R7-branes

— and how to use them —

Based on:

2212.05077 and 2305.05689
with Jonathan J. Heckman, Miguel Montero and Ethan Torres

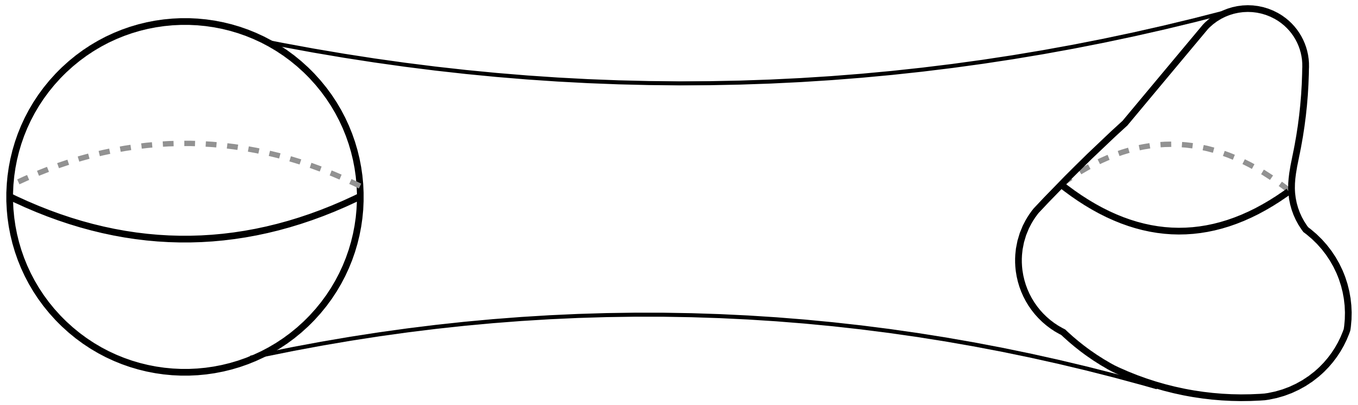
String Pheno 2023 - July 4, 2023

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Markus Dierigl

No Global Symmetries in Quantum Gravity

See e.g. [Banks, Dixon ’88; Banks, Seiberg ’11; Harlow, Ooguri ’18]



Topological features

(in gauge and gravity sector)

that cannot be deformed away

Global symmetries

→ **Everything can be deformed away!** [McNamara, Vafa ’19]

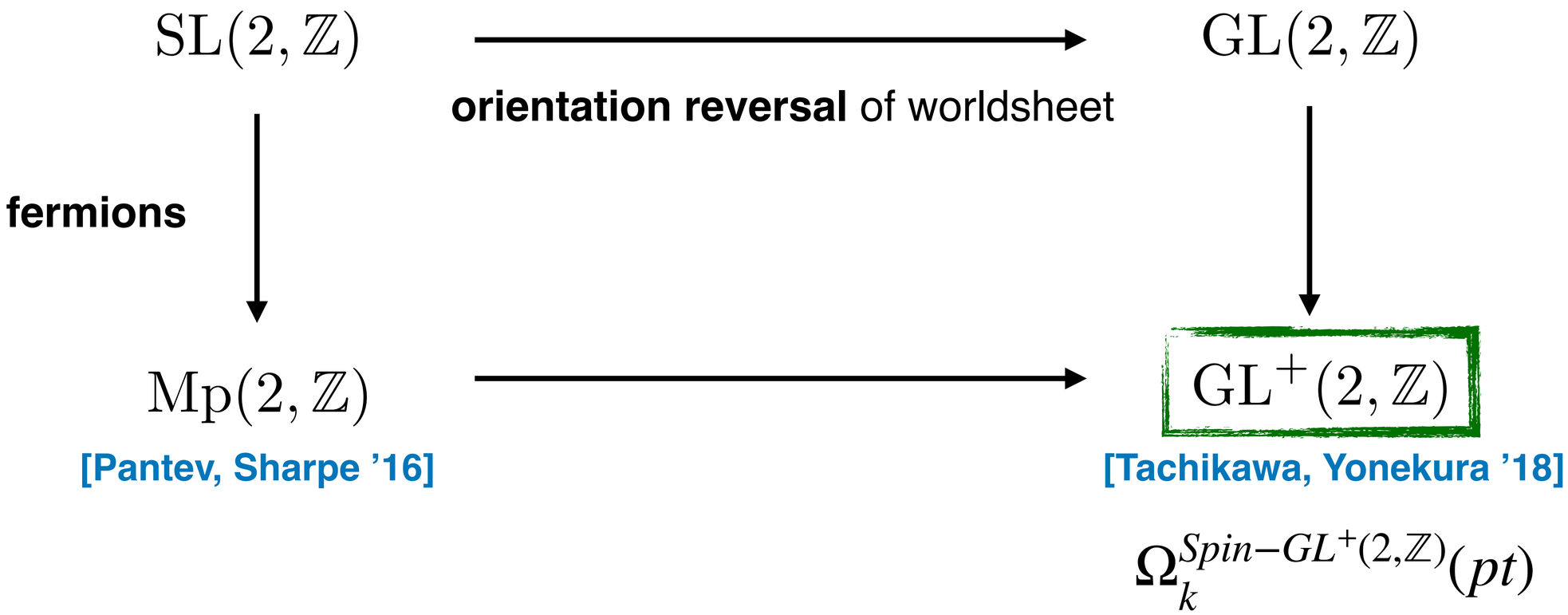
$$\Omega_k^{QG} = \varnothing$$

Cobordism Conjecture

Type IIB string theory

Let us test the **Cobordism Conjecture** in **type IIB string theory** with focus on **spacetime** and **duality**:

[Debray, MD, Heckman, Montero '23]



[Pantev, Sharpe '16]

[Tachikawa, Yonekura '18]

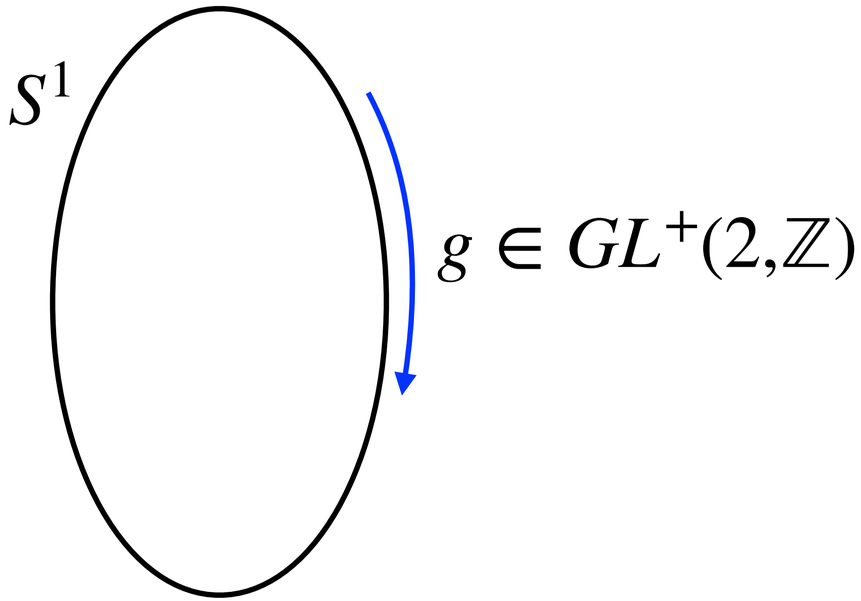
$$\Omega_k^{Spin-GL^+(2,\mathbb{Z})}(pt)$$

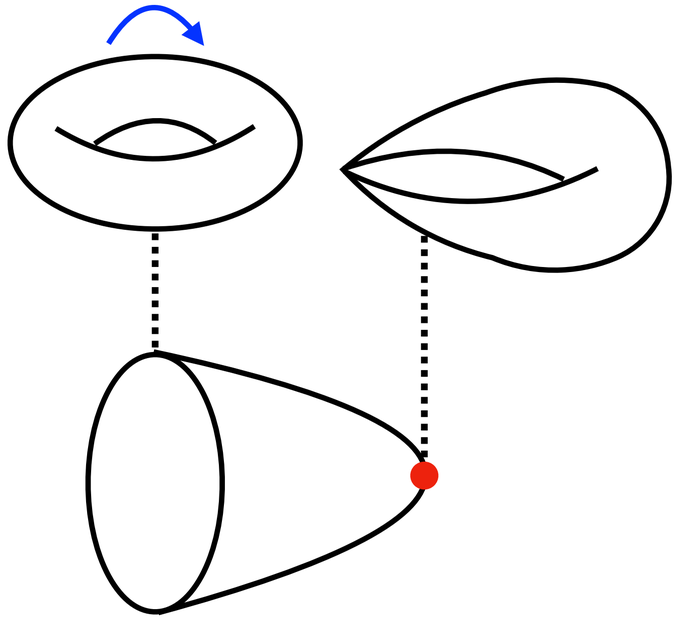
k = 1: 7-branes

$$\Omega_1^{Spin-GL^+(2,\mathbb{Z})}(pt) = \mathbb{Z}_2 \oplus \mathbb{Z}_2$$

taken care of by [p,q]-7-branes

(F-theory) **see also [MD, Heckman '20]**



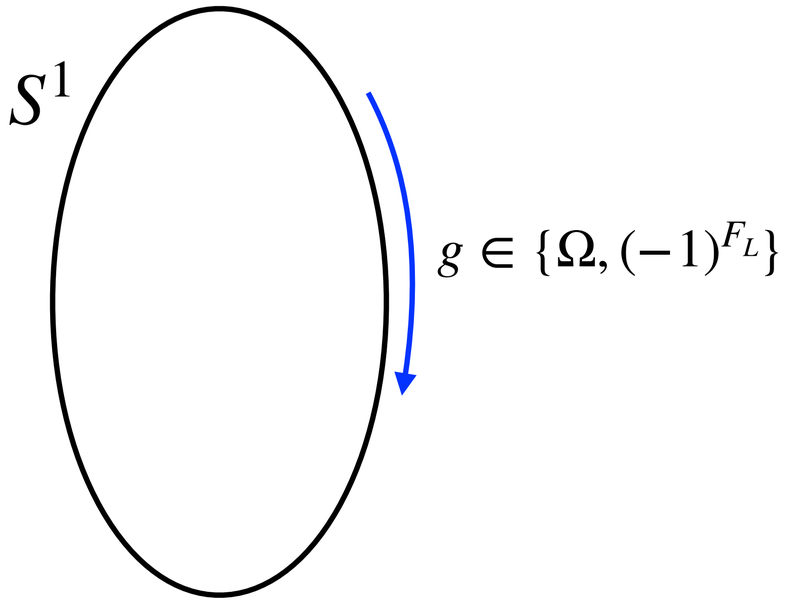


k = 1: 7-branes

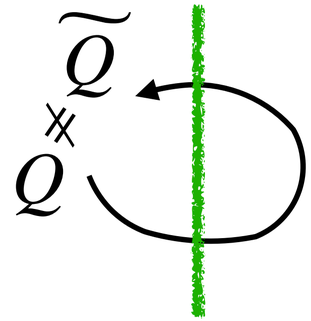
$$\Omega_1^{Spin-GL^+(2,\mathbb{Z})}(pt) = \mathbb{Z}_2 \oplus \mathbb{Z}_2$$

new ‘reflection’ 7-brane

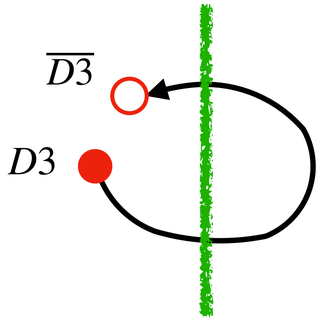
hinted at in [Distler, Freed, Moore ’09]



Breaks supersymmetry

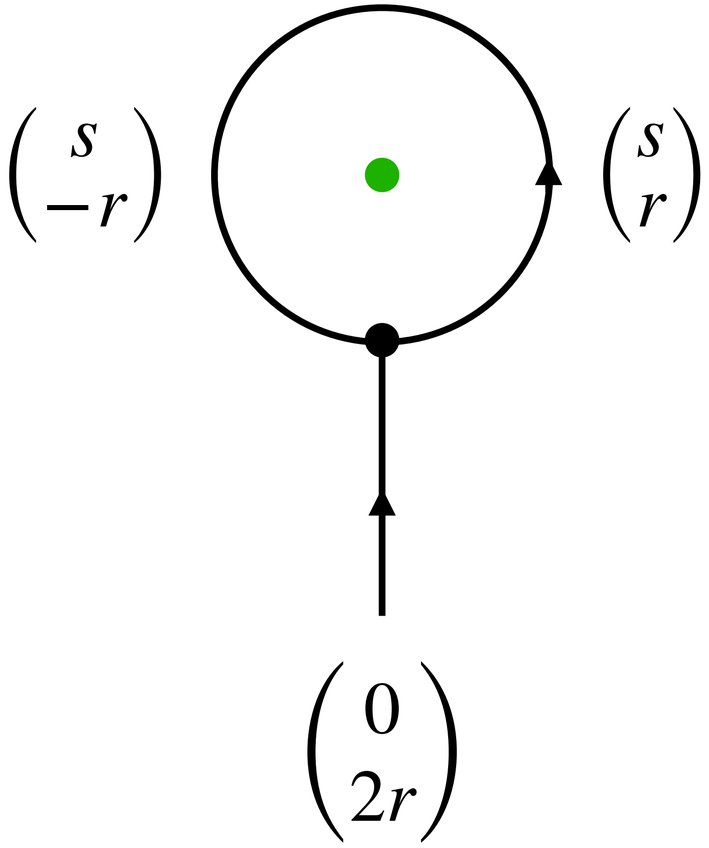


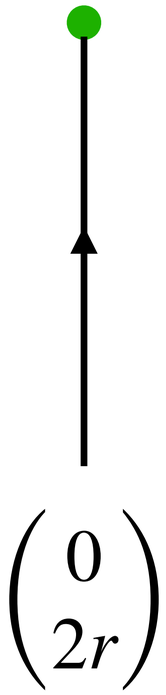
Alice string for D3 branes



Strings can end on R7-brane

[MD, Heckman, Montero, Torres ’22]





F1-strings end on Ω brane

D1-strings end on $(-1)^{F_L}$ brane

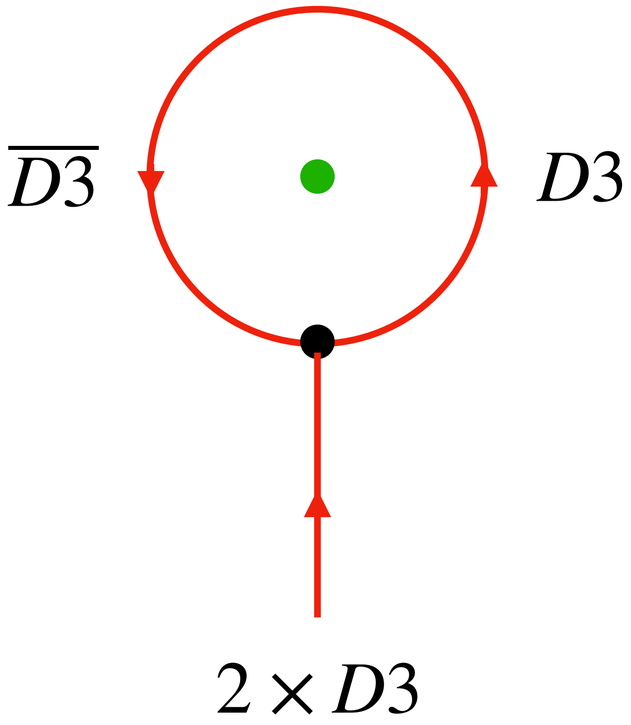
(at least in pairs)

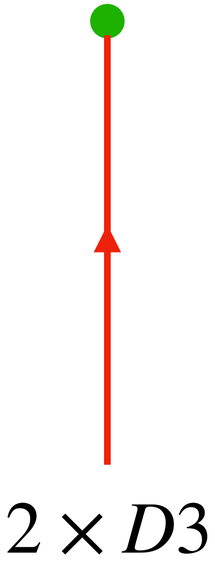
→ something, e.g., gauge fields, should absorb charge

See also [Cvetic, MD, Lin, Zhang ’21, ’22]

for [p,q]-7-branes

D3-branes can end on R7-brane



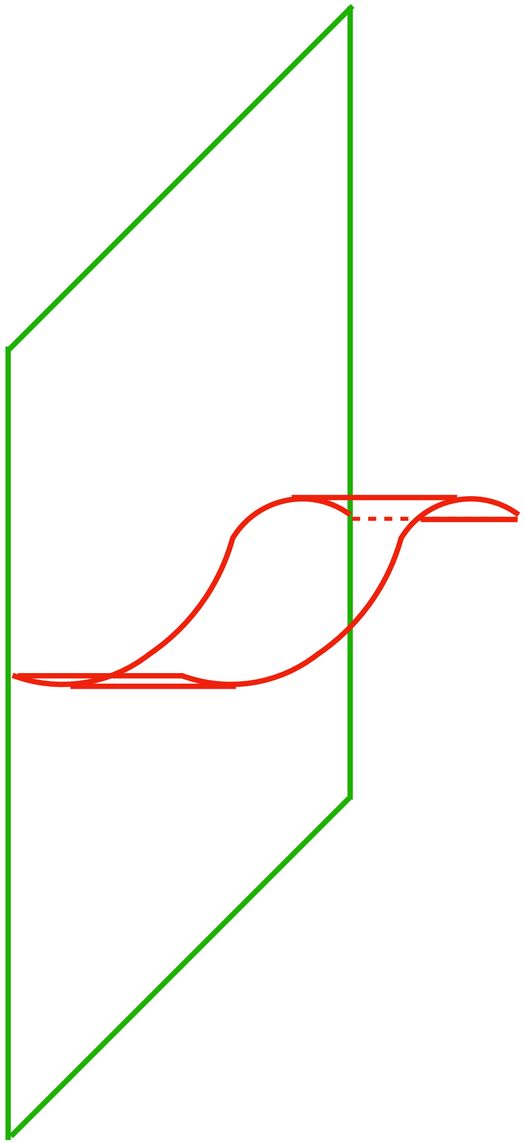


D3-branes end because of
$C_4 \rightarrow -C_4$ transformation

(at least in pairs)

→ something should absorb charge

3-form fields



D3-brane creates 3d worldvolume in R7-brane

➡ flux on transverse S^4

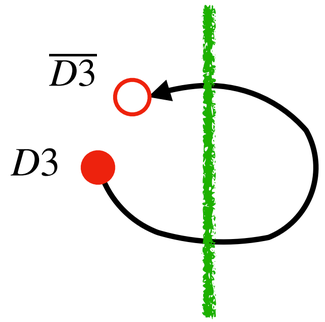
suggests $F_4 = dC_3$ (odd under reflections)

➡ **massless 3-form on R7-brane**

(potentially interesting behavior under S-duality;
interacting non-supersymmetric CFT in 8d???)

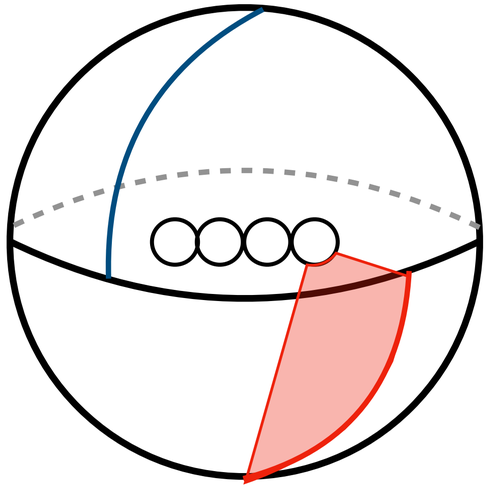
Charge conjugation

[MD, Heckman, Montero, Torres '23]



Acts as **charge conjugation** on **D3-branes**

➡ acts as **charge conjugation** on **effective strings** in $\mathcal{N} = (2,0)$ theories in **6d** (D3-branes wrapped on relative cycles)

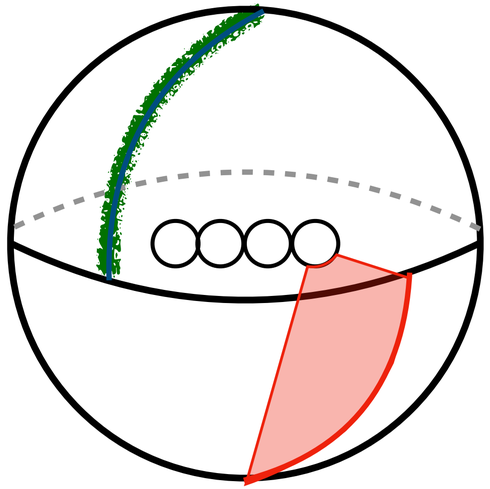


$$S^3/\Gamma_{ADE} = \partial\left(\mathbb{C}^2/\Gamma_{ADE}\right)$$

Decouple dynamics

[Garcia-Etxebarria ’22], [Apruzzi, Bah, Bonetti, Schafer-Nameki ’22], [Heckman, Hübner, Torres, Zhang ’22]

Decouple local degrees of freedom by ‘**wrapping at infinity**’



➡ Only **topological phase** associated to linking survives

Does not work for $\mathcal{N} = (1,0)$, since there are additional [p,q]-7-branes

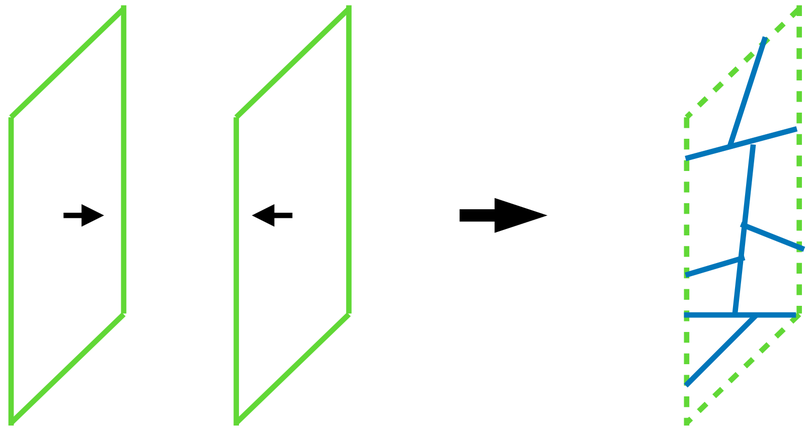
$(b_i B_2^i \wedge \mathrm{tr}(F \wedge F))$

Non-invertible

…, [Bhardwaj, Tachikawa ’17], [Tachikawa ’17], [Heidenreich, McNamara, Montero, Reece, Rudelius, Valenzuela ’21], [Kaidi, Ohmori, Zheng ’21],…

Topological terms allowing absorption of string and D3-branes charge lead to **non-trivial fusion rules:**

$$\mathcal{U}_\Omega \mathcal{U}_\Omega^\dagger = \mathscr{P}_0 \cdot \mathscr{P}_2 \cdot \mathscr{P}_4 \quad (\neq \mathbf{1})$$



condensation-like defects

$$\mathscr{P}_i \sim \sum_{\Sigma \in H_{5-i}} \exp\left[2\pi i \alpha \int_\Sigma G\right]$$

Summary

There seems to be **many new string theory objects!!!**

see also [Kaidi, Ohmori, Tachikawa, Yonekura ’23] for heterotic string

Let us:

- **Find them** (application of Cobordism Conjecture)
- **Explore them** (localized degrees of freedom)
- **Use them** (symmetry defects, $\mathbb{H}$-theory)