Open-Moduli Infinite-Distance Limits in Six-Dimensional F-Theory

Rafael Álvarez-García
work together with Seung-Joo Lee and Timo Weigand

arXiv:2304.XXXXX

8th March 2023

Strings and Geometry 2023

University of Pennsylvania

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

Motivating questions:

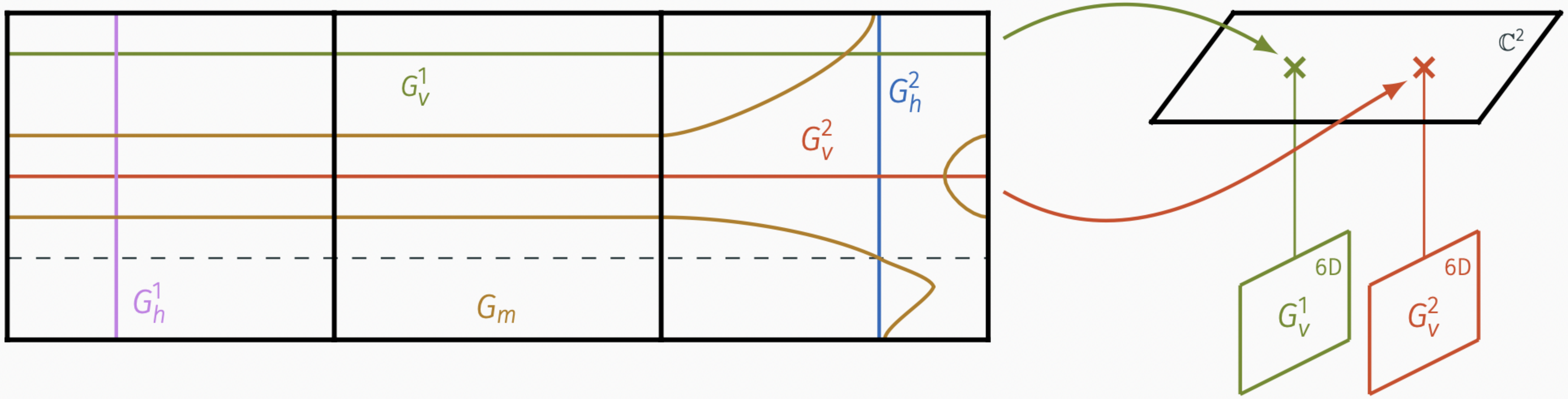
- Swampland motivation: Understand open-moduli ∞-distance limits in 6D F-theory.
- F-theory motivation: Understand codim-1 and codim-2 non-minimal singularities.

Open-Moduli Infinite-Distance Limits in Six-Dimensional F-Theory

Codim	ord(f, g)	Interpretation
2	$([4,8),[6,12))$	SCFT's
1	$(\geq 4, \geq 6)$	∞-distance
2	$(\geq 8, \geq 12)$	∞-distance

- $\mathrm{Bl}^k(\mathbb{F}_n)$: origin of tensor branch gives $\mathbb{F}_n$.
- $\mathbb{P}^2$: finite-distance away from $\mathbb{F}_1$.
- $\mathbb{F}_n$: start our detailed analysis here.

- Resulting models: chain of surfaces intersecting at curves.
- Explicitly analyze how they are constructed, their types and the structure of the discriminant.
- Ongoing analysis: decompactification limits in a dual sense.



Aspects of Symmetries from Branes

wip w/ Fabio Apruzzi, Federico Bonetti, Sakura Schafer-Nameki
Dewi Gould
University of Oxford

Dewi Gould
wip w/ Fabio Apruzzi, Federico Bonetti, Sakura Schafer-Nameki

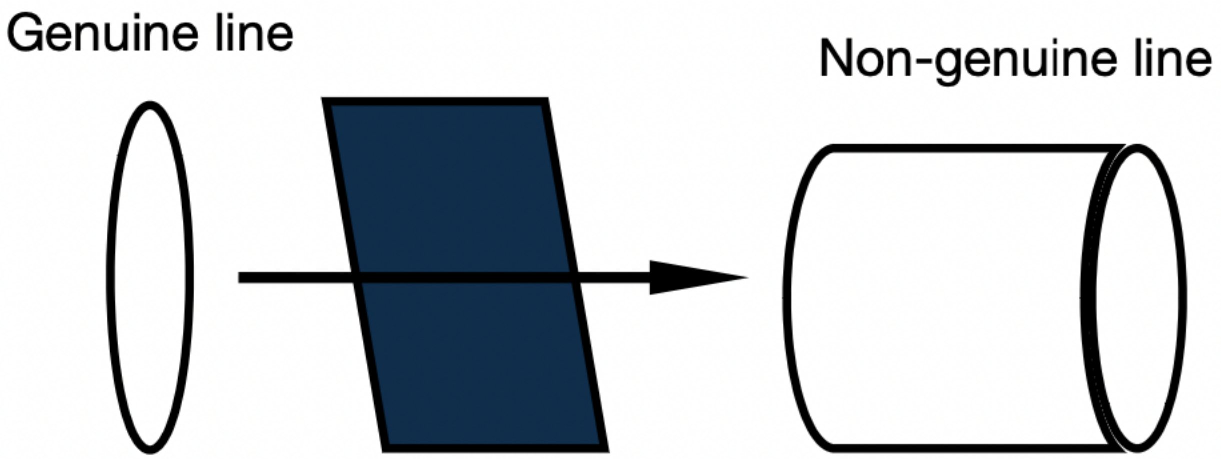
UNIVERSITY OF OXFORD

- Starting point: topological symmetry generators = wrapped branes "at infinity"

[Apruzzi, Bah, Bonetti, Schafer-Nameki] [Heckman, Hubner, Torres, Zhang] [Heckman, Hubner, Torres, Yu, Zhang] [Etxebarria] [Etheredge, Etxebarria, Heidenreich, Rauch]

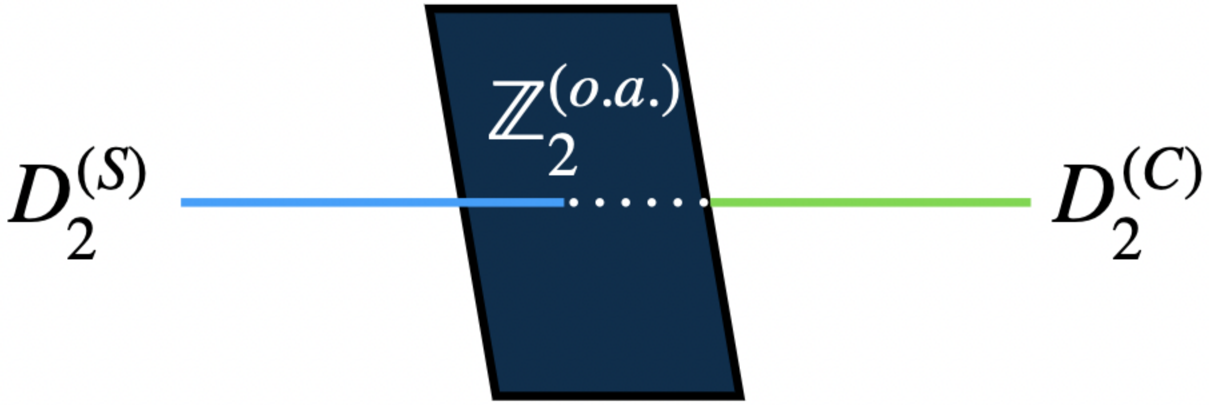
- Use **brane physics** to compute symmetries properties, including…

1. Hanany-Witten Moves



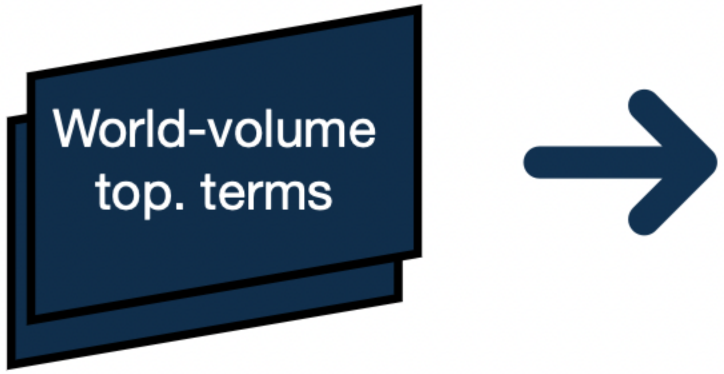
Non-invertible action

2. Brane Intersections



0-form acting on 1-form

3. Brane Stacking



Fusion Rules from branes

Ruiwen Ouyang

Gauge and Yukawa Unification in Grand Unified Theories

2212.11315 [hep-ph]
2106.15822 [hep-ph]

PhD student at NICPB, Tallinn, Estonia

Supervisor: Martti Raidal, Abdelhak Djouadi

March 8, 2023

KBFI NICPB

Ruiwen Ouyang

Past works:

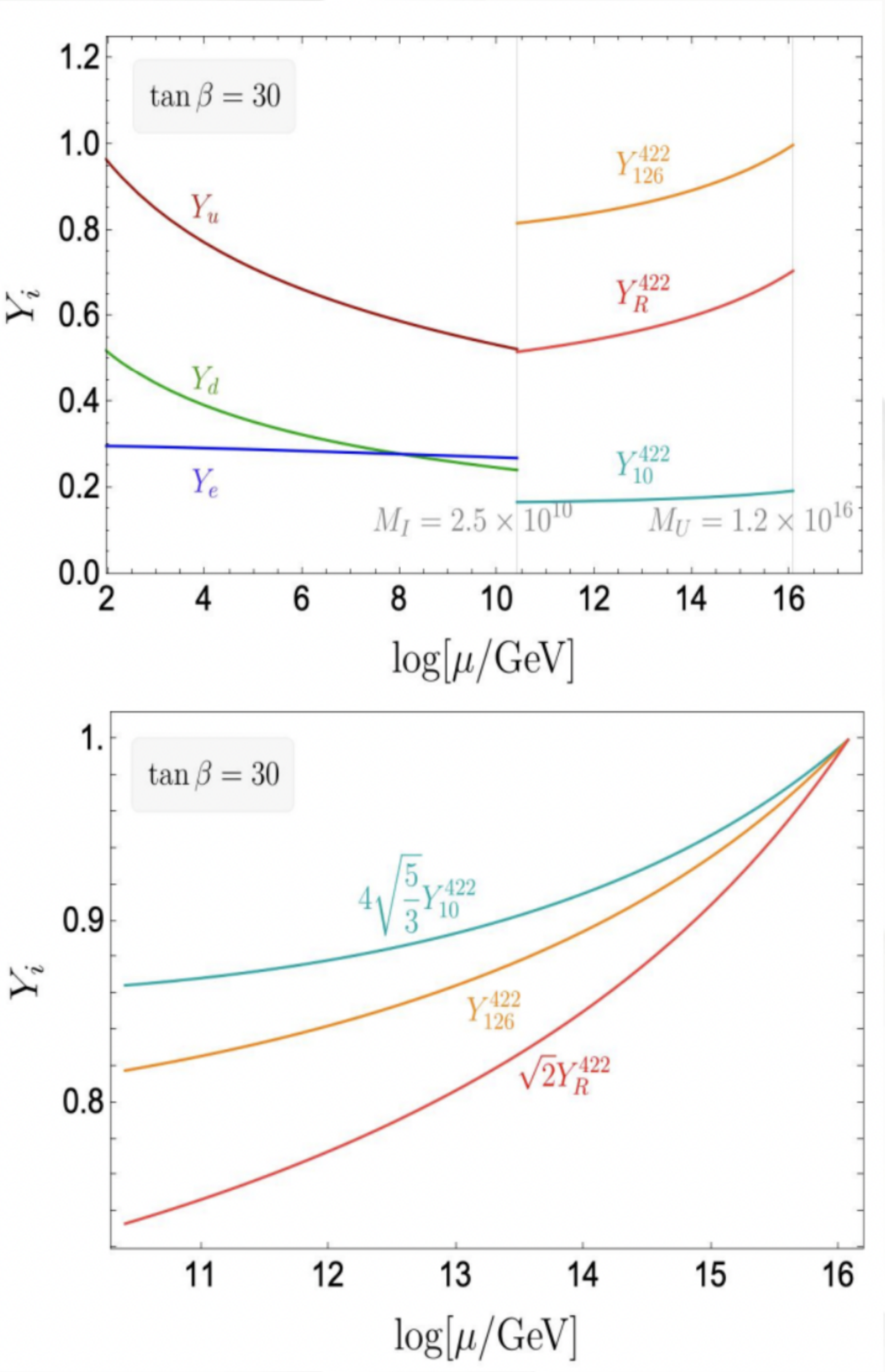
Unification of Yukawa couplings in SO(10)

Current interests:

1. Family unification in GUTs (e.g. SO(18), SU(19), …)

2. Generalized symmetries in GUTs

3. Application of Swamplands constraints in BSM model building.



(Stringy) Time-Reversal Defects at Rational θ in 4d SU(M) YM

Enoch Leung (Johns Hopkins University)

in collaboration with Thomas Waddleton & Ibrahima Bah

Strings and Geometry 2023

- Time-reversal symmetry in 4d Maxwell theory and massive QED at rational $\theta = \pi(p/N)$ (Choi, Lam, Shao '22)
- Defect (sym. generator) has interesting properties, e.g. $\mathscr{D} \otimes \overline{\mathscr{D}} \neq \mathrm{Id}$
- Purely field-theoretic analysis

- QUESTION: What about $\mathrm{SU}(M)$? Any holographic realization?

- Insert a certain combination of probes in some IIB background
- R-R fields live in H_{NS}-twisted K-theory $\Longrightarrow$ nontrivial Dirichlet b.c.
- (Non-invertible) time-reversal defects at rational θ in dual field theory!!!

Condensate Defects from Tachyon Condensation

Thomas Waddleton

in collaboration with Enoch Leung and Ibrahima Bah

March 7, 2023

Johns Hopkins University

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Condensates from Condensation

$$
\begin{array}{ccc}
\mathrm{D}p\text{–brane} & \xrightarrow{\mathrm{D}p \otimes \overline{\mathrm{D}p}} & \mathrm{D}(p-2)\text{–brane} \\
\Big\downarrow \text{Reduction} & & \Big\downarrow\, ? \\
D(M_n) & \xrightarrow{D \otimes D^\dagger} & \mathcal{C} = \sum L(M_{n-1})
\end{array}
$$

- We have examples of non-invertible symmetry in QFT/ST: $D \otimes D^\dagger = \mathcal{C} \sim \sum L$
- Can we get $\mathcal{C}$ directly from something stringy?
- Model with brane dynamics: get $\mathrm{D}(p-2)$-brane from tachyon condensation
- Find condensate defects in ST constructions

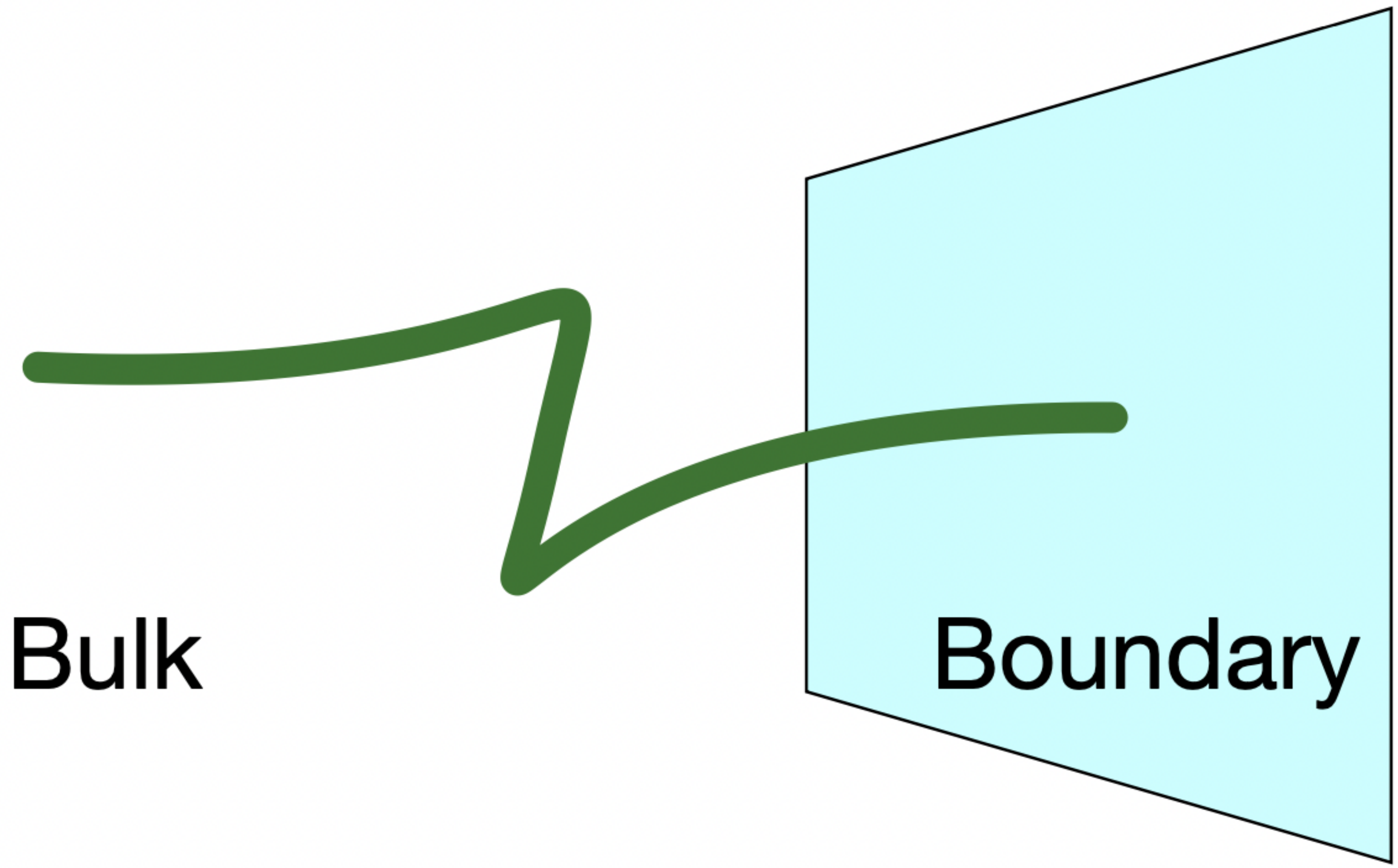
arXiv:2302.14068 (hep–th)

[Submitted on 27 Feb 2023]

Branes and symmetries for $\mathcal{N} = 3$ S-folds

Muldrow Etheredge, Iñaki García Etxebarria, Ben Heidenreich, Sebastian Rauch

Symmetries of 4d $\mathcal{N} = 3$ Theories



CONFORMAL INTERFACES OF 5D SCFTS FROM G2 ORBIFOLDS

Ethan Torres, University of Pennsylvania

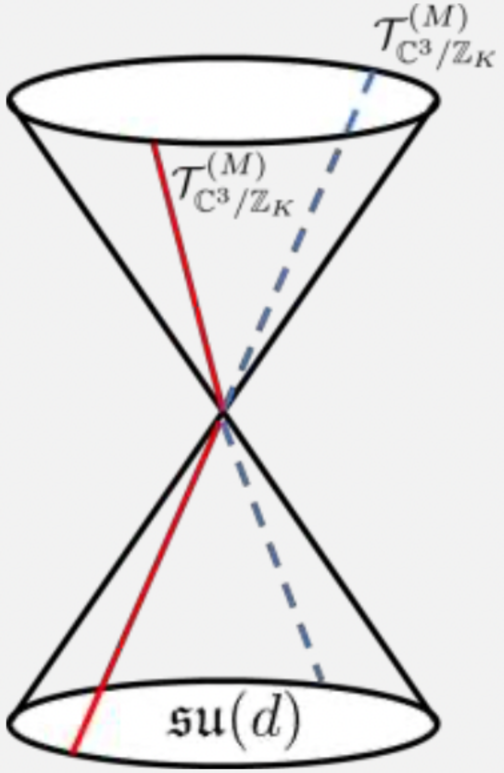
Geometry and Strings 2023 Gong Show

March 8th

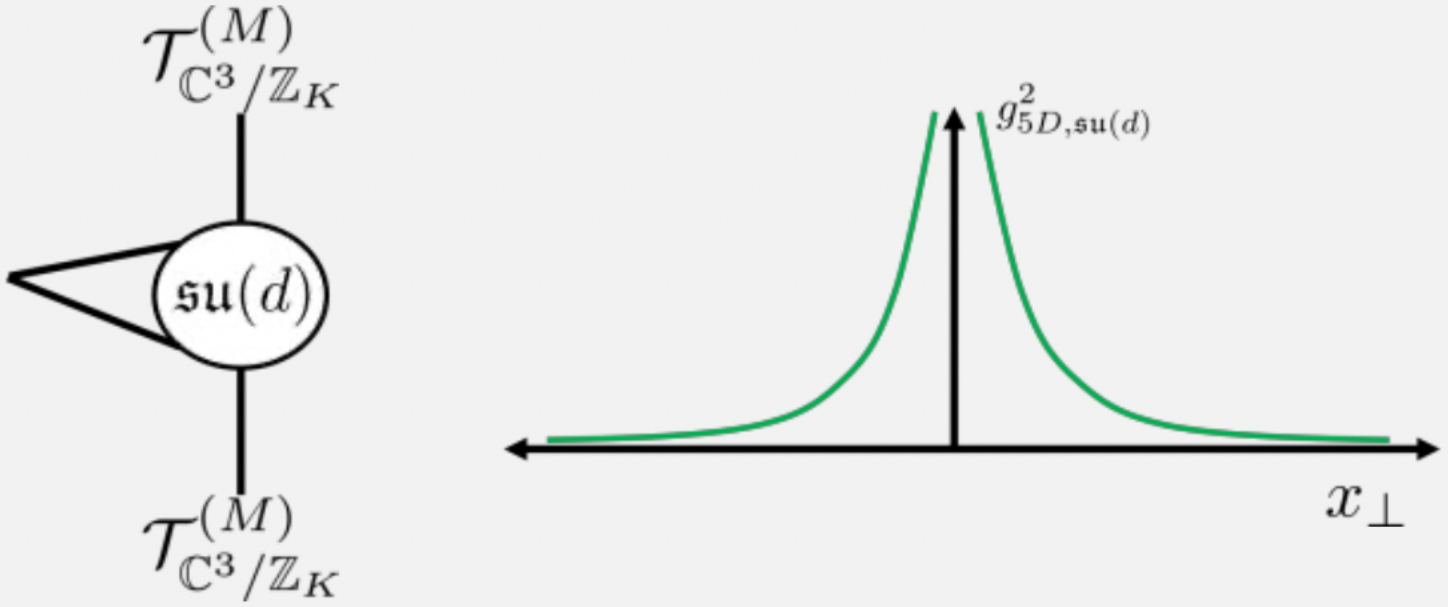
To appear with B. Acharya, M. Del Zotto, J.J. Heckman, and M. Hübner

Goal: Study M-theory on quotients of Cone($\mathbb{CP}^3$) and Cone($SU(3)/U(1)^2$)

Geometry:



Field Theory:



Symmetries: Mayer-Vietoris sequence of asymptotic boundary with respect to cutting/gluing codim-6 singularities tell us how, for example, 4D 0-form symmetries are inherited by 5D 1-form symmetries

(See also Michele's talk from Monday)

Non-invertible Symmetries of 2D Gauge Theories from IIB String Theory

Xingyang Yu, NYU

arXiv:2212.09743 Heckman, Hubner, Torres, XY, Zhang

arxiv:2304.xxxxx XY

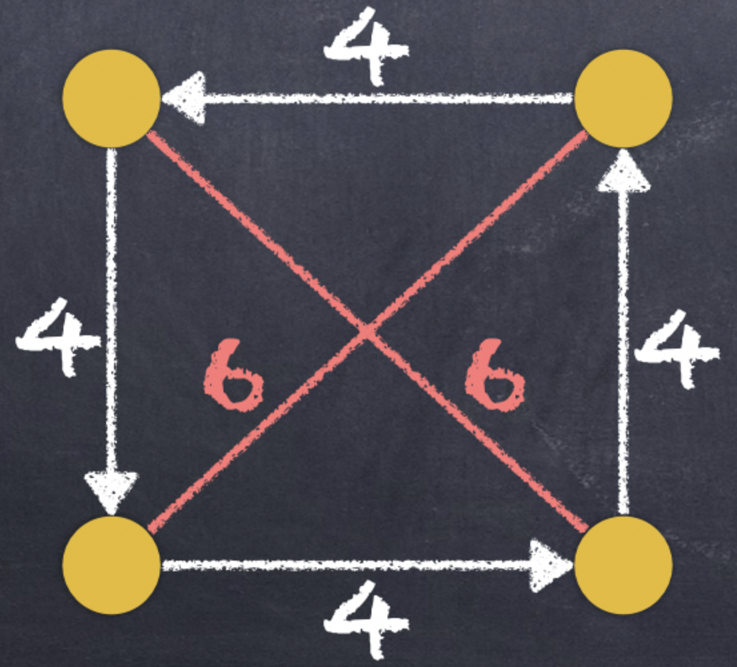
w.i.p Franco, XY

IIB string theory on $\mathbb{R}^{1,1} \times$ CY4

↑ D1-branes

[Garcia-Compean, Uranga]
[Franco, Ghim, Lee, Seong, Yokoyama]
[Franco, Lee, Seong, Vafa]
[Franco, XY]
...

$\mathbb{C}^4/\mathbb{Z}_4$:



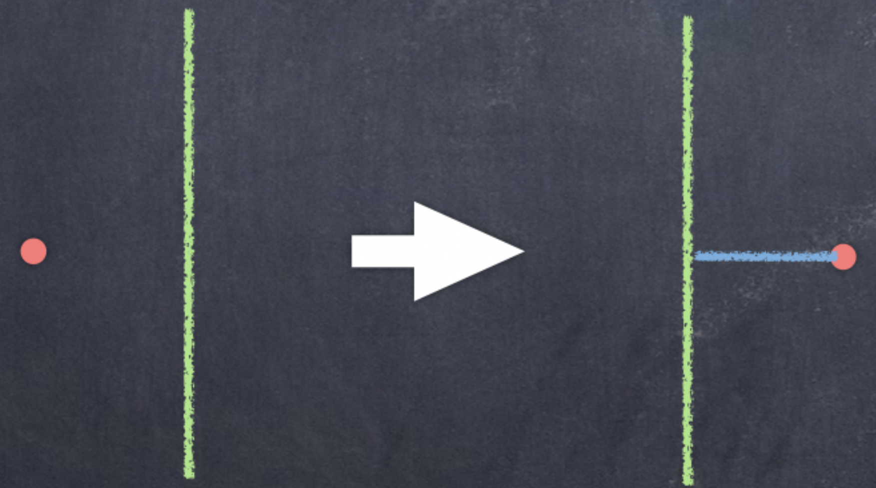
3D Symmetry TFTs on $\mathbb{R}^{1,1} \times \mathbb{R}_+$ from IIB reduction on $\partial(CY4)$

↖ Asymptotic boundary of CY4

[Apruzzi, Bonetti, Etxebarria, Hosseini, Schafer-Namek]
[Heckman, Hubner, Torres, XY, Zhang]
...

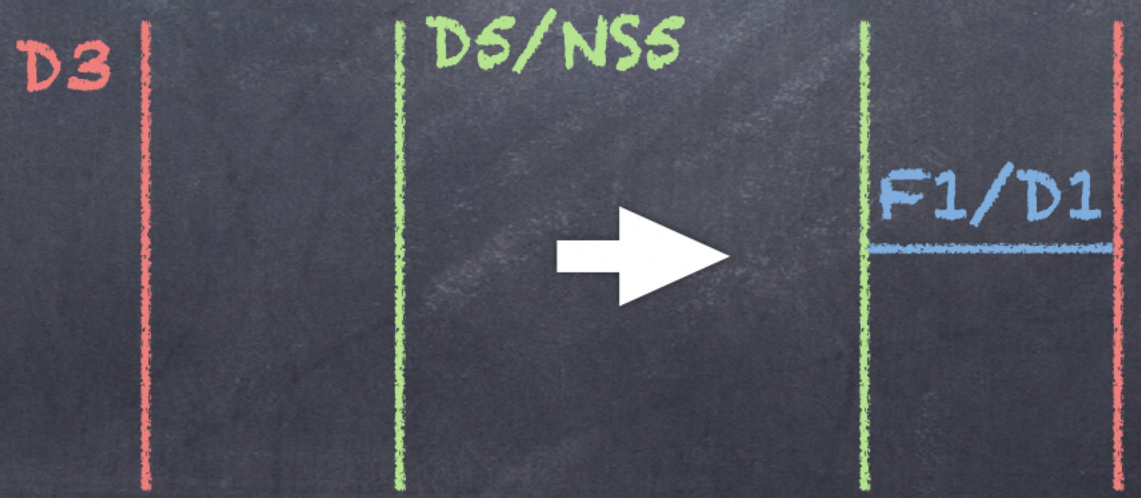
Example $\mathbb{C}^4/\mathbb{Z}_4 : S_{\text{TFT}} \supset \frac{1}{4}\int_{\mathbb{R}^{1,1}\times\mathbb{R}_+} E_1^{(D3)} \cup B_1^{(F1)} \cup C_1^{(D1)}$

Gauging two of the three $\mathbb{Z}_4^{(0)}$ symmetries, the left-over one becomes non-invertible. [Kaidi, Ohmori, Zheng 2021]



[Verlinde]
[Komargodski, Ohmori, Roumpedakis, Seifnashri]

=



[Hanany, Witten]
[Apruzzi, Bah, Bonetti, Schafer-Namek]
[Heckman, Hubner, Torres, XY, Zhang]

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M-theory Frozen Singularities in 7D: Orthogonalization Map

Hao Y. Zhang

University of Pennsylvania

Based [wip] with M. Cvetič, M. Dierigl, L. Lin, and E. Torres
(see also on [2203.03644] with M. Cvetič, M. Dierigl, L. Lin)

Goal: study 7D frozen singularity:

$$\text{M-theory on } \mathbb{C}^2/\Gamma_{\mathfrak{g}} \text{ with } \int_{S^3/\Gamma_{\mathfrak{g}}} C_3 = \frac{n}{d}, d > 1$$

A list of post-freezing gauge algebra has been known in [De Bohr, Dijkgraaf, Hori, Keurentjes, Morgan, Morrison, Sethi '01], based on **global** considerations and string dualities. E.g.

$$\mathfrak{g} = \mathfrak{so}(2n+8) \text{ with } 1/2 \text{ flux } \Rightarrow \mathfrak{h} = \mathfrak{sp}(n)$$

How it arise from the original gauge algebra?

We want to further clarify this!

Using M-/F-theory "frozen" duality in [Tachikawa '15], we derived such a **local freezing map** M-theory via string junctions and (p, q) 7-branes $(\mathbb{C} \times S^1)/\mathbb{Z}_d$!

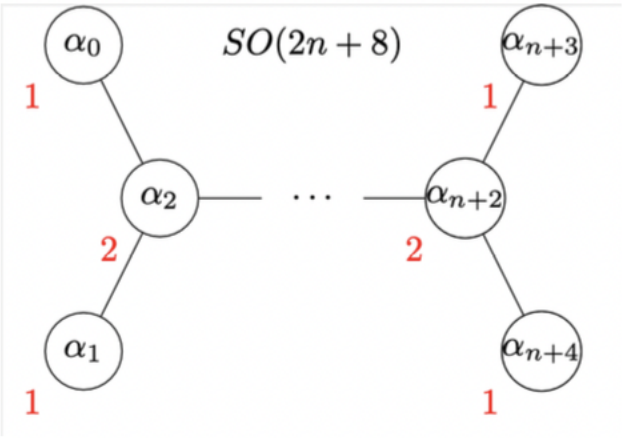
***Statement**:*

*under any choice of affine simple roots of $\mathfrak{g}$, an order-d frozen flux projects the entire $\mathfrak{g}$ root system onto the **orthogonal complement** of $\langle\{\alpha_{\text{frozen}}\}\rangle$, where $\{\alpha_{\text{frozen}}\}$ are simple roots whose (Dynkin) comarks are NOT multiples of d.*

Works for all cases in [Tachikawa '15]!

E.g. $(\mathfrak{g} = \mathfrak{so}(2n+8), d = 2)$

Take orthogonal complement of the span of four corner nodes $\langle\{\alpha_{\text{frozen}}\}\rangle = \langle\{\alpha_0, \alpha_1, \alpha_{n-1}, \alpha_n\}\rangle$ with Dynkin comark 1:



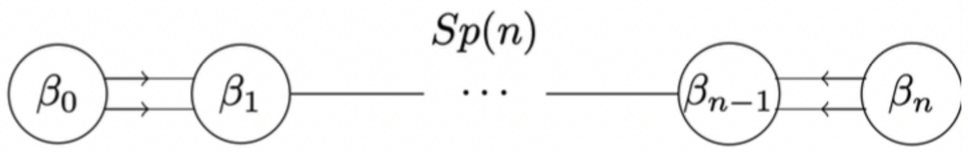
for $n \geq 2$:

$$\beta_0 = \alpha_0 + \alpha_1 + 2\alpha_2$$

$$\beta_j = \alpha_{j+2}, \quad (0 < j < n)$$

$$\beta_n = \alpha_{n+3} + \alpha_{n+4} + 2\alpha_{n+2}$$

They span the root system of $\mathfrak{h} = \mathfrak{sp}(n)$ as a set of (rescaled) affine simple roots:



Reminiscent of freezing rules in [Atiyah, Witten, '01] [De Bohr, Dijkgraaf, Hori, Keurentjes, Morgan, Morrison, Sethi '01] [Fraiman, De Freitas, '21a,b]