MASSIVE TENSOR TOWERS AND EFFECTIVE ACTIONS

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based on FB, T. W. Grimm, S. Hohenegger [1209.3017, 1302.2918, 1303.2661]

Introduction

- Main subject of the talk:

  5d action for 6d self-dual tensors

- Some motivations:

  1. F-theory effective actions
     - no 12d effective action, we need duality with M-theory
     - 6d F-theory action = lift of 5d M-theory action on CY_3
     - natural transdimensional treatment of 6d tensors
  2. (2,0) theories
     - superconformal theories with 16 supersymmetries
     - non-Abelian gauge group but no vectors in the spectrum
     - various 5d proposals to decode 6d dynamics

       (e.g. Douglas, Lambert et al., Ho et al.)

6d self-dual tensor on a circle

Compactify on a circle: $x^5 \sim x^5 + 2\pi R$. Kaluza-Klein expansion of $\hat{B}$:

$$\hat{B}_{\mu\nu} = \sum_{n\in\mathbb{Z}} e^{inx^5/R} B^{(n)}_{\mu\nu} \qquad \hat{B}_{\mu 5} = R^{-1} \sum_{n\in\mathbb{Z}} e^{inx^5/R} A^{(n)}_{\mu}$$

6d gauge transformation

$$\delta\hat{B} = d\hat{\Lambda}$$

→

5d gauge transformation

$$\delta B^{(n)} = d\Lambda^{(n)} \quad \delta A^{(n)} = d\lambda^{(n)} - in\Lambda^{(n)}$$

6d self-duality

$$d\hat{B} = \hat{*} d\hat{B}$$

→

5d duality between zeromodes

$$R * dB^{(0)} = dA^{(0)}$$

- Stückelberg mechanism: $B^{(n)}$ eats $A^{(n)}$ for $n \neq 0$
- $B^{(0)}$ and $A^{(0)}$ describe the same d.o.f.'s

5d action for massive tensor tower

Action for the massless vector $A^{(0)}$ and the tower of massive tensors $B^{(n)}$

$$S = \int -\frac{1}{2g^2} F^{(0)} \wedge *F^{(0)} + \sum_{n=1}^{\infty} \left[i\bar{B}^{(n)} \wedge dB^{(n)} - m_n \bar{B}^{(n)} \wedge *B^{(n)} \right]$$

5d gauge coupling
$g^2 = R$

first-order, parity violating kinetic term

KK mass
$m_n = nR^{-1}$

Parity-violating massive fields

5d massive little group = 6d massless little group = $SO(4) \cong SU(2) \times SU(2)$

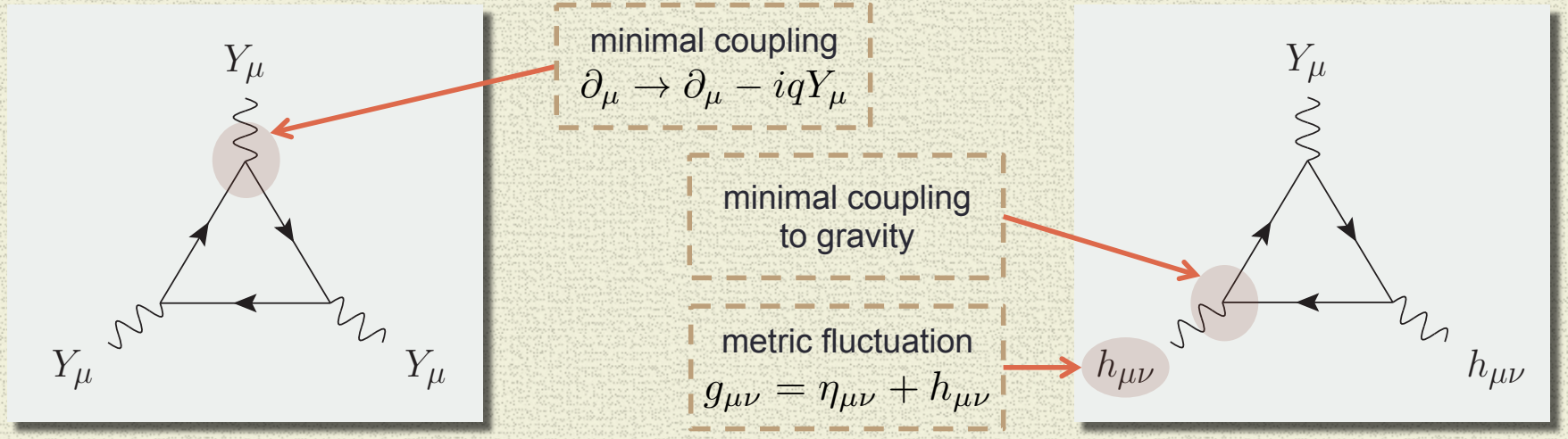
SO(4) rep	6d field	5d field	5d EOM
$(1/2, 0)$ $(0, 1/2)$	spin-1/2 symplectic Majorana-Weyl fermion	spin-1/2 Dirac fermion	$(i\gamma^\mu \partial_\mu \pm m)\psi = 0$
$(1/2, 1)$ $(1, 1/2)$	spin-3/2 symplectic Majorana-Weyl fermion	spin-3/2 Dirac fermion	$(i\gamma^{\rho\mu\nu} \partial_\mu \pm m\gamma^{\rho\nu})\psi_\nu = 0$
$(1, 0)$ $(0, 1)$	(anti)self-dual tensor	complex tensor	$(i * d \pm m)B = 0$

6d chirality ⟷ sign of 5d mass term

One-loop Chern-Simons terms

Parity violating massive fields induce Chern-Simons terms at one loop

$Y \equiv$ U(1) vector; $\mathcal{R} \equiv$ curvature 2-form



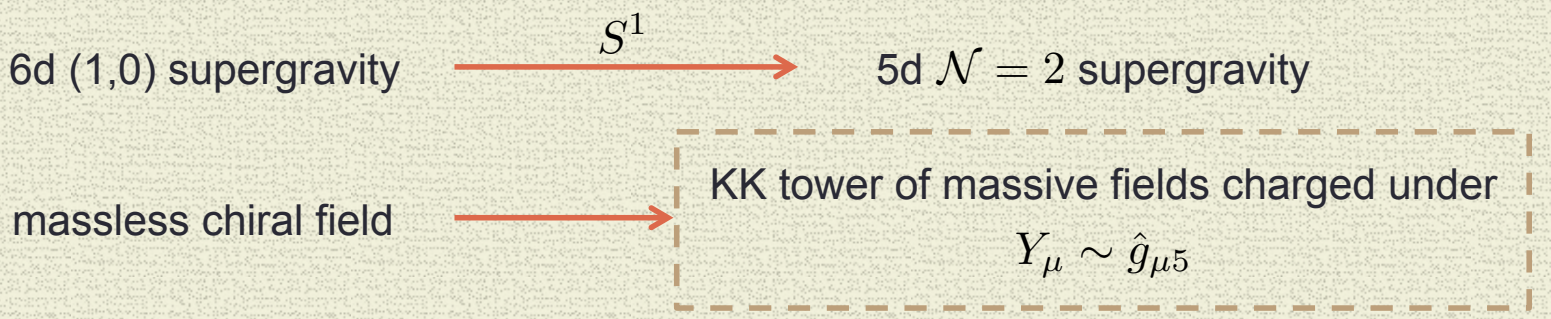
$$-\frac{\mathrm{sgn}(m) q^3}{48\pi^2}\, k \int Y \wedge dY \wedge dY$$

$$-\frac{\mathrm{sgn}(m) q}{384\pi^2}\, \kappa \int Y \wedge \mathrm{tr}\, \mathcal{R} \wedge \mathcal{R}$$

independent of the mass scale!

	spin-1/2 fermion	spin-3/2 fermion	massive tensor
k	1	5	−4
κ	1	−19	8

Example: (1,0) supergravity on a circle



6d spectrum: T tensor multiplets, V vector multiplets, H hypermultiplets

5d loop computation:

$$k_{\text{1-loop}} = \sum_{n=1}^{\infty} n^3 \Big[\underbrace{2(V-H-T)}_{\text{spin-1/2 fermions}} + \underbrace{2\cdot 5}_{\text{gravitino}} + \underbrace{(1-T)\cdot(-4)}_{\text{tensors}} \Big] = \frac{1}{2}(T-9)$$

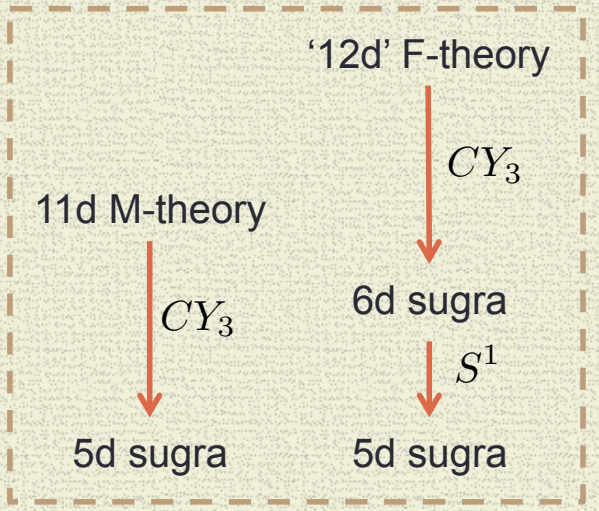
Anomaly cancellation condition $H - V = 273 - 29T$

KK sum regularization $\zeta(-3) = 1/120$

This term cannot arise from classical dimensional reduction: $k_{\text{class}} = 0$

Two applications

1. F-theory/M-theory duality
   - F-theory effective action derived via duality with M-theory
   - One-loop CS terms are crucial in the match of 5d actions and are related to 6d anomalies



2. 6d origins of 5d theory
   - Given a 5d theory, can it come from 6d?
   - Necessary conditions come from comparison between tree-level and one-loop CS terms

Non-Abelian tensor towers - I

Natural non-Abelian extension of the tensor tower action:

$$S = \int -\frac{1}{2g^2}\mathrm{Tr}\left[F^{(0)} \wedge *F^{(0)}\right] + \sum_{n=1}^{\infty}\mathrm{Tr}\left[i\bar{B}^{(n)} \wedge DB^{(n)} - m_n\,\bar{B}^{(n)} \wedge *B^{(n)}\right]$$

zeromodes are promoted to non-Abelian gauge fields

$$F^{(0)} = dA^{(0)} + \tfrac{1}{2}[A^{(0)}, A^{(0)}]$$

excited modes are promoted to adjoint matter

$$DB^{(n)} = dB^{(n)} + [A^{(0)}, B^{(n)}]$$

- This system does not admit a straightforward lift to 6d
- Proposal: use non-Abelian tensor towers to study (2,0) theories

Non-Abelian tensor towers - II

- This non-Abelian action can be extended to a 5d action with
  - ✓ 8 real supercharges
  - ✓ full spectrum expected from circle reduction of a (2,0) theory
  - ✓ all couplings specified by KK level and group theoretical invariants
- Two special cases
  1. truncate excited modes: susy enhances to 5d MSYM
  2. switch off non-Abelian structure constants: susy enhances to Abelian (2,0) theory on a circle
- Hope: non-Abelian tensor towers can capture some robust quantities of (2,0) theories (e.g. anomalies)

Conclusions

6d self-dual tensor ⟶ 5d massless vector + massive tensor tower

massive tensors at one loop

- 5d massive tensors break parity
- CS terms are induced at one-loop by integrating them out

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- Better understanding of F-theory/ M-theory duality in 6d
- Tests for 6d origins of a given 5d theory

non-Abelian massive tensors

- Natural non-Abelian extension
- Supersymmetric models with all d.o.f.'s expected for (2,0) theories on a circle

↓

- 5d window on robust features of (2,0) theories?

Thank you for your attention.