Supersymmetrizing Massive Gravity

O. Malaeb

Department of Physics
American University of Beirut

Seventh Aegean Summer School, 2013

based on arXiv:1303.3580
Outline

- Motivation
- Forming matter action
- Coupling to Supergravity
- Main results
- Summary
Forming massive gravity via Higgs mechanism (by Chamseddine and Mukhanov)

- Four scalar fields with global Lorentz symmetry coupled to gravity
- Scalar fields taking a vacuum expectation value breaking diffeomorphism invariance spontaneously
- Result massive graviton


→ Generalize this to the supersymmetric case
Forming massive gravity via Higgs mechanism (by Chamseddine and Mukhanov)

Four scalar fields with global Lorentz symmetry coupled to gravity

Scalar fields taking a vacuum expectation value breaking diffeomorphism invariance spontaneously

Result massive graviton


Generalize this to the supersymmetric case
Forming massive gravity via Higgs mechanism (by Chamseddine and Mukhanov)

Four scalar fields with global Lorentz symmetry coupled to gravity

Scalar fields taking a vacuum expectation value breaking diffeomorphism invariance spontaneously

Result massive graviton


Generalize this to the supersymmetric case
Forming massive gravity via Higgs mechanism (by Chamseddine and Mukhanov)

Four scalar fields with global Lorentz symmetry coupled to gravity

Scalar fields taking a vacuum expectation value breaking diffeomorphism invariance spontaneously

Result massive graviton


→ Generalize this to the supersymmetric case
Motivation

**The Massive Gravity Model**

**MOTIVATION**

- Forming massive gravity via Higgs mechanism (by Chamseddine and Mukhanov)
- Four scalar fields with global Lorentz symmetry coupled to gravity
- Scalar fields taking a vacuum expectation value breaking diffeomorphism invariance spontaneously
- Result massive graviton


→ Generalize this to the supersymmetric case
FOUR CHIRAL SUPERFIELDS

Consider four $N = 1$ chiral superfields with global Lorentz symmetry

$$\overline{D}_\alpha \Phi^A (x, \theta, \bar{\theta}) = 0$$

Given by

$$\Phi_A = \varphi_A + i (\theta \sigma^\mu \bar{\theta}) \partial_\mu \varphi_A - \frac{1}{4} \theta \theta \bar{\theta} \bar{\theta} \partial_\mu \partial^\mu \varphi_A + \sqrt{2} \theta \psi_A$$

$$- \frac{i}{\sqrt{2}} \theta \theta \left( \partial_\mu \psi_A \sigma^\mu \bar{\theta} \right) + \theta \theta F_A$$
Consider four $N = 1$ chiral superfields with global Lorentz symmetry

$$\overline{D}_\dot{\alpha} \Phi^A (x, \theta, \bar{\theta}) = 0$$

Given by

$$\Phi_A = \varphi_A + i (\theta \sigma^\mu \bar{\theta}) \partial_\mu \varphi_A - \frac{1}{4} \theta \theta \bar{\theta} \bar{\theta} \partial_\mu \partial^\mu \varphi_A + \sqrt{2} \theta \psi_A$$

$$- \frac{i}{\sqrt{2}} \theta \theta (\partial_\mu \psi_A \sigma^\mu \bar{\theta}) + \theta \theta F_A$$
BASIC FIELD

- In bosonic case: $H_{AB} = g^{\mu\nu} \partial_\mu \phi_A \partial_\nu \phi_B$
- Our case: Define $H_{ABC}$ as the basic field

\[ H_{ABC} = D_\alpha \Phi_A(\sigma_B)_{\alpha\dot{\alpha}} \bar{D}^{\dot{\alpha}} \Phi^*_C = D\Phi_A\sigma_B \bar{D}\Phi^*_C \]  

- Work instead with $\bar{H}_{ABC} = H_{ABC} - D x_A\sigma_B \bar{D} x_C^*$ to avoid including higher order terms
BASIC FIELD

- In bosonic case: \( H_{AB} = g^{\mu\nu} \partial_\mu \phi_A \partial_\nu \phi_B \)
- Our case: Define \( H_{ABC} \) as the basic field

\[
H_{ABC} = D^\alpha \Phi_A (\sigma_B)_{\alpha\dot{\alpha}} \bar{D}^{\dot{\alpha}} \Phi^*_C = D\Phi_A \sigma_B \bar{D}\Phi^*_C
\]  

(1)

- Work instead with \( \bar{H}_{ABC} = H_{ABC} - Dx_A \sigma_B \bar{D}x^*_C \) to avoid including higher order terms
In bosonic case: \( H_{AB} = g^{\mu\nu} \partial_\mu \phi_A \partial_\nu \phi_B \)

Our case: Define \( H_{ABC} \) as the basic field

\[
H_{ABC} = D^\alpha \Phi_A(\sigma_B)_{\alpha\dot{\alpha}} \bar{D}^{\dot{\alpha}} \Phi^*_C = D\Phi_A\sigma_B \bar{D}\Phi^*_C
\]

Work instead with \( \overline{H}_{ABC} = H_{ABC} - D\chi_A\sigma_B \bar{D}\chi^*_C \) to avoid including higher order terms
FORMING OUR ACTION

- Using this $\overline{H}_{ABC}$ construct D-type terms to form the matter multiplets ($\overline{H}_{ABC}\overline{H}_{BCA,..}$)

- Couple to the Supergravity Lagrangian using the rules of tensor calculus.

$$L_{S.G} = -\frac{e}{2\kappa^2} R(e, w) - \frac{e}{3} |u|^2 + \frac{e}{3} A_\mu A^\mu - \frac{1}{2} \phi_\mu R^\mu$$  \hspace{1cm} (2)

- Lagrangian field content:
  - spin-2 field, $e_{a\mu}$
  - spin-3/2 field, $\phi_\mu$
  - auxiliary fields $u, A_\mu$
Using this $H_{ABC}$ construct D-type terms to form the matter multiplets ($H_{ABC}H_{BCA},\ldots$)

Couple to the Supergravity Lagrangian using the rules of tensor calculus.

$$L_{S.G} = -\frac{e}{2\kappa^2} R(e, w) - \frac{e}{3} |u|^2 + \frac{e}{3} A_{\mu} A^{\mu} - \frac{1}{2} \phi_{\mu} R^{\mu}$$  \hspace{1cm} (2)$$

Lagrangian field content:
- spin-2 field, $e_{a\mu}$
- spin-3/2 field, $\phi_{\mu}$
- auxiliary fields $u, A_{\mu}$
FORMING OUR ACTION

Using this $\mathcal{H}_{ABC}$ construct D-type terms to form the matter multiplets ($\mathcal{H}_{ABC}\mathcal{H}_{BCA},\ldots$).

Couple to the Supergravity Lagrangian using the rules of tensor calculus.

$$L_{S.G} = -\frac{e}{2\kappa^2} R(e, w) - \frac{e}{3} |u|^2 + \frac{e}{3} A_\mu A^\mu - \frac{1}{2} \phi_\mu R^\mu \tag{2}$$

Lagrangian field content:

- spin-2 field, $e_{a\mu}$
- spin-3/2 field, $\phi_\mu$
- auxiliary fields $u, A_\mu$
COUPLING VECTOR MULTIPLE TO SUPERGRAVITY

- Vector multiplet
  \[ V = (C, \xi, M, V_\mu, \lambda, D) \]  

- D-type multiplet action formula
  \[ e^{-1} L_D = D + \frac{i\kappa}{2} \bar{\phi}_\mu \gamma^5 \gamma_\mu \lambda - \frac{\kappa}{3} (uM^* + u^* M) + \frac{i\kappa^2}{8} \epsilon^{\mu\nu\rho\sigma} \bar{\phi}_\mu \gamma_\nu \phi_\rho \bar{\xi} \phi_\sigma \]
  \[ + \frac{2}{3} \kappa V_\mu \left( A_\mu + \frac{3}{8} i e^{-1} \epsilon^{\mu\rho\sigma\tau} \bar{\phi}_\rho \gamma_\tau \phi_\sigma \right) - i \frac{\kappa}{3} e^{-1} \bar{\xi} \gamma_5 \gamma_\mu R^\mu \]
  \[ - \frac{2}{3} \kappa^2 C e^{-1} L_{S.G.} + e^{-1} L_{S.G.} \]


OUR WORK
Forming the Matter Action

COUPLING VECTOR MULTIPLET TO SUPERGRAVITY

- Vector multiplet
  \[ V = (C, \xi, M, V_\mu, \lambda, D) \]  

- D-type multiplet action formula
  \[
e^{-1} L_D = D + \frac{i\kappa}{2} \bar{\phi} \gamma^5 \gamma^\mu \gamma^\lambda - \frac{\kappa}{3} (uM^* + u^* M) + \frac{i\kappa^2}{8} \epsilon^{\mu\nu\rho\sigma} \bar{\phi} \phi^\nu \phi^\rho \bar{\xi} \phi^\sigma \\
+ \frac{2}{3} \kappa V_\mu \left( A_\mu + \frac{3}{8} i e^{-1} \epsilon^{\mu\rho\sigma\tau} \bar{\phi} \gamma^\rho \gamma^\tau \phi^\sigma \right) - i \frac{\kappa}{3} e^{-1} \bar{\xi} \gamma^5 \gamma_\mu R^\mu \\
- \frac{2}{3} \kappa^2 C e^{-1} L_{S.G.} + e^{-1} L_{S.G.}
\]  


WHAT WE WANT?

- Expanding the fields around the vacuum solution

\[ \varphi^A = \chi^A + \chi^A, \quad \theta_\mu^A = \delta_\mu^A + \bar{\theta}_\mu^A, \]  

(5)

- An action with the following required conditions
  - A Fierz-Pauli term for the vierbeins \((\bar{e}^\mu_\mu^A \bar{e}_A - \bar{e}^2)\)
  - No linear vierbein term
  - Maxwell form for the \(\chi_A\) fields

\[ L \left( \partial_\mu \chi_A \partial^\mu \chi^A_\ast - \partial_A \chi^A \partial_B \chi^B_\ast \right) \]  

where \(L\) is a constant

- Ghost free: no terms like

\[ \partial_\mu \chi_A \partial^\mu \chi^A, \quad \text{or} \quad \partial_A \chi^A \partial_B \chi^B \]  

(7)

- Massive gravitinos
WHAT WE WANT?

- Expanding the fields around the vacuum solution

\[ \varphi^A = \chi^A + \chi^A, \quad \epsilon_\mu^A = \delta_\mu^A + \bar{\epsilon}_\mu^A, \quad (5) \]

- An action with the following required conditions
  - A Fierz-Pauli term for the vierbeins \((\bar{\epsilon}_\mu^A \bar{\epsilon}_\mu^A - \bar{\epsilon}^2)\)
  - No linear vierbein term
  - Maxwell form for the \(\chi_A\) fields

\[ I \left( \partial_\mu \chi_A \partial_\mu \chi^A - \partial_A \chi^A \partial_B \chi^B \right) \quad (6) \]

where \(I\) is a constant
- Ghost free: no terms like

\[ \partial_\mu \chi_A \partial_\mu \chi^A, \quad \text{or} \quad \partial_A \chi^A \partial_B \chi^B \quad (7) \]

- Massive gravitinos
WHAT WE WANT?

- Expanding the fields around the vacuum solution

\[ \varphi^A = X^A + \chi^A, \quad \varphi^\mu_A = \delta^\mu_A + \bar{e}^\mu_A, \quad (5) \]

- An action with the following required conditions
  - A Fierz-Pauli term for the vierbeins \((\bar{e}^\mu_A \bar{e}^A_\mu - \bar{e}^2)\)
  - No linear vierbein term
  - Maxwell form for the \(\chi^A\) fields

\[
I \left( \partial_\mu \chi_A \partial^\mu \chi^A* - \partial_A \chi^A \partial_B \chi^B* \right) \quad (6)
\]

where \(I\) is a constant
  - Ghost free: no terms like

\[
\partial_\mu \chi_A \partial^\mu \chi^A, \quad \text{or} \quad \partial_A \chi^A \partial_B \chi^B \quad (7)
\]

- Massive gravitinos
WHAT WE WANT?

- Expanding the fields around the vacuum solution
  \[ \varphi^A = \chi^A + \chi^A, \quad \theta^\mu_A = \delta^\mu_A + \bar{\theta}^\mu_A, \]  
  (5)

- An action with the following required conditions
  - A Fierz-Pauli term for the vierbeins \((\bar{\theta}^\mu_A \bar{\theta}_A^\mu - \bar{\theta}^2)\)
  - No linear vierbein term
  - Maxwell form for the \(\chi^A\) fields
    \[ I \left( \partial_\mu \chi^A \partial^\mu \chi^A \right) - \partial_A \chi^A \partial_B \chi^B \]  
    (6)
    where \(I\) is a constant
  - Ghost free: no terms like
    \[ \partial_\mu \chi^A \partial^\mu \chi^A, \quad \text{or} \quad \partial_A \chi^A \partial_B \chi^B \]  
    (7)

- Massive gravitinos
WHAT WE WANT?

- Expanding the fields around the vacuum solution

\[ \varphi^A = \chi^A + \chi^A, \quad \epsilon^\mu_A = \delta^\mu_A + \bar{\epsilon}^\mu_A, \]  

(5)

- An action with the following required conditions
  - A Fierz-Pauli term for the vierbeins \((\bar{\epsilon}^\mu_A \bar{\epsilon}^A_\mu - \bar{\epsilon}^2)\)
  - No linear vierbein term
  - Maxwell form for the \(\chi_A\) fields

\[ l \left( \partial_\mu \chi_A \partial^\mu \chi^A_* - \partial_A \chi^A \partial_B \chi^B_* \right) \]  

(6)

where \(l\) is a constant

- Ghost free: no terms like

\[ \partial_\mu \chi_A \partial^\mu \chi^A, \quad \text{or} \quad \partial_A \chi^A \partial_B \chi^B \]  

(7)

- Massive gravitinos
WHAT WE WANT?

- Expanding the fields around the vacuum solution
  \[ \varphi^A = \chi^A + \chi^A, \quad \theta^\mu_A = \delta^\mu_A + \bar{\epsilon}^\mu_A, \]  
  (5)

- An action with the following required conditions
  - A Fierz-Pauli term for the vierbeins \((\bar{\epsilon}^\mu_A \bar{\epsilon}^A_\mu - \bar{\epsilon}^2)\)
  - No linear vierbein term
  - Maxwell form for the \(\chi^A\) fields
    \[ l \left( \partial_\mu \chi_A \partial^\mu \chi^A* - \partial_A \chi^A \partial_B \chi^B* \right) \]  
    (6)
    where \(l\) is a constant
  - Ghost free: no terms like
    \[ \partial_\mu \chi_A \partial^\mu \chi^A, \quad \text{or} \quad \partial_A \chi^A \partial_B \chi^B \]  
    (7)

- Massive gravitinos
WHAT WE WANT?

- Expanding the fields around the vacuum solution

\[ \varphi^A = X^A + \chi^A, \quad e^\mu_A = \delta^\mu_A + \bar{e}^\mu_A, \] (5)

- An action with the following required conditions
  - A Fierz-Pauli term for the vierbeins \((\bar{e}^\mu_A \bar{e}_\mu^A - \bar{e}^2)\)
  - No linear vierbein term
  - Maxwell form for the \(\chi_A\) fields

\[ l \left( \partial_\mu \chi_A \partial^\mu \chi^*_A - \partial_A \chi^A \partial_B \chi^*_B \right) \] (6)

where \(l\) is a constant

- Ghost free: no terms like

\[ \partial_\mu \chi_A \partial^\mu \chi^A, \quad \text{or} \quad \partial_A \chi^A \partial_B \chi^B \] (7)

- Massive gravitinos
First four conditions well satisfied with three D-type terms:
- $\bar{H}_{ABC} \bar{H}_{BCA}$
- $\bar{H}_{ABB} \bar{H}_{CCA}$
- $\bar{H}_{AB} \bar{H}_{AB}^*$, where $H_{AB} = D\Phi_A D\Phi_B$

Gravitino massive by adding two F-type terms and coupling them to supergravity:
- $\bar{D}^2 (D\Phi_A\sigma^{AB} D\Phi_B)$
- $\bar{D}^2 (D\Phi_A D\Phi^A \bar{D}\Phi_B^* \bar{D}\Phi^{B*})$
First four conditions well satisfied with three D-type terms:

\[
\bar{H}_{ABC} \bar{H}_{BCA} \\
\bar{H}_{ABB} \bar{H}_{CCA} \\
\bar{H}_{AB} \bar{H}^{*}_{AB} \text{ where } H_{AB} = D\Phi_A D\Phi_B
\]

Gravitino massive by adding two F-type terms and coupling them to supergravity:

\[
\bar{D}^2 \left( D\Phi_A \sigma^{AB} D\Phi_B \right) \\
\bar{D}^2 \left( D\Phi_A D\Phi^A \bar{D}\Phi^*_B \bar{D}\Phi^{B*} \right)
\]
COUPLING CHIRAL MULTIPLET TO SUPERGRAVITY

- Chiral multiplet (F-type)

\[ F = (z, X_L, h) \]  \hspace{1cm} (8)

- Complex scalar field \( z \)
- Left-handed Weyl spinors \( X_L \)
- Complex auxiliary field \( h \)

- Action formula

\[ e^{-1} L_F = h + \kappa uz + \kappa \bar{\phi} \gamma^\mu \chi + i \kappa^2 \bar{\phi} \gamma^{\mu\nu} \phi_{\nu R} z + h.c. \]  \hspace{1cm} (9)
COUPLING CHIRAL MULTIPLET TO SUPERGRAVITY

- Chiral multiplet (F-type)

\[ F = (z, X_L, h) \]  \hspace{1cm} (8)

- Complex scalar field \( z \)
- Left-handed Weyl spinors \( X_L \)
- Complex auxiliary field \( h \)

- Action formula

\[ e^{-1} L_F = h + \kappa uz + \kappa \bar{\phi} \gamma^\mu \chi + i \kappa^2 \bar{\phi} \gamma^{\mu\nu} \phi_{\nu R} z + \text{h.c.} \]  \hspace{1cm} (9)
Main Results

- Global supersymmetry promoted to a local one using the rules of tensor calculus
- Scalar components of the chiral multiplets $\varphi_A$ acquired a vacuum expectation value
- Diffeomorphism invariance and local supersymmetry broken spontaneously
Global supersymmetry promoted to a local one using the rules of tensor calculus

Scalar components of the chiral multiplets $\varphi_A$ acquired a vacuum expectation value

$\rightarrow$ Diffeomorphism invariance and local supersymmetry broken spontaneously
MAIN RESULTS

- Global supersymmetry promoted to a local one using the rules of tensor calculus
- Scalar components of the chiral multiplets $\varphi_A$ acquired a vacuum expectation value
- $\rightarrow$ Diffeomorphism invariance and local supersymmetry broken spontaneously
MAIN RESULTS

- Global Lorentz index $A$ identified with the space-time Lorentz index
  - Scalar fields $\chi_A \rightarrow$ vectors
  - Chiral spinors $\psi_A \rightarrow$ spin-3/2 Rarita-Schwinger fields

- Spectrum of the model in the broken phase:
  - A massive spin-2 field
  - Two massive spin-3/2 fields with different masses
  - A massive vector
MAIN RESULTS

- Global Lorentz index $A$ identified with the space-time Lorentz index
  - Scalar fields $\chi_A \rightarrow$ vectors
  - Chiral spinors $\psi_A \rightarrow$ spin-$3/2$ Rarita-Schwinger fields

- Spectrum of the model in the broken phase:
  - A massive spin-2 field
  - Two massive spin-$3/2$ fields with different masses
  - A massive vector
Counting degrees of freedom: supergravity coupled to a $N = 1$ supersymmetry model similar to the Wess-Zumino model

Before the coupling, supergravity contains

- one massless spin-2 graviton (two bosonic dof)
- one massless spin-3/2 gravitino (two fermionic dof)
Counting degrees of freedom: supergravity coupled to a $N = 1$ supersymmetry model similar to the Wess-Zumino model

Before the coupling, supergravity contains
- one massless spin-2 graviton (two bosonic dof)
- one massless spin-3/2 gravitino (two fermionic dof)
$N = 1$ supersymmetry model:

- Four spin-0 particles, $\varphi^A$, with only six degrees of freedom (3 times 2) since $\varphi^0$ decouples due to Fierz-Pauli choice
- Six fermionic degrees of freedom forming a multiplet

Overall eight fermionic degrees of freedom and eight bosonic degrees of freedom
**DEGREES OF FREEDOM: BEFORE COUPLING**

- $N = 1$ supersymmetry model:
  - Four spin-0 particles, $\varphi^A$, with only six degrees of freedom (3 times 2) since $\varphi^0$ decouples due to Fierz-Pauli choice
  - Six fermionic degrees of freedom forming a multiplet

- Overall eight fermionic degrees of freedom and eight bosonic degrees of freedom
Our Results

Main Results

DEGREES OF FREEDOM: BEFORE COUPLING

- $N = 1$ supersymmetry model:
  - Four spin-0 particles, $\varphi^A$, with only six degrees of freedom (3 times 2) since $\varphi^0$ decouples due to Fierz-Pauli choice
  - Six fermionic degrees of freedom forming a multiplet

- Overall eight fermionic degrees of freedom and eight bosonic degrees of freedom
After coupling to supergravity: \( N = 1 \) massive representation

- **Bosonic degrees of freedom**
  - A massive spin-2 particle, with five degrees of freedom
  - A massive vector field (spin-1 particle), three degrees of freedom

- Overall eight bosonic degrees of freedom
After coupling to supergravity: $N = 1$ massive representation

Bosonic degrees of freedom

- A massive spin-2 particle, with five degrees of freedom
- A massive vector field (spin-1 particle), three degrees of freedom

Overall eight bosonic degrees of freedom
Our Results

Main Results

DEGREES OF FREEDOM: AFTER COUPLING

- After coupling to supergravity: $N = 1$ massive representation
- Bosonic degrees of freedom
  - A massive spin-2 particle, with five degrees of freedom
  - A massive vector field (spin-1 particle), three degrees of freedom
- Overall eight bosonic degrees of freedom
DEGREES OF FREEDOM: AFTER COUPLING

- Fermionic degrees of freedom
  - Two massive spin-3/2 particles, \( \phi_\mu \) and \( \psi_A \) with four degrees of freedom each

- Overall eight fermionic degrees of freedom
- Same number of degrees of freedom as before coupling
Fermionic degrees of freedom

- Two massive spin-3/2 particles, $\phi_\mu$ and $\psi_A$ with four degrees of freedom each

Overall eight fermionic degrees of freedom

- Same number of degrees of freedom as before coupling
Fermionic degrees of freedom
- Two massive spin-3/2 particles, $\phi_\mu$ and $\psi_A$ with four degrees of freedom each

Overall eight fermionic degrees of freedom
- Same number of degrees of freedom as before coupling
SUMMARY

- Constructed a supersymmetric theory of massive gravity
- Coupled a pure Supergravity multiplet to a matter multiplet
- Left with two massive spin-3/2 particles, $\phi_\mu$ and $\psi_A$ with completely different masses
- Similar to the $N = 2$ supersymmetry in which we have two gravitinos, but there they have the same mass.
SUMMARY

- Constructed a supersymmetric theory of massive gravity
- Coupled a pure Supergravity multiplet to a matter multiplet
- Left with two massive spin-3/2 particles, $\phi_\mu$ and $\psi_A$ with completely different masses
- Similar to the $N = 2$ supersymmetry in which we have two gravitinos, but there they have the same mass.
Constructed a supersymmetric theory of massive gravity
Coupled a pure Supergravity multiplet to a matter multiplet
Left with two massive spin-3/2 particles, $\phi_\mu$ and $\psi_A$ with completely different masses
Similar to the $N=2$ supersymmetry in which we have two gravitinos, but there they have the same mass.
Constructed a supersymmetric theory of massive gravity
Coupled a pure Supergravity multiplet to a matter multiplet
Left with two massive spin-3/2 particles, $\phi_\mu$ and $\psi_A$ with completely different masses
Similar to the $N = 2$ supersymmetry in which we have two gravitinos, but there they have the same mass.
Supersymmetry completely broken exactly at the same scale as the diffeomorphism breaking

Before diffeomorphism breaking:
spin-1/2 and not spin-3/2 $\rightarrow$ two gravitinos with different masses

$\phi_\mu$: genuine gravitino

$\psi_A$: identified with a gravitino after the breaking

Thank You for Your Attention!
Supersymmetry completely broken exactly at the same scale as the diffeomorphism breaking.

Before diffeomorphism breaking:
spin-1/2 and not spin-3/2 $\rightarrow$ two gravitinos with different masses

- $\phi_\mu$: genuine gravitino
- $\psi_A$: identified with a gravitino after the breaking

Thank You for Your Attention!
Supersymmetry completely broken exactly at the same scale as the diffeomorphism breaking

Before diffeomorphism breaking:
spin-1/2 and not spin-3/2 → two gravitinos with different masses

$\phi_\mu$: genuine gravitino

$\psi_A$: identified with a gravitino after the breaking

Thank You for Your Attention!
Summary

Supersymmetry completely broken exactly at the same scale as the diffeomorphism breaking

Before diffeomorphism breaking:
spin-1/2 and not spin-3/2 $\rightarrow$ two gravitinos with different masses

$\phi_\mu$: genuine gravitino

$\psi_A$: identified with a gravitino after the breaking

Thank You for Your Attention!