NLSUSY given by

$L_{\rm VA} = -\frac{1}{2\kappa^2}|w_{VA}| = -\frac{1}{2\kappa^2}\left[1 - t^a{}_a + \frac{1}{2}(t^a{}_a t^b{}_b - t^a{}_b t^b{}_a) + \cdots\right]$,

$|w_{VA}| = \det w^a{}_b = \det(\delta^a_b + t^a{}_b)$, $\quad t^a{}_b = -i\kappa^2(\bar{\psi}\gamma^a\partial_b\psi - \partial_b\bar{\psi}\gamma^a\psi)$,

which is invariant under N=1 NLSUSY transformation:

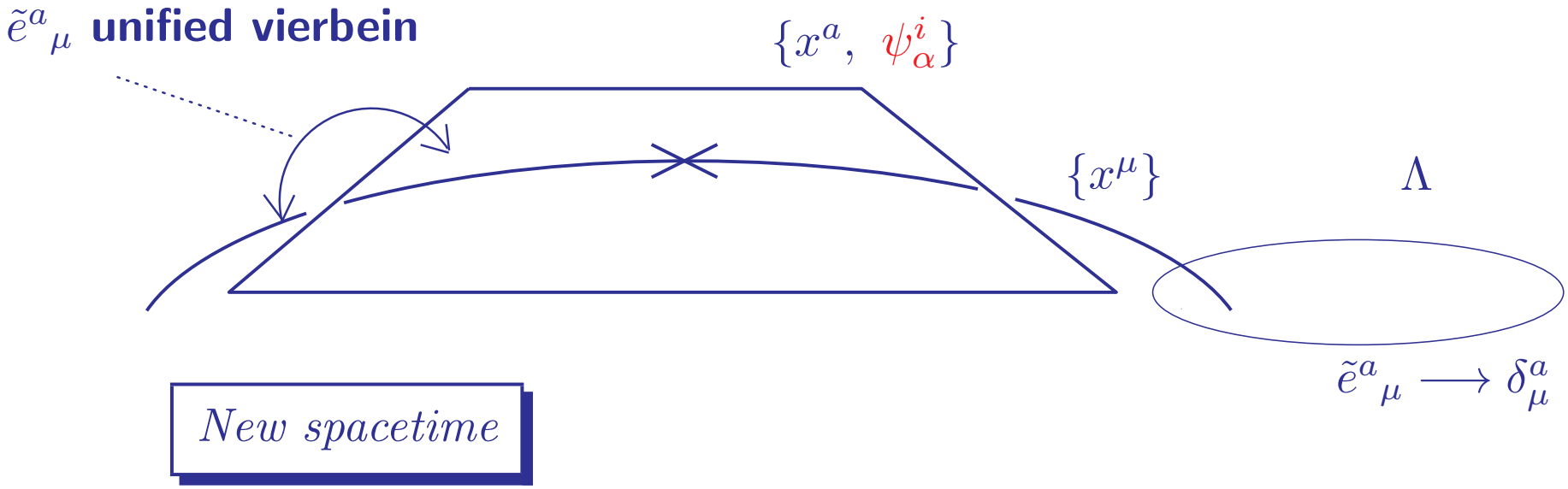
$\delta_\zeta\psi = \frac{1}{\kappa}\zeta - i\kappa(\bar{\zeta}\gamma^a\psi - \bar{\psi}\gamma^a\zeta)\partial_a\psi$, $\quad [\delta_1, \delta_2] = \delta_{\rm P}$.

- **ψ is Nambu-Goldstone(NG) fermion for $\frac{supertranslation}{translation}$.**
- **ψ is quantized canonically in compatible with SUSY algebra.**
- **Conserved supercurrent, supercharge:**

$$J^0 \to Q = c\psi + (\cdots\partial_a\psi\cdots)$$

2. Nonlinear-supersymmetric general relativity theory(NLSGR)

As an ultimate shape of Nature,
considering (unstable) Riemann space-time whose tangent space posesses NLSUSY structure specified by the Grassmann coordinates ψ_α for SL(2,C) and the ordinary Minkowski coorddinates x^a for SO(1,3). we can construct the unified vierbein $\tilde{e}^a_\mu$ which enables the ordinary geometric argument of the general relativity(GR) principle and obtain straightforwardly a new Einstein-Hilbert(EH)-type NLSUSY-invariant general relativity action L_{NLSGR} equipped with the promising gauge symmetry and the cosmological term Λ.



@The geometrical arguments of Einstein general relativity(GR) can be extended to new (unstable) space-time.

- **Unified vierbein $\tilde{e}^a{}_\mu(x)$ of new space-time:**

$$\tilde{e}^a{}_\mu(x) = e^a{}_\mu + t^a{}_\mu(\psi) \equiv w^a{}_b e^b{}_\mu, \qquad w^a{}_b = \delta^a{}_b + t^a{}_b,$$

$$t^a{}_b(\psi) = \frac{\kappa^2}{2i}(\bar{\psi}^I \gamma^a \partial_b \psi^I - \partial_b \bar{\psi}^I \gamma^a \psi^I), (I = 1, 2, .., N)$$

$$\tilde{e}^\mu{}_a(x) = e^\mu{}_a - t^\mu{}_a + t^\mu{}_\rho t^\rho{}_a - t^\mu{}_\sigma t^\sigma{}_\rho t^\rho{}_a + t^\mu{}_\kappa t^\kappa{}_\sigma t^\sigma{}_\rho t^\rho{}_a + \cdots + O(t)^4 \equiv e^\mu{}_b (w^{-1})^b{}_a,$$

$$\tilde{e}^a{}_\mu(x)\tilde{e}^\mu{}_b(x) = \delta^a{}_b, \quad \tilde{e}^a{}_\mu(x)\tilde{e}^\nu{}_a(x) = \delta^\nu{}_\mu,$$

$$t^a{}_\mu(\psi) = \frac{\kappa^2}{2i}(\bar{\psi}^I \gamma^a \partial_\mu \psi^I - \partial_\mu \bar{\psi}^I \gamma^a \psi^I), \quad (I = 1, 2, .., N)$$

(Note that Grassmann *odd* d.o.f. induces **the imaginary part of $\tilde{e}^a{}_\mu(x)$** .)

- **N-extended NLSGR action of EH-type for new space-time:**

$$L_{\rm NLSGR}(\tilde{e}) = -\frac{c^4}{16\pi G}|\tilde{e}|\{R(\tilde{e}) + \Lambda\},$$

$$|\tilde{e}| = \det \tilde{e}^a_\mu = \det(e^a{}_\mu + t^a{}_\mu(\psi)),$$

$$t^a{}_\mu(\psi) = \frac{\kappa^2}{2i}(\bar{\psi}^I\gamma^a\partial_\mu\psi^I - \partial_\mu\bar{\psi}^I\gamma^a\psi^I), (I = 1, 2, .., N)$$

- $\tilde{e}^a{}_\mu(x)$, $\tilde{e}^\mu{}_a(x)$: **the unified vierbein of new space-time**
- $e^a{}_\mu(x)$: **the ordinary vierbein for the local SO(1,3) d.o.f.of GR,**
- $t^a{}_\mu(\psi(x))$: **the mimic vierbein for the local SL(2,C) d.o.f. composed of the stress-energy-momentum of NG fermion $\psi(x)^I$(called superons),**
- $R(\tilde{e})$: **Ricci scalar curvature of new space-time computed in terms of $\tilde{e}^a{}_\mu(x)$ and $\tilde{e}^\mu{}_a(x)$:**
- $\tilde{g}_{\mu\nu} \equiv \tilde{e}^a{}_\mu\eta_{ab}\tilde{e}^b{}_\nu$, $\tilde{g}^{\mu\nu}(x) \equiv \tilde{e}^\mu{}_a(x)\eta^{ab}\tilde{e}^\nu{}_a(x)$: **metric tensors of new space-time.**
- G : **the Newton gravitational constant.**
- $\Lambda > 0$: **cosmological constant**

@NLSGR scenario shows:

- **The arbltrary constatnt κ^2 of NLSUSY is fixed at $\kappa^2 = (\frac{c^4\Lambda}{8\pi G})^{-1}$,**
- **$\Lambda > 0$ in the action $L_{\rm NLSGR}$ allows negative dark energy density interpretation of $\frac{\Lambda}{G}$**
- **No-go theorem for $N > 8$ SUSY has been circumvented by the global NLSUSY, i.e. by the degeneracy of the vacuum(flat space).**
- **Note that $SO(1, D-1) \cong SL(d, C)$, i.e. $\frac{D(D-1)}{2} = 2(d^2-1)$ holds for only $D = 4, d = 2$.**

NLSGR scenario predicts 4 dimensional space-time.

- **Space-time symmetries $(\sim sP)$:**

$$[\text{new NLSUSY}] \otimes [\text{local GL}(4,\text{R})] \otimes [\text{local Lorentz}]$$

- **Internal symmetries for N-extended NLSUSY GR (N-superons ψ^I $(I = 1, 2, ..N)$):**

$$[\text{global SO(N)}] \otimes [\text{local U(1)}^{\text{N}}] \otimes [\text{chiral}]. \qquad (1)$$

For example:

- **Invariance under the new NLSUSY transformation;**

$$\delta_\zeta \psi^I = \frac{1}{\kappa}\zeta^I - i\kappa \bar{\zeta}^J \gamma^\rho \psi^J \partial_\rho \psi^I, \quad \delta_\zeta e^a{}_\mu = i\kappa \bar{\zeta}^J \gamma^\rho \psi^J \partial_{[\mu} e^a{}_{\rho]}. \tag{2}$$

induces GL(4,R) transformations on $\tilde{e}^a_\mu$ and the unified metric $\tilde{g}_{\mu\nu}$

$$\delta_\zeta \tilde{e}^a_\mu = \xi^\nu \partial_\nu \tilde{e}^a_\mu + \partial_\mu \xi^\nu \tilde{e}^a_\nu, \quad \delta_\zeta \tilde{g}_{\mu\nu} = \xi^\kappa \partial_\kappa \tilde{g}_{\mu\nu} + \partial_\mu \xi^\kappa \tilde{g}_{\kappa\nu} + \partial_\nu \xi^\kappa \tilde{g}_{\mu\kappa},$$

where ζ is a constant spinor parameter, $\partial_{[\rho} e^a{}_{\mu]} = \partial_\rho e^a{}_\mu - \partial_\mu e^a{}_\rho$ and $\xi^\rho = -i\kappa \bar{\zeta}^I \gamma^\rho \psi^I$.

- **Commutators of two new NLSUSY transformation on ψ^I and $e^a{}_\mu$ close on GL(4,R),**

$$[\delta_{\zeta_1}, \delta_{\zeta_2}]\psi^I = \Xi^\mu \partial_\mu \psi^I, \quad [\delta_{\zeta_1}, \delta_{\zeta_2}] e^a{}_\mu = \Xi^\rho \partial_\rho e^a{}_\mu + e^a{}_\rho \partial_\mu \Xi^\rho, \tag{3}$$

where $\Xi^\mu = 2i\bar{\zeta}^I{}_1 \gamma^\mu \zeta^I{}_2 - \xi^\rho_1 \xi^\sigma_2 e_a{}^\mu \partial_{[\rho} e^a{}_{\sigma]}$.

- **New NLSUSY is the square-root of GL(4,R);**

$$[\delta_1, \delta_2] = \delta_{\mathrm{GL(4,R)}}, \quad i.e. \quad \delta \sim \sqrt{\delta_{\mathrm{GL(4,R)}}}.$$

- **Invariance under new local Lorentz transformation;**

$$\delta_L \psi^I = -\frac{i}{2}\epsilon_{ab}\sigma^{ab}\psi^I, \quad \delta_L e^a{}_\mu = \epsilon^a{}_b e^b{}_\mu + \frac{\kappa^4}{4}\varepsilon^{abcd}\bar{\psi}^I\gamma_5\gamma_d\psi^I$$

induce the familiaform form of the local Lorentz transformation on $\tilde{e}^a{}_\mu$**:**

$$\delta_L \tilde{e}^a{}_\mu = \epsilon^a{}_b \tilde{e}^b{}_\mu$$

with the local parameter $\epsilon_{ab} = (1/2)\epsilon_{[ab]}(x)$
and close the algebra, e. g., the new form on $e^a{}_\mu(x)$

$$[\delta_{L_1}, \delta_{L_2}]e^a{}_\mu = \beta^a{}_b e^b{}_\mu + \frac{\kappa^4}{4}\varepsilon^{abcd}\bar{\psi}^j\gamma_5\gamma_d\psi^j(\partial_\mu\beta_{bc}),$$

where $\beta_{ab} = -\beta_{ba}$ **is given by** $\beta_{ab} = \epsilon_{2ac}\epsilon_1{}^c{}_b - \epsilon_{2bc}\epsilon_1{}^c{}_a$**.**

- **The ordinary local GL(4,R) invariance is manifest by the construction.**

3. Evolution of NLSGR [Cosmology]: Big Collapse and SGM Model

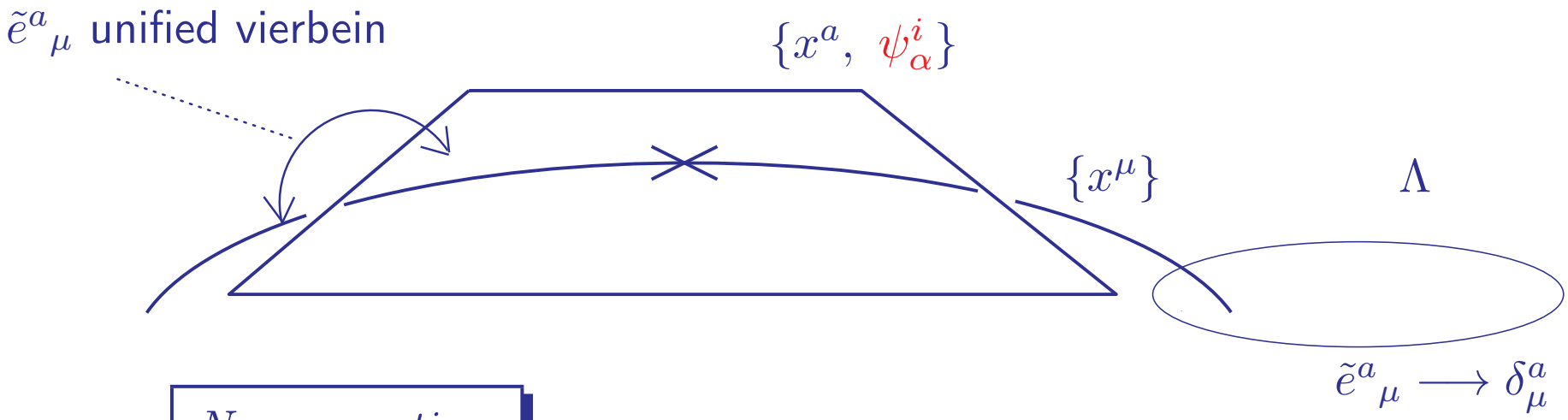
@ Due to the NLSUSY structure of space-time, L_{NLSGR} would collapse to (called Big Collapse(BC)) spontaneously to the vacuum configuration.

i. e.,

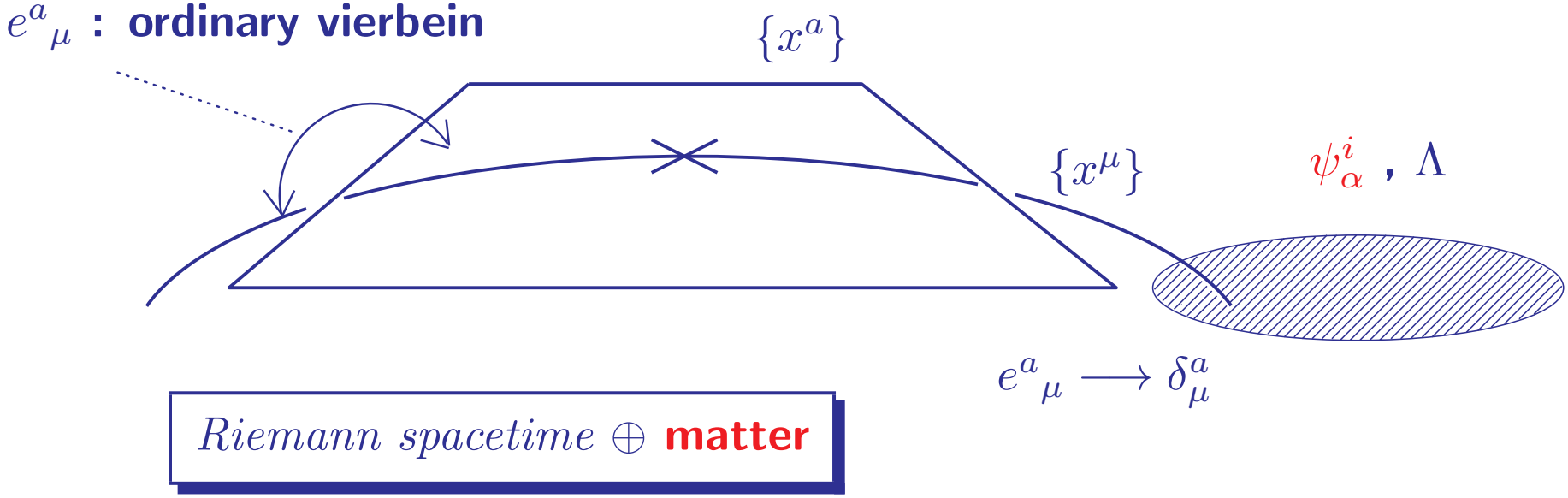
BC to ordinary EH action of graviton $e^a{}_\mu$,
NLSUSY action of Nambu-Goldstone(NG) fermion ψ (called superon)
and their gravitational interaction (called superon-graviton model(SGM)) .

$$L_{SGM}(e,\psi) = -\frac{c^4}{16\pi G}|e|\{R(e) + |w(\psi^I)_{VA}|\Lambda + \tilde{T}(e,\psi^I)\}.$$

SGM action $L_{SGM}(e,\psi)$ describes the vacuum configuration of NLSGR for ultimate shape of Nature.



⇓ **Big Collapse**



• The variation with respect to $e^a{}_\mu$ produces Einstein equation of SGM space-time equipting with negative dark energy density :

$$R_{\mu\nu}(e) - \frac{1}{2}g_{\mu\nu}R(e) = \frac{8\pi G}{c^4}\{\tilde{T}_{\mu\nu}(e,\psi) - g_{\mu\nu}\frac{c^4\Lambda}{8\pi G}\}. \quad (4)$$

• Big collapse(BC) induces 3 dimensional (space-like region) rapid expansion of space-time by Pauli principle(**Quantum Inflation b/a BB**):

$$ds^2 = s_{\mu\nu}(x)dx^\mu dx^\nu = \{g_{\mu\nu} + \underline{\Phi_{\mu\nu}(e,\psi)}\}dx^\mu dx^\nu.$$

$$\{\psi(x)_a, \bar{\psi}(y)_b\}_{x_0=y_0} = 0 \quad \Rightarrow \quad \{\psi(x)_a, \bar{\psi}(y)_b\}_{x_0=y_0} = \delta^{(3)}(\mathbf{x}-\mathbf{y})\delta_{\mathbf{ab}}$$

$$(\ \{\psi(x)_a, \bar{\psi}(y)_b\} = 0 \quad \Rightarrow \quad \{\psi(x)_a, \bar{\psi}(y)_b\} = iS(x-y)\delta_{ab}\ )$$

• The conserved supercurrent $S^{I\mu} = i\sqrt{\frac{c^4\Lambda}{8\pi G}}\gamma^\mu\psi^I + (\cdots\partial\psi,\psi\cdots)$.
couples the superon(NG fermion) to the vacuum
$< \psi_\beta{}^J|S_\alpha{}^{I\mu}|0 >= i\sqrt{\frac{c^4\Lambda}{8\pi G}}\delta^{IJ}(\gamma^\mu)_{\alpha\beta}$ with the strength $g_{sv} \equiv \sqrt{\frac{c^4\Lambda}{8\pi G}} = \kappa^{-1}$,
a new universal fundamental constant in Nature characterizing Big Collapse.

How to extract the (low energy) particle physics from SGM.

4. Linearization of NLSUSY and the NL/L SUSY relation (Equivalence)

@ BC is the ignition of BB and the evoluttion of the universe:

At BC the universal attractive force graviton would produce all possible gravitational-composites of superons,
which span the (massless) irreducible representation of the LSUSY SO(N) super-Poincaré(sP) algebra of nature.

- This can be regarded as the ignition of the Big Bang of the universe.

- The vacuum structure of SGM is studied by
linearizing NLSUSY in SGM and creating the equivqlent **global** LSUSY theory in terms of the **superon-composite global SUSY supermultiplet** (called **NL/L SUSY relation**).

- The global (NL and L) SUSY algebra plays an essential role.

- How to find NL/L SUSY relation;: We can adopt ,

Commutator based linearization and/or Superfield based one.

As an example of NL/L SUSY relation:

• NL/L SUSY relation(equivalence) for N=2 SUSY in $d = 2$ flat space;

$$L_{\text{N=2LSUSYQED}}(v_a, \lambda^i, A, \phi^i D, \chi, F^i, \cdots)$$
$$= f(\xi, \xi^i) L_{\text{N=2NLSUSY}}(\psi^j) + [\text{suface terms}],$$

$$v^a = -\tfrac{i}{2}\xi\kappa\epsilon^{ij}\bar{\psi}^i\gamma^a\psi^j|w|,\ \lambda^i = \xi\psi^i|w| \quad , A = \tfrac{1}{2}\xi\kappa\bar{\psi}^i\psi^i|w|,\ \ D = \tfrac{\xi}{\kappa}|w| \qquad \text{etc.}$$
$$\chi = \xi^i\left[\psi^i|w| + \tfrac{i}{2}\kappa^2\partial_a\{\gamma^a\psi^i\bar{\psi}^j\psi^j|w|\}\right], \cdots$$

SUSY compositeness

• NL/L SUSY relation bridges the cosmology and the low energy particle physics in NLSGR scenario. e.g., N=2SUSYQED : $e = \tilde{f}(\xi, \xi^i, G, \Lambda)$

Broken LSUSY(QED) gauge theory is encoded in the vacuum of NLSUSY theory as composites of NG fermion.

• For linearizing /analyzing the vacuum of NLSGR/SGM
we need broken global LSUSY SUGRA-analogue model which realizes:

NL/L SUSY relation (*equivalence*):

$$L_{\text{NLSGR}}(w) = L_{\text{SGM}}(e, \psi) = L_{\text{LSUSY}}(e^a{}_\mu, \psi_\nu(e, \psi), M(e, \psi), N(e, \psi), \cdots).$$

5. Cosmological implications of SGM scenario

The variation of SGM action $L_{\rm SGM}(e,\psi)$ with respect to $e^a{}_\mu$ yields
Einstein equation equipping with matter and cosmological term:

$$R_{\mu\nu}(e) - \frac{1}{2}g_{\mu\nu}R(e) = \frac{8\pi G}{c^4}\{\tilde{T}_{\mu\nu}(e,\psi) - g_{\mu\nu}\frac{c^4\Lambda}{8\pi G}\}. \tag{5}$$

where $\tilde{T}_{\mu\nu}(e,\psi)$ abbreviates the stress-energy-momentum of superon(NG fermion) including the gravitational interaction.

• Note that the cosmological term $-\frac{c^4\Lambda}{8\pi G}$ can be interpreted as
the negative energy density of space-time,
i.e. the dark energy density ρ_D.

• Big collapse(BC) induces 3 dimensional (space-like region) rapid expansion of space-time by Pauli principle:

$$ds^2 = s_{\mu\nu}(x)dx^\mu dx^\nu = \{g_{\mu\nu} + \underline{\Phi_{\mu\nu}(e,\psi)}\}dx^\mu dx^\nu.$$

$$\{\psi(x)_a, \bar{\psi}(y)_b\}_{x_0=y_0} = 0 \quad \Rightarrow \{\psi(x)_a, \bar{\psi}(y)_b\}_{x_0=y_0} = \delta^{(3)}(\mathbf{x}-\mathbf{y})\delta_{\mathbf{ab}}$$

$$(\ \{\psi(x)_a, \bar{\psi}(y)_b\} = 0 \quad \Rightarrow \{\psi(x)_a, \bar{\psi}(y)_b\} = iS(x-y)\delta_{ab}\ )$$

• BC produces gravitational composite (massless) eigenstates of SO(N) sP angebra, which is the ignition of the Big Bang(BB) SM scenario.

• As shown in the toy model, the vacuum of SGM
may explain naturally observed mysterious (numerical) relations:

$$dark\ energy\ density\ \rho_D \sim O(\kappa^{-2}) \sim {m_\nu}^4 \sim (10^{-12}GeV)^4 \sim {g_{sv}}^2,$$

provided ${\lambda_D}^0$ is identified with neutrino and $f\xi \sim O(1)$.

6. Summary

NLSGR(SGM) for unity of nature:

• Ultimate entity; **Unstable** $d = 4$ **space-time:**$[x^a, \psi_\alpha{}^N; x^\mu]$ described by $[L_{\rm NLSGR}(w^a{}_\mu)]$ **:** Global SUSY NLSGR on New space-time with $\Lambda > 0$

$\Longrightarrow$ **Big Collapse** (BC)

• The creation of ordinary Riemann space-time [graviton $e^a{}_\mu$] and massless NG fermionic matter [superon $\psi_\alpha{}^{\rm N}$], rapid expansion by Pauli principle $[L_{\rm SGM} = L_{\rm EH}(e) - \Lambda + T(\psi.e)]$ **:** Einstein GR with $\Lambda > 0$ and N superon

• The universal attractive force graviton dictates the evolution of $[L_{\rm SGM}$ by forming gravitational composite global LSUSY supermultiplet corresponding to (massless) eigenstates of space-time symmetry SO(10) sP.

$\Longrightarrow$ **Ignition of Big Bang of the universe toward ΛCDM scenario**

• In flat space-time, broken N-LSUSY theory emerges from the N-NLSUSY cosmological term of $L_{\rm SGM}(e, \psi)$ [NL/L SUSY relation]. $\longleftrightarrow$ BCS vs GL

The cosmological term is the origin of everything!

• NLSGR((SGM) paradigm can bridge naturally the cosmology and the low energy particle physics, which provides new insights into unsolved problems of cosmology and particle physics,, e.g. the space-time dimension $four$, the origin of mass and SUSY breaking, the dark energy and the dark matter, the dark energy density $\approx (neutrino\ mass)^4$ the tiny neutrino mass, inflation of space-time, the three-generations structure of quarks and leptons, the rapid expansion of space-time, the magnitude of the bare gauge coupling constant, matter dominance of nature , the shape and the role of black hole etc. $NLSGR \to (BC) \to SGM \to (BB) \to SMs \to \cdots \to BH \to NLSGR \to \cdots$

• Many important problems are yet to be studied,
e.g., global SUSY for higher spins (5/2 3) and SUGRA

• Direct linearization of NLSGR/SGM

• The revisit of global SUSY superfield fomulation from SGM/SQM. viewpoint. $\leftrightarrow$ C-asymmetry, proton decay, etc.

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