N=1 domain wall solutions of massive type II supergravity as generalized geometries

J. Louis, S.V. JHEP 08 (2006) 058

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Napoli, RTN Workshop 2006

Plan of the talk + (a few) References

- Type IIB flux compactifications

S.B. Giddings, S. Kachru and J. Polchinski, Phys. Rev. D **66** (2002) 106006
J. Michelson, Nucl. Phys. B **495** (1997) 127
T.R. Taylor and C. Vafa, Phys. Lett. B **474** (2000) 130
G. Dall'Agata, JHEP **0111** (2001) 005
J. Louis and A. Micu, Nucl. Phys. B **635** (2002) 395

- D=4 gauged sugra models with massive tensor multiplets

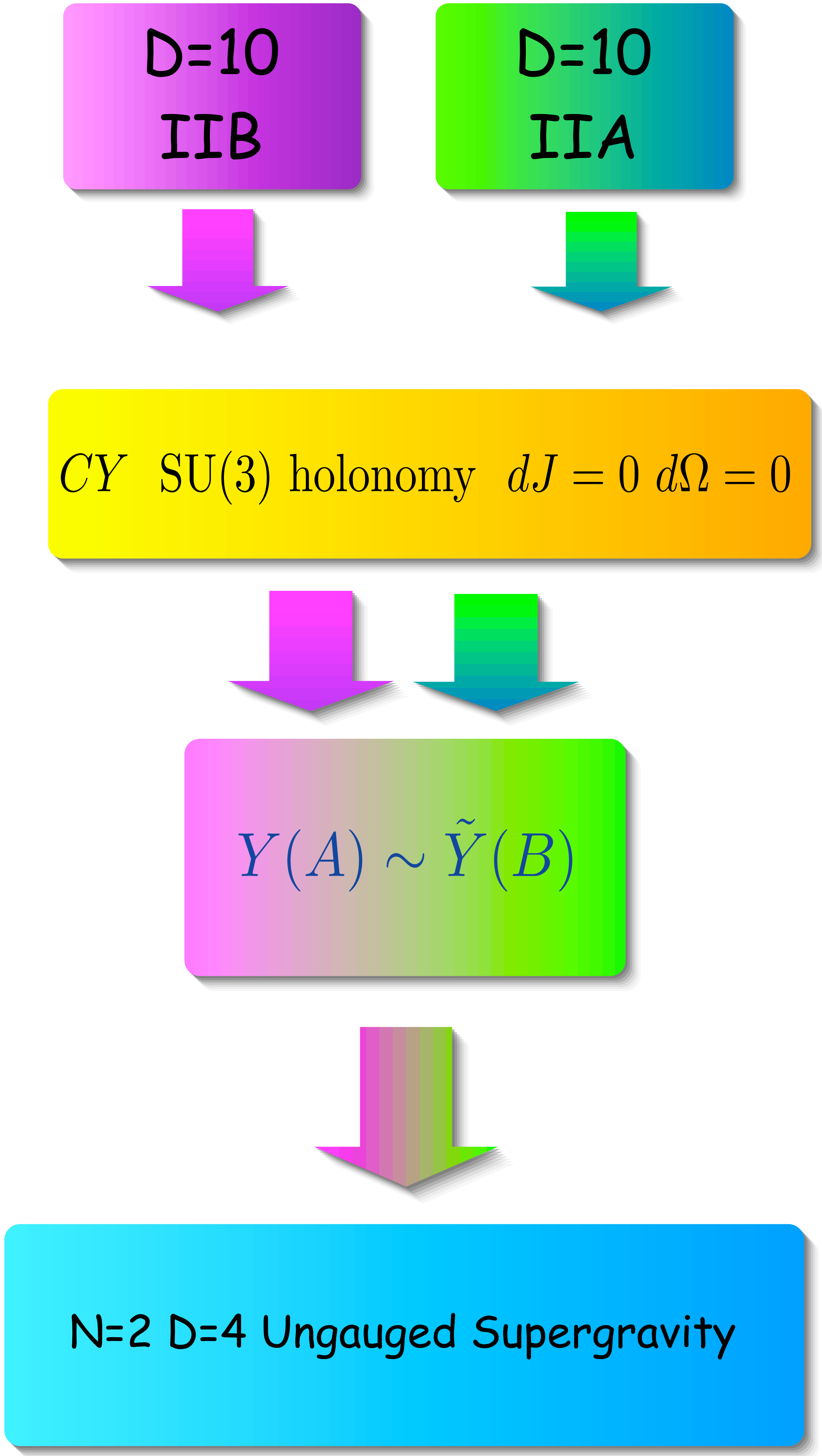
G. Dall'Agata, R. D'Auria, L. Sommovigo and S. V. Nucl. Phys. B **682** (2004) 243
L. Sommovigo and S. V. Phys. Lett. B **602** (2004) 130

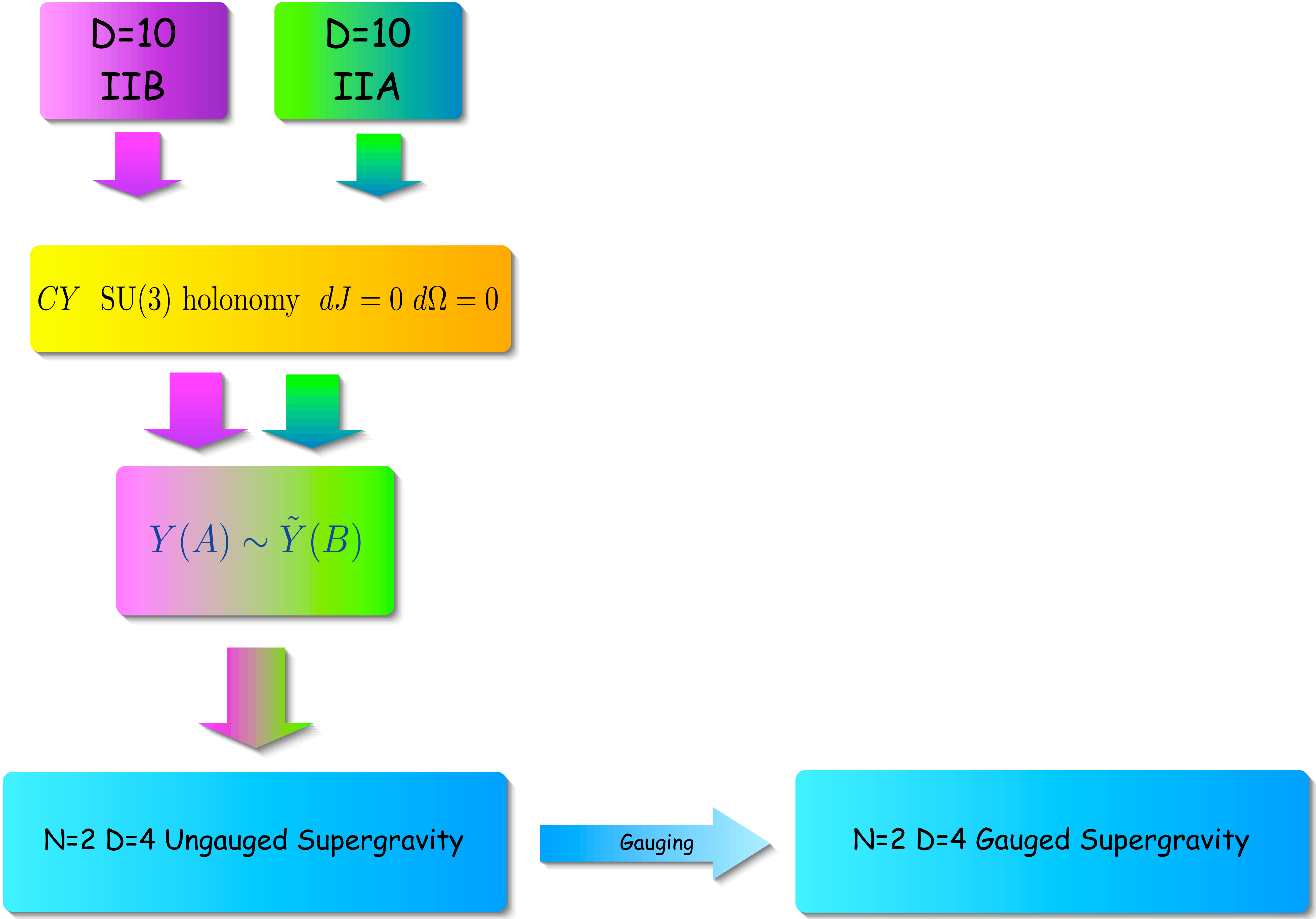
- N=1 BPS Domain Wall solutions

C. Mayer and T. Mohaupt, Class. Quant. Grav. **22** (2005) 379
J. Louis, S.V. JHEP **08** (2006) 058

- Generalized geometry, SU(3) x SU(3) structure manifolds

N. Hitchin, ``Generalized Calabi--Yau manifolds,'' arXiv:math.DG/0209099.
C. Jeschek and F. Witt, JHEP **0503** (2005) 053
M. Grana, J. Louis and D. Waldram, JHEP **0601** (2006) 008
I. Benmachiche and T.W. Grimm, Nucl. Phys. B **748** (2006) 200


D=10
IIB
D=10
IIA
CY SU(3) holonomy $dJ = 0$ $d\Omega = 0$
$Y(A) \sim \tilde{Y}(B)$
N=2 D=4 Ungauged Supergravity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$Y(A) \sim \tilde{Y}(B)$
N=2 D=4 Ungauged Supergravity
Gauging
N=2 D=4 Gauged Supergravity

D=10
IIB

$CY \quad \mathrm{SU}(3)$

Y

Gauging:

$$\partial_\mu \phi^a \to \nabla_\mu \phi^a \equiv \partial_\mu \phi^a + k_I^a A_\mu^I$$

Killing vectors — gauge potentials

Stückelberg coupling:

$$\mathcal{F}_{\mu\nu}^I \equiv \partial_{[\mu} A_{\nu]}^I \to \hat{\mathcal{F}}_{\mu\nu}^I \equiv \partial_{[\mu} A_{\nu]}^I + m^{Ia} B_{a\mu\nu}$$

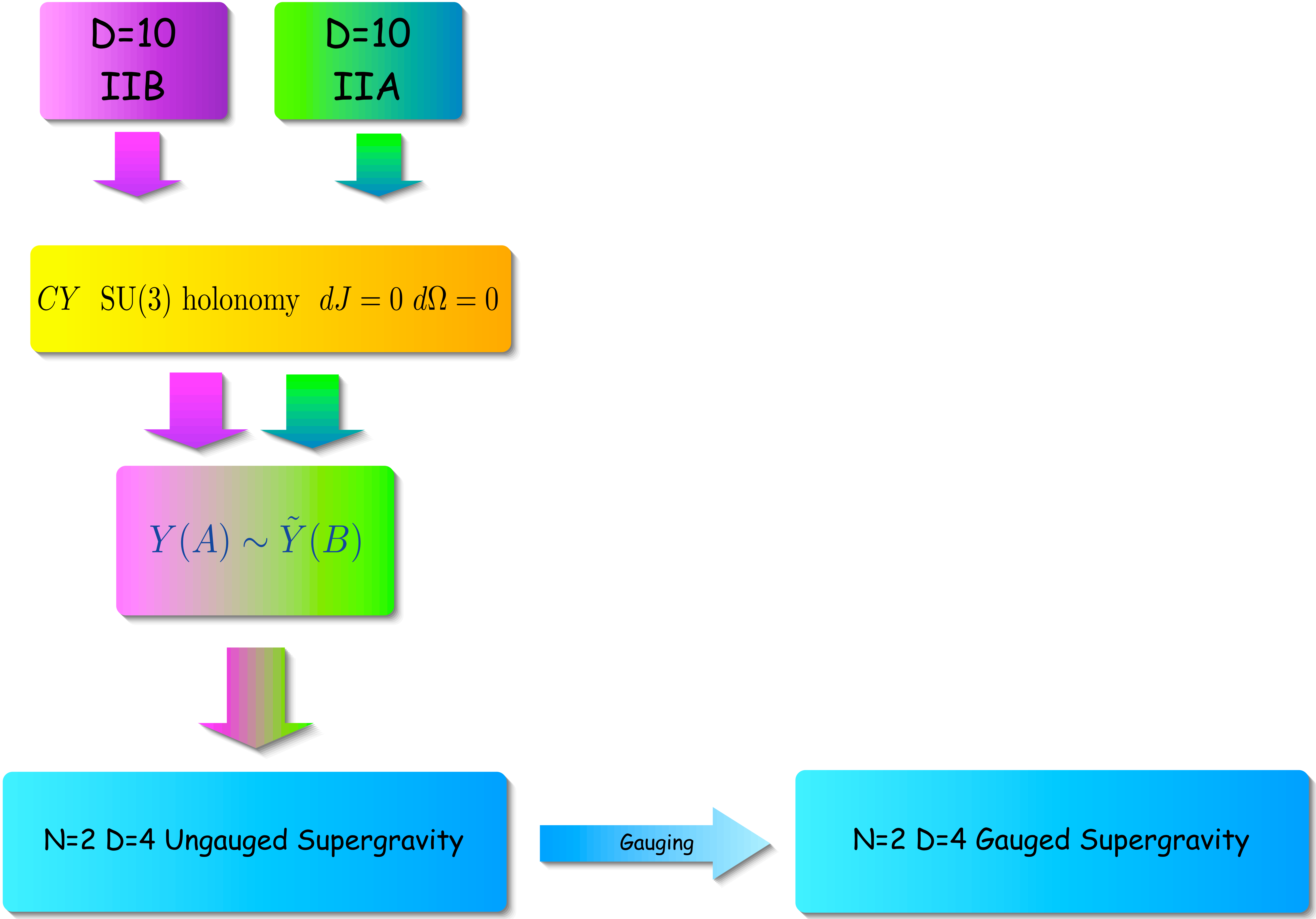
magnetic charges — antisymm. tensors

Green-Schwarz coupling:

$$\mathcal{L} \to \mathcal{L} + e_I^a \mathcal{F}_{\mu\nu}^I B_{a\rho\sigma} \epsilon^{\mu\nu\rho\sigma} + \dots$$

Abelian electric charges

N=2 D=4 Ungauged Supergravity → Gauging → N=2 D=4 Gauged Supergravity



D=10
IIB
D=10
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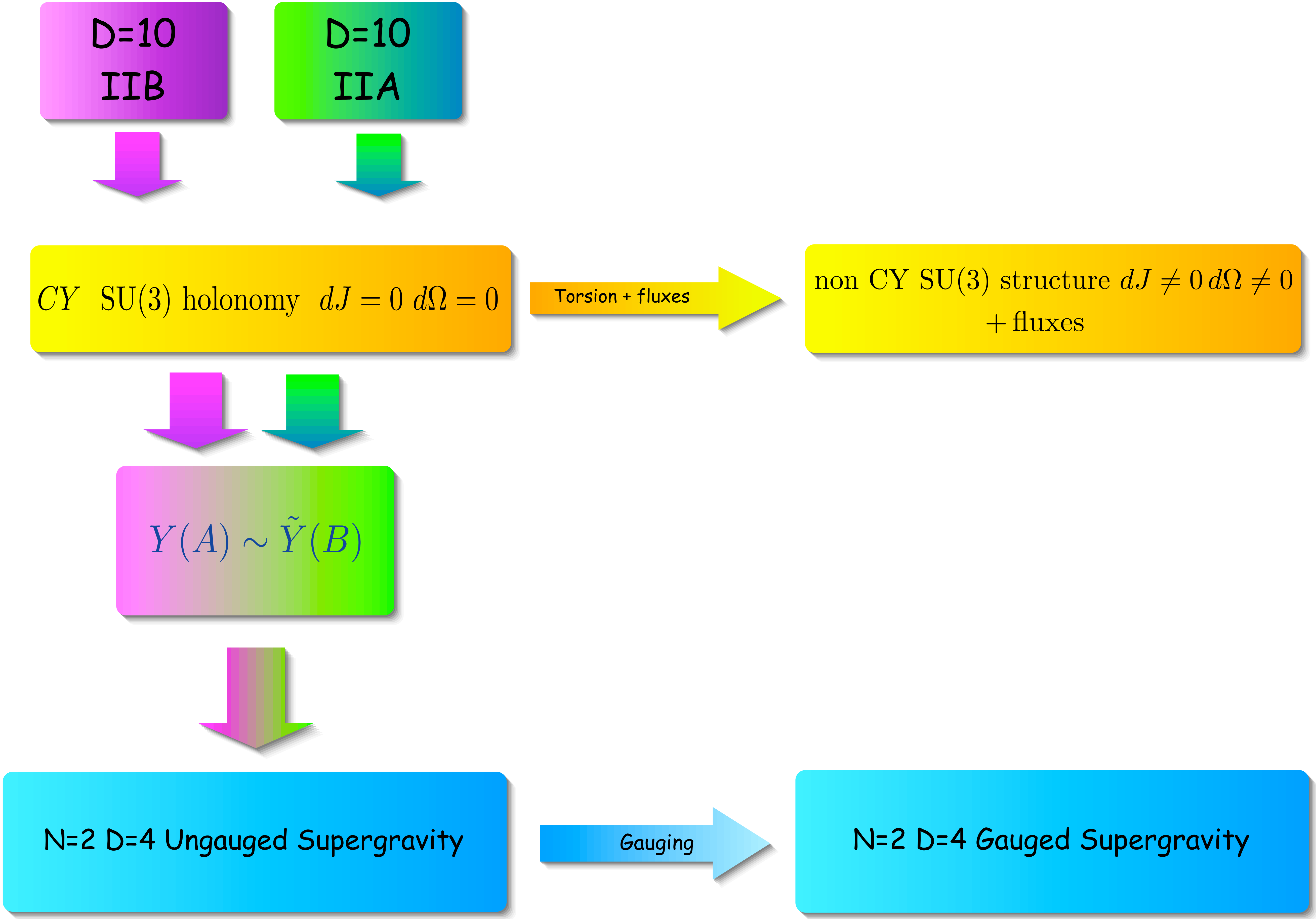
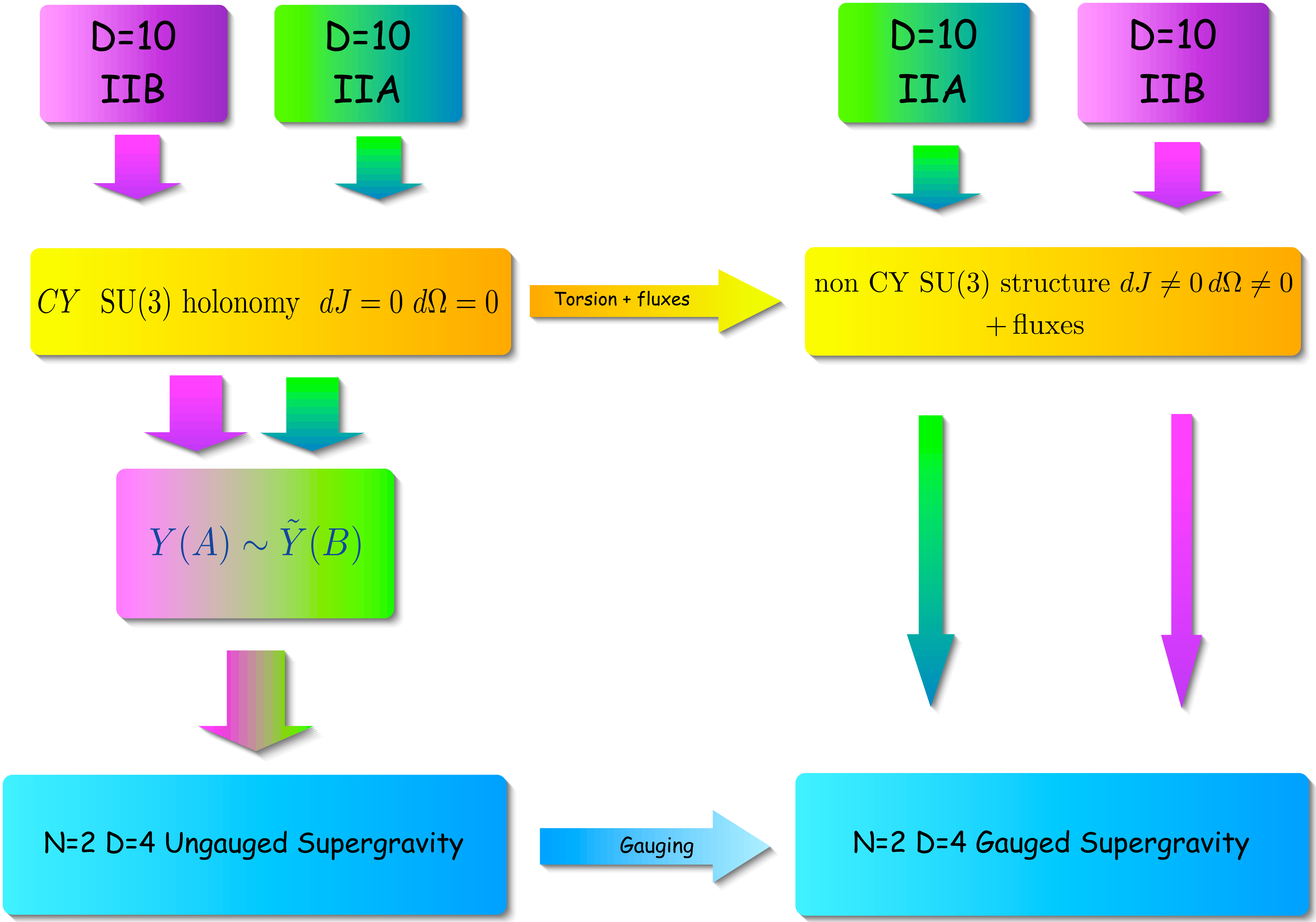
$Y(A) \sim \tilde{Y}(B)$
N=2 D=4 Ungauged Supergravity
Gauging
N=2 D=4 Gauged Supergravity



D=10
IIB
D=10
IIA
CY SU(3) holonomy $dJ = 0$ $d\Omega = 0$
Torsion + fluxes
non CY SU(3) structure $dJ \neq 0$ $d\Omega \neq 0$
+ fluxes
$Y(A) \sim \tilde{Y}(B)$
N=2 D=4 Ungauged Supergravity
Gauging
N=2 D=4 Gauged Supergravity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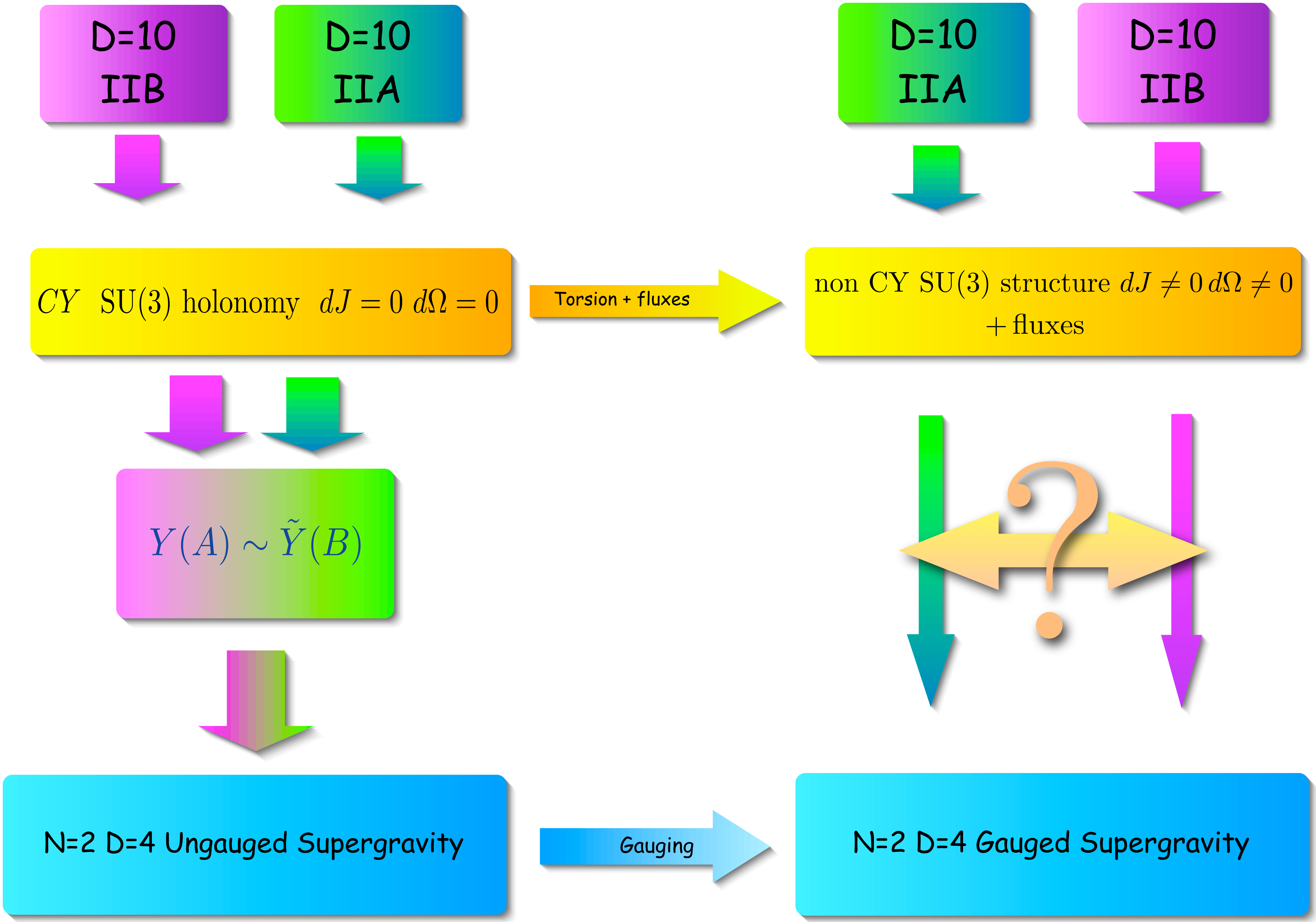
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Torsion + fluxes
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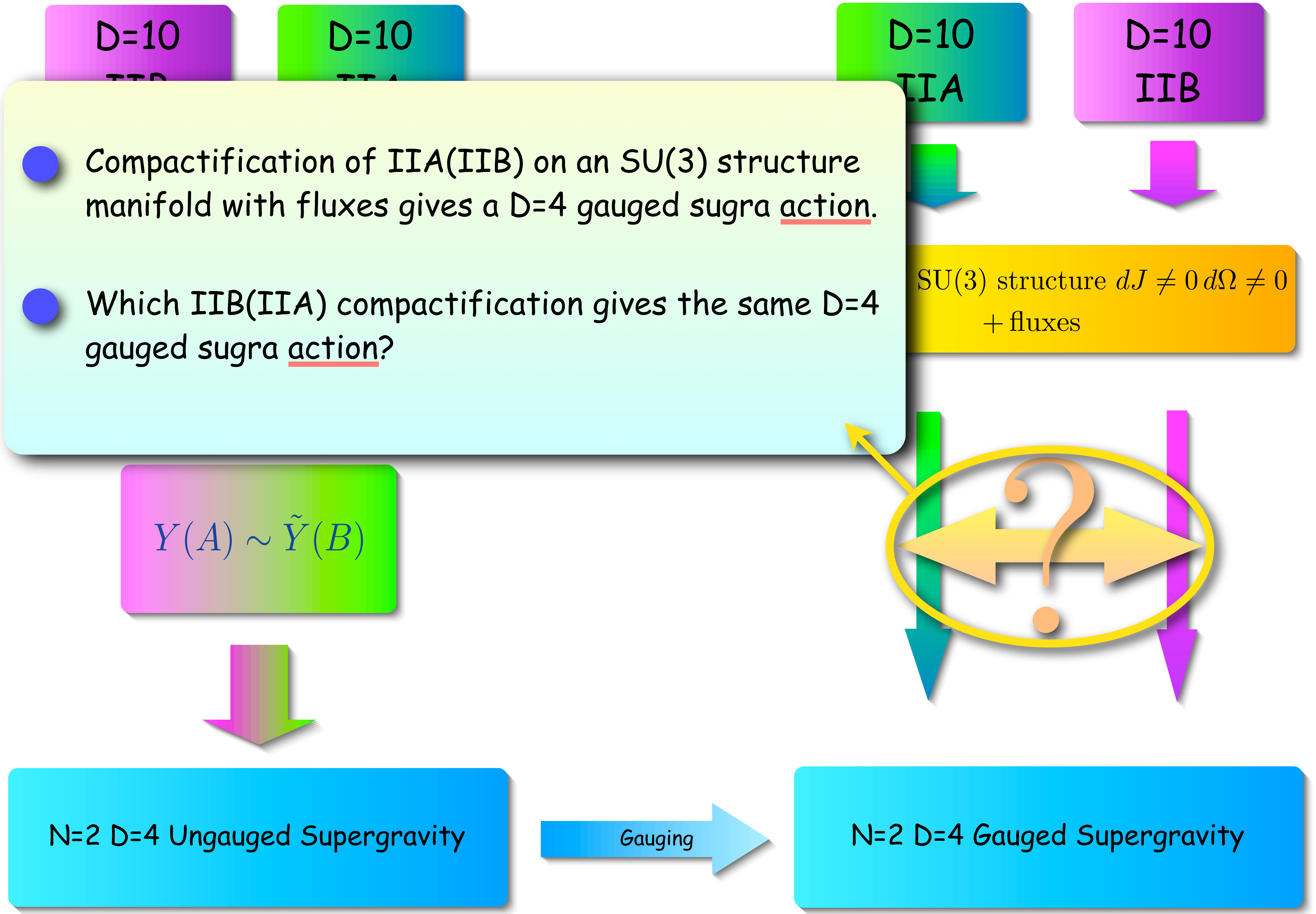
+ fluxes
$Y(A) \sim \tilde{Y}(B)$
?
N=2 D=4 Ungauged Supergravity
Gauging
N=2 D=4 Gauged Supergravity

- Compactification of IIA(IIB) on an SU(3) structure manifold with fluxes gives a D=4 gauged sugra action.
- Which IIB(IIA) compactification gives the same D=4 gauged sugra action?



IIA

IIB

RR fluxes

$$\hat{F}^{(2)} = d\hat{C}^{(1)} + m^i \omega_i$$

$$\hat{F}^{(4)} = d\hat{C}^{(3)} + e_i \omega^i$$

$$\hat{F}^{(3)} = d\hat{C}^{(2)} + m^I \alpha_I - e_I \beta^I$$

$$2h^{(1,1)} + m + e \sim C^{(3)} = 2h^{(1,1)} + 2$$

$$2\tilde{h}^{(2,1)} + 2$$

Louis, Micu,
Nucl. Phys.B635:395-431,2002

	IIA	IIB
RR fluxes	$\hat{F}^{(2)} = d\hat{C}^{(1)} + m^i\omega_i$ $\hat{F}^{(4)} = d\hat{C}^{(3)} + e_i\omega^i$	$\hat{F}^{(3)} = d\hat{C}^{(2)} + m^I\alpha_I - e_I\beta^I$
	$2h^{(1,1)} + m \; + \; e \sim C^{(3)} = 2h^{(1,1)} + 2$	$2\tilde{h}^{(2,1)} + 2$
		Louis, Micu, Nucl. Phys.B635:395-431,2002
NSNS fluxes	$\hat{H}^{(3)} = d\hat{B}^{(2)} + m^\Lambda\alpha_\Lambda - e_\Lambda\beta^\Lambda$	$dJ \neq 0 \quad (d\Omega \neq 0)$
	$dJ \neq 0 \quad (d\Omega \neq 0)$	$\hat{H}^{(3)} = d\hat{B}^{(2)} + m^I\alpha_I - e_I\beta^I$

	IIA	IIB
RR fluxes	$\hat{F}^{(2)} = d\hat{C}^{(1)} + m^i \omega_i$ $\hat{F}^{(4)} = d\hat{C}^{(3)} + e_i \omega^i$	$\hat{F}^{(3)} = d\hat{C}^{(2)} + m^I \alpha_I - e_I \beta^I$
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	$dJ \neq 0 \quad (d\Omega \neq 0)$	$\hat{H}^{(3)} = d\hat{B}^{(2)} + m^I \alpha_I - e_I \beta^I$

Electric NSNS fluxes ⇔ Half flat manifold

Gurrieri, Louis, Micu, Waldram
Nucl. Phys.B654:61-113,2003

Gurrieri, Micu,
Class. Quant. Grav.20:2181,2003

	IIA	IIB
RR fluxes	$\hat{F}^{(2)} = d\hat{C}^{(1)} + m^i \omega_i$ $\hat{F}^{(4)} = d\hat{C}^{(3)} + e_i \omega^i$	$\hat{F}^{(3)} = d\hat{C}^{(2)} + m^I \alpha_I - e_I \beta^I$
	$2h^{(1,1)} + m + e \sim C^{(3)} = 2h^{(1,1)} + 2$	$2\tilde{h}^{(2,1)} + 2$

Louis, Micu,
Nucl. Phys.B635:395-431,2002

	IIA	IIB
NSNS fluxes	$\hat{H}^{(3)} = d\hat{B}^{(2)} + m^\Lambda \alpha_\Lambda - e_\Lambda \beta^\Lambda$	$dJ \neq 0 \quad (d\Omega \neq 0)$
	$dJ \neq 0 \quad (d\Omega \neq 0)$	$\hat{H}^{(3)} = d\hat{B}^{(2)} + m^I \alpha_I - e_I \beta^I$

¿ Magnetic NSNS fluxes ?

1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

Type IIB
on a CY $\tilde{Y}$ + fluxes

$$\mathcal{M}^{(1,3)} \times_w \tilde{Y}^{(6)}$$

10 = 4 + 6

1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

Type IIB
on a CY $\tilde{Y}$ + fluxes

$$\mathcal{M}^{(1,3)} \times_w \tilde{Y}^{(6)}$$

10 = 4 + 6

D=4 supergravity
DW background

$$\mathcal{M}^{(1,2)} \times_w \mathbb{R}$$

4 = 3 + 1

1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

Type IIB
on a CY $\tilde{Y}$ + fluxes

$$\mathcal{M}^{(1,3)} \times_w \tilde{Y}^{(6)}$$

10 = 4 + 6

D=4 supergravity
DW background

$$\mathcal{M}^{(1,2)} \times_w \mathbb{R}$$

4 = 3 + 1

D=10 uplift of the
DW solution

$$\mathcal{M}^{(1,2)} \times_w (\mathbb{R} \times \hat{Y}^{(6)})$$

10 = 3 +(1 + 6)

1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

Type IIB on a CY $\tilde{Y}$ + fluxes — $\mathcal{M}^{(1,3)} \times_w \tilde{Y}^{(6)}$ — 10 = 4 + 6

D=4 supergravity DW background — $\mathcal{M}^{(1,2)} \times_w \mathbb{R}$ — 4 = 3 + 1

D=10 uplift of the DW solution — $\mathcal{M}^{(1,2)} \times_w (\mathbb{R} \times \hat{Y}^{(6)})$ — 10 = 3 +(1 + 6)

$\hat{Y}^{(6)}$ is half flat ⟷ $\mathbb{R} \times \hat{Y}^{(6)}$ has G_2 holonomy

1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

Type IIB on a CY $\tilde{Y}$ + fluxes — $\mathcal{M}^{(1,3)} \times_w \tilde{Y}^{(6)}$ — 10 = 4 + 6

D=4 supergravity DW background — $\mathcal{M}^{(1,2)} \times_w \mathbb{R}$ — 4 = 3 + 1

D=10 uplift of the DW solution — $\mathcal{M}^{(1,2)} \times_w (\mathbb{R} \times \hat{Y}^{(6)})$ — 10 = 3 +(1 + 6)

$\hat{Y}^{(6)}$ is half flat ⟷ $\mathbb{R} \times \hat{Y}^{(6)}$ has G_2 holonomy

D.W. solutions of type IIB with electric NSNS fluxes, describe a 1+6 manifold of G_2 holonomy for type IIA

C.Mayer, T.Mohaupt
Class.Quant.Grav. 22 (2005)

1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

Type IIB on a CY $\tilde{Y}$ + fluxes	$\mathcal{M}^{(1,3)} \times_w \tilde{Y}^{(6)}$	10 = 4 + 6
D=4 supergravity DW background	$\mathcal{M}^{(1,2)} \times_w \mathbb{R}$	4 = 3 + 1
D=10 uplift of the DW solution	$\mathcal{M}^{(1,2)} \times_w (\mathbb{R} \times \hat{Y}^{(6)})$	10 = 3 +(1 + 6)

In the presence of electric and magnetic NSNS fluxes in type IIB, which is the geometry of $\mathbb{R} \times \hat{Y}^{(6)}$ for type IIA?

1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

J. Louis, S.V.
JHEP 08 (2006) 058

$$ds^2 = e^{2U(z)} g_{mn}(x^m) dx^m dx^n - e^{-2pU(z)} dz dz$$

$\delta\psi_{A\mu} = \delta\lambda^{iA} = \delta\zeta^{\alpha} = 0$ for $\frac{1}{2}$ of the supercharges $\varepsilon_A = \bar{h} A_{AB} \gamma_3 \varepsilon^B$

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D=4 massive sugra supersymmetry transformation laws

$$\delta\psi_{A\mu} = \mathcal{D}_\mu \varepsilon_A - h^I_\mu \omega_{I\,A}{}^B \varepsilon_B + \epsilon_{AB} T^-_{\mu\nu} \gamma^\nu \varepsilon^B + i S_{AB} \gamma_\mu \varepsilon^B$$

$$\delta\lambda^{iA} = i \nabla_\mu z^i \gamma^\mu \varepsilon^A + G^{-i}_{\mu\nu} \gamma^{\mu\nu} \varepsilon_B \epsilon^{AB} + W^{iAB} \varepsilon_B$$

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G. Dall'Agata, R.D'Auria, L.Sommovigo,S.V. Nucl. Phys. B682 (2004)
L.Sommovigo, S.V. Phys. Lett. B602 (2004)

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D=4 massive sugra supersymmetry transformation laws

$$\delta\psi_{A\mu} = \mathcal{D}_{\mu} \ldots {}_{\mu\nu}\gamma^{\nu}\varepsilon^B + i S_{AB}\gamma_{\mu}\varepsilon^B$$

Originated from the quaternionic vielbein once the scalars are dualized into tensors

$$\delta\lambda^{iA} = i\nabla \ldots + W^{iAB}\varepsilon_B$$

$$\delta\zeta_{\alpha} = i P_{uA\alpha}\partial_{\mu} q^u \gamma^{\mu}\varepsilon^A - i h^I_{\mu} \mathcal{U}_{IA\alpha}\gamma^{\mu}\varepsilon^A + N^A_{\alpha}\varepsilon_A$$

1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

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D=4 massive sugra supersymmetry transformation laws

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Originated from the quaternionic vielbein once the scalars are dualized into tensors

$$h^{I}_{\mu} = \epsilon_{\mu\nu\rho\sigma}\partial^{\nu}B^{I\,\rho\sigma}$$

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D=4 massive sugra supersymmetry transformation laws

$$\delta\psi_{A\mu} = \mathcal{D}_\mu \varepsilon_A - h^I_\mu \omega_{I\,A}{}^B \varepsilon_B + \epsilon_{AB} T^-_{\mu\nu} \gamma^\nu \varepsilon^B + i S_{AB} \gamma_\mu \varepsilon^B$$

Originated from the SU(2) connection on the quaternionic manifold

$$\delta\lambda^{iA} \quad \ldots \; \varepsilon_B \epsilon^{AB} + W^{iAB} \varepsilon_B$$

$$\delta\zeta_\alpha \quad \ldots \; \mathcal{U}_{IA\alpha} \gamma^\mu \varepsilon^A + N^A_\alpha \varepsilon_A$$

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Fermion shifts proportional to the fluxes

We consider the relevant moduli for the description of the IIA internal manifold

Vector multiplets: $z^i = v^i + i\, b^i$ $\quad e^{-K_V} = \frac{4}{3} c_{ijk} v^i v^j v^k$ $\quad \hat{B} = B + b^i \omega_i$ $\quad A_\mu^\Lambda = 0$

Hyper multiplets: $e^{-K_H} = \frac{4}{3} d_{abc} \lambda^a \lambda^b \lambda^c$ $\quad B^I_{\mu\nu} = 0$ $\quad$ other scalars=0

$$\delta\psi_{A\mu} = \mathcal{D}_\mu \varepsilon_A - h^I_\mu \omega_{I\,A}{}^B \varepsilon_B + \epsilon_{AB} T^-_{\mu\nu} \gamma^\nu \varepsilon^B + i S_{AB} \gamma_\mu \varepsilon^B$$

$$\delta\lambda^{iA} = i \nabla_\mu z^i \gamma^\mu \varepsilon^A + G^{-i}_{\mu\nu} \gamma^{\mu\nu} \varepsilon_B \epsilon^{AB} + W^{iAB} \varepsilon_B$$

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Hyper multiplets: $e^{-K_H} = \frac{4}{3} d_{abc} \lambda^a \lambda^b \lambda^c \qquad B^I_{\mu\nu} = 0$ other scalars=0

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D=4 massive sugra supersymmetry transformation laws

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1/2 BPS Domain Wall solutions vs SU(3)xSU(3) structure manifolds

$$ds^2 = e^{2U(z)} g_{mn}(x^m) dx^m dx^n - e^{-2pU(z)} dz dz$$

$$\omega_m^{a3} = e^{(p+1)U(z)} U'(z) \hat{e}_m^a$$

D=4 massive sugra supersymmetry transformation laws

$$\delta\psi_{A\mu} = \mathcal{D}_\mu \varepsilon_A - h_\mu^I \omega_{I A}{}^B \varepsilon_B + \epsilon_{AB} T_{\mu\nu}^- \gamma^\nu \varepsilon^B + i S_{AB} \gamma_\mu \varepsilon^B$$

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$$\nabla_i S_{AB} = \frac{1}{2} g_{i\bar{j}} W_{AB}^{\bar{j}}$$

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$$U' = \frac{1}{2} e^{-pU} (hW + \bar{h}\bar{W})$$

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Flat DW → Ricci Flat 7-dimensional manifold

Vector multiplets

$$t^i = v^i + ib^i \qquad t^i = \frac{X^i}{X^0}$$

$$\partial_w \begin{pmatrix} \mathrm{Im}X^\Lambda \\ \mathrm{Im}F_\Lambda \end{pmatrix} = -\begin{pmatrix} m^\Lambda \\ e_\Lambda \end{pmatrix}$$

$$\mathrm{Im}X^\Lambda e_\Lambda - \mathrm{Im}F_\Lambda m^\Lambda = 0$$

Hyper multiplets

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IIA Kähler class deformations

$$\Phi_+ = X^\Lambda \omega_\Lambda - F_\Lambda \, \omega^\Lambda$$

$$\partial_w \mathrm{Im} \Phi_+ = e_\Lambda \omega^\Lambda - m^\Lambda \omega_\Lambda$$

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SU(3)xSU(3) structure cohomology

$$d\alpha_0 = m^\Lambda \omega_\Lambda - e_\Lambda \omega^\Lambda$$

$$d\omega_\Lambda = e_\Lambda \beta^0 \qquad d\omega^\Lambda = m^\Lambda \beta^0$$

$$\partial_w \begin{pmatrix} \mathrm{Im} X^\Lambda \\ \mathrm{Im} F_\Lambda \end{pmatrix} = - \begin{pmatrix} m^\Lambda \\ e_\Lambda \end{pmatrix}$$

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...ations

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$\partial_w \mathrm{Ir}\ldots$ $d\mathrm{Re}\Phi_+$

Generalized Hitchin' flow equations

$$d\,\mathrm{Im}\Phi_- = 0$$

$$d\,\mathrm{Im}\Phi_+ = 0$$

$$\partial_y \mathrm{Im}\Phi_+ = -d\,\mathrm{Re}\Phi_-$$

$$\partial_y \mathrm{Im}\Phi_- = d\,\mathrm{Re}\Phi_+$$

Conclusions

- We considered D=4 gauged sugra corresponding to type IIB on CY with electric and magnetic RR and NSNS fluxes.

- We found a 1/2 BPS Domain Wall solution.

- We interpreted the DW equations on the relevant scalars as Hitchin's flow equation on a 6-dim manifold with SU(3)xSU(3) structure fibered over the direction transverse to the DW.

- The results confirms that compactifications in the presence of electric and magnetic NSNS fluxes correspond under mirror symmetry to compactifications on SU(3)xSU(3) structure manifolds.