AdS7 solutions and their holographic duals

Alessandro Tomasiello

Dubna, 26.11.2015

based on
1506.05462 with A. Passias, A. Rota;
1502.06620 with F. Apruzzi, M. Fazzi, A. Passias; 1502.06622 with A. Rota
1309.2949 with F. Apruzzi, M. Fazzi, D. Rosa; 1404.0711 with D. Gaiotto
[1407.6359 with M. del Zotto, J.Heckman, C.Vafa]
+ work in progress with S. Cremonesi

Introduction

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[Gaiotto '09, Alday, Gaiotto, Tachikawa '09...]

- Harder to define.

e.g. $\mathrm{Tr}(F_{\mu\nu})^2$ relevant in $d > 4$. Similar problem to $\sqrt{-g}R$ in $d > 2$

- They might allow us to get a handle on the elusive (2,0) theory living on M5-brane stacks

crucial features:

- number of degrees of freedom $\sim N^3$
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This talk: Holographic approach

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- Match of Weyl anomaly!

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- $\mathrm{AdS}_7 \times M_3$ in type II: 'pure spinor' methods [Apruzzi, Fazzi, Rosa, AT '13]

originally applied to $\mathrm{AdS}_4 \times M_6$ in type II [Graña, Minasian, Petrini, AT '05]

later extended to any 10d solution in type II [AT '11]

we will later see a similar classification for $\mathrm{AdS}_5 \times M_5$ in IIA [Apruzzi, Fazzi, Passias, AT '15]

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$A(r)$, $\phi(r)$, $v(r)$ determined by ODEs

solved at first numerically [Apruzzi, Fazzi, Rosa, AT '13]

then analytically with the help of AdS4 and AdS5

[Rota, AT '15] [Apruzzi, Fazzi, Passias, AT '15]

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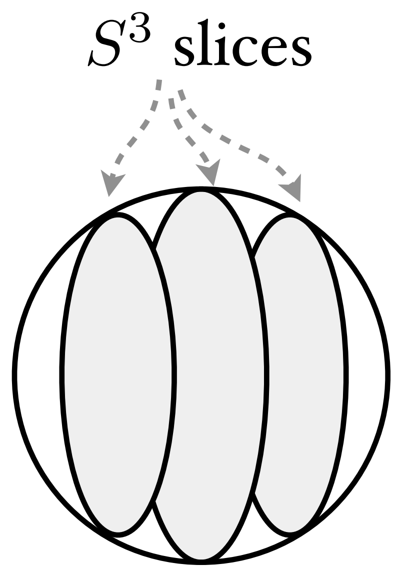
$S^4 =$ 

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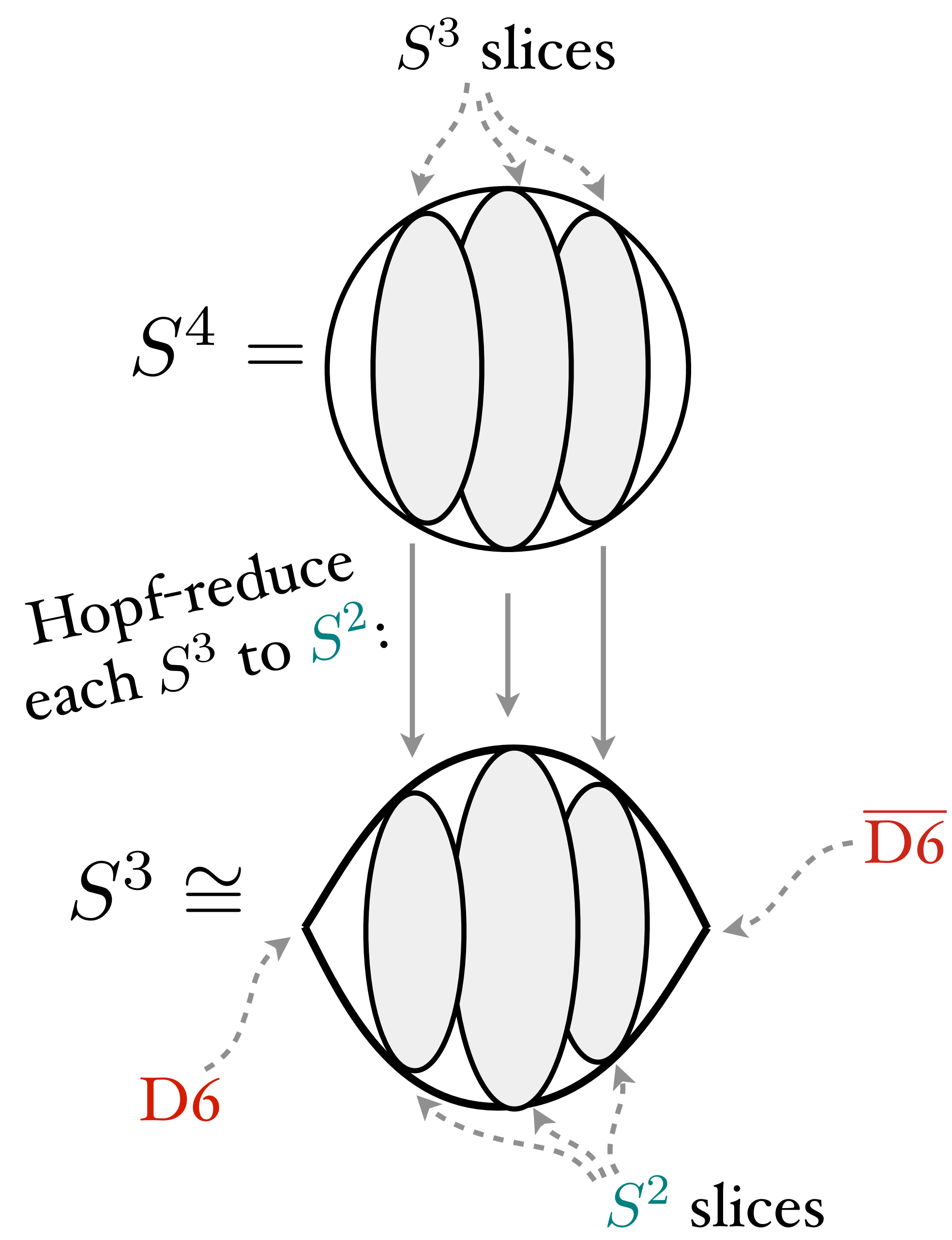

- $F_0 \neq 0$: many new solutions

we can make
one of the poles regular:

local solutions also in [Blåbäck, Danielsson, Junghans, Van Riet, Wrase, Zagermann '11]
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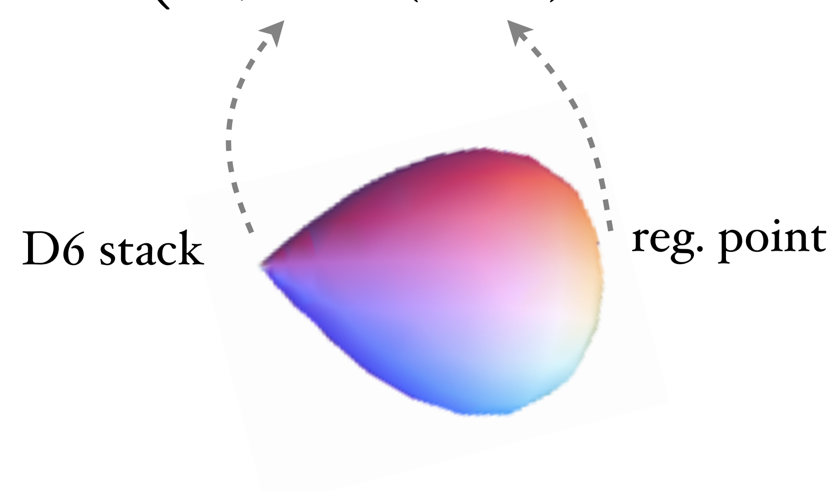
$$ds^2_{M_3} = \frac{n_{\rm D6}}{F_0}\left(\frac{dy^2}{4\sqrt{y+2}(1-y)} + \frac{1}{3}\frac{(1-y)(y+2)^{3/2}}{8-4y-y^2}ds^2_{S^2}\right) .$$



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these solutions are also analytic, but a bit more complicated.

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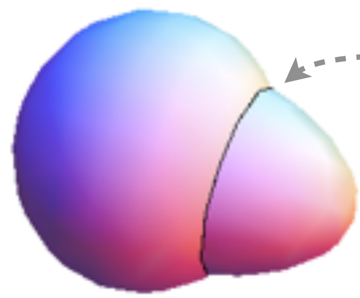
include D8's:

D8–D6 stack



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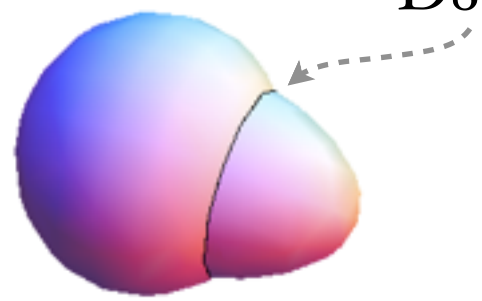

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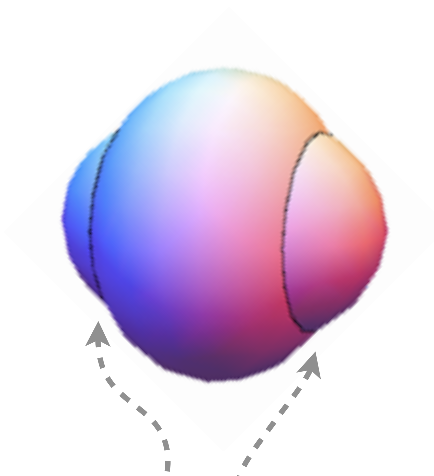
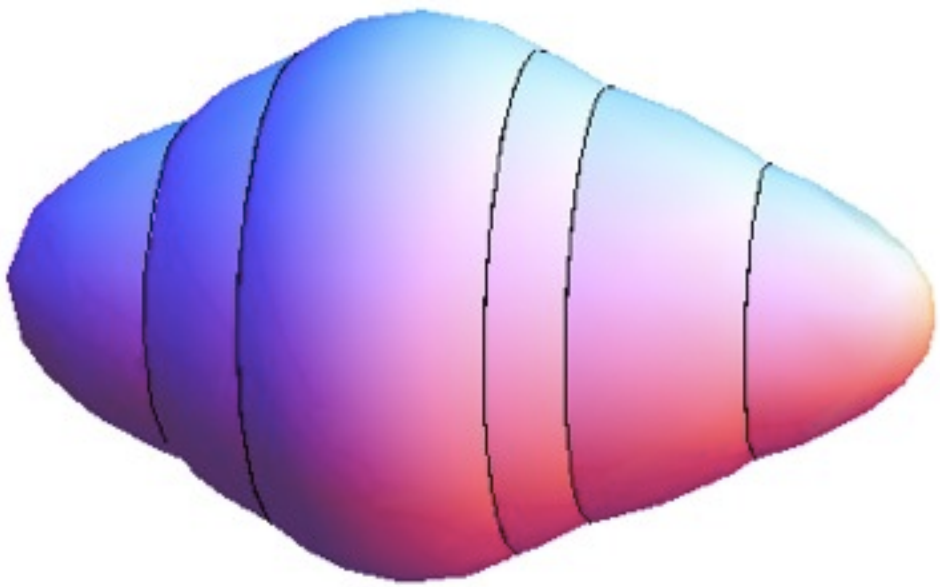


intuitively: D8's don't slip off
because of electric attraction

stacks with opposite D6 charge

metric: gluing of two pieces of metric in prev. slide
+ central region from two slides ago

and so on...



Holographic duals

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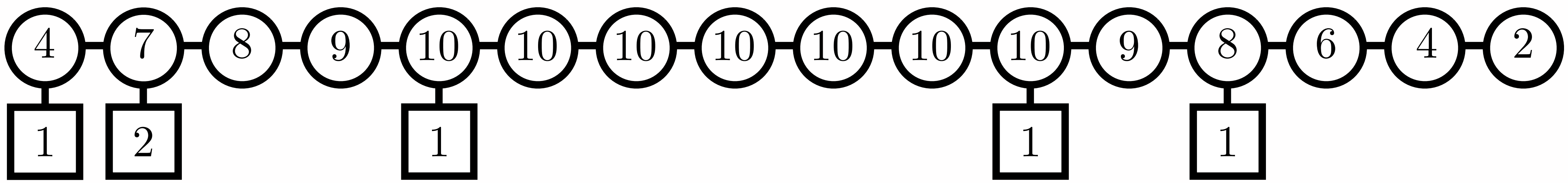
Natural class: linear quivers

At each node, $n_F = 2n_c$



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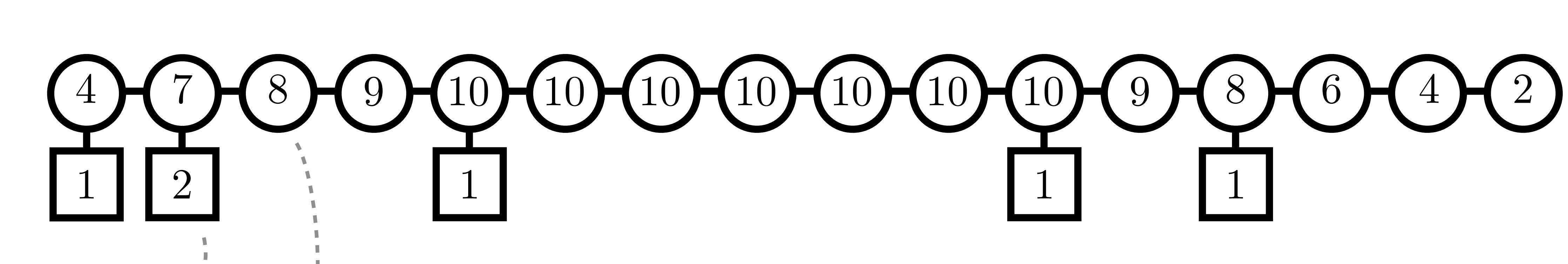
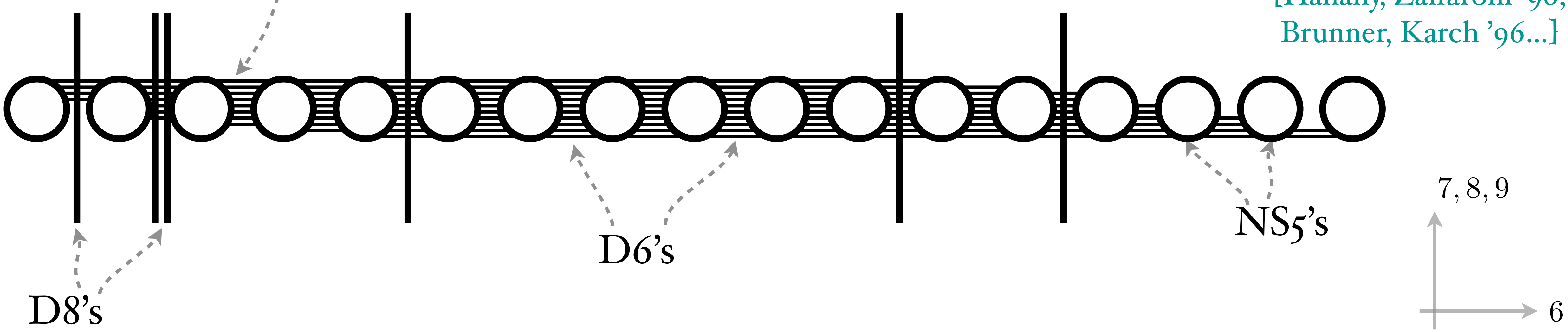


D-brane engineering:

[Hanany, Zaffaroni '96, Brunner, Karch '96...]



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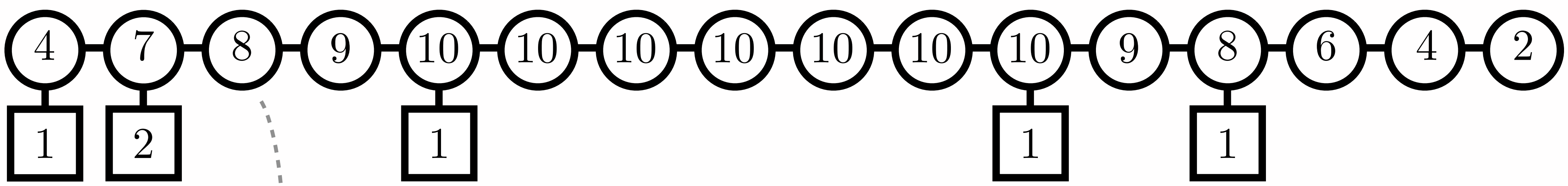

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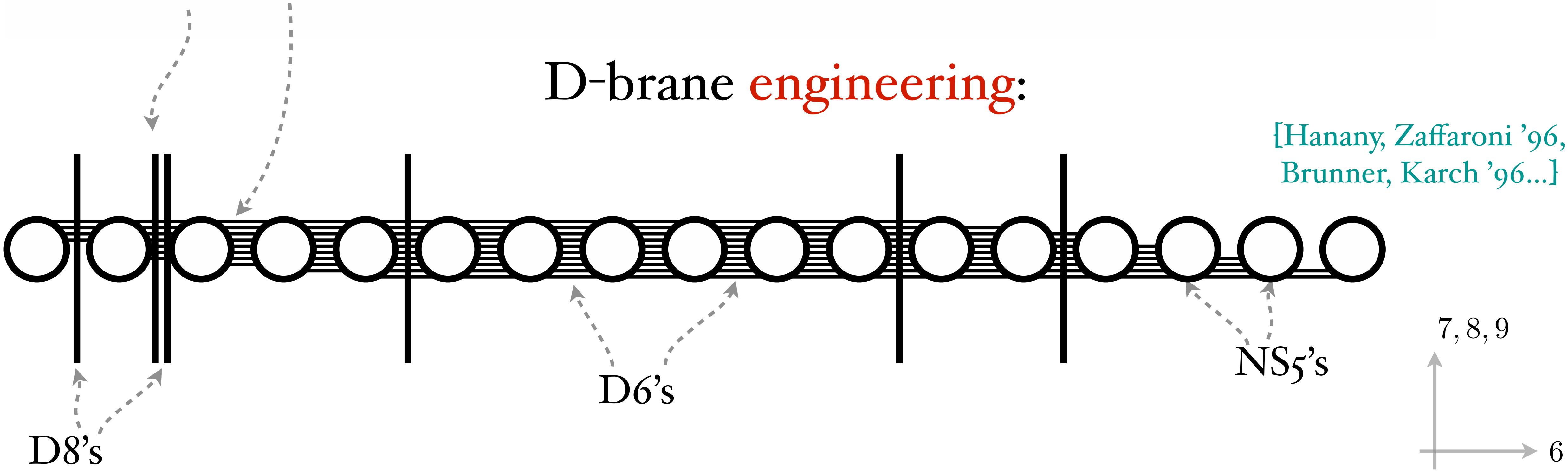

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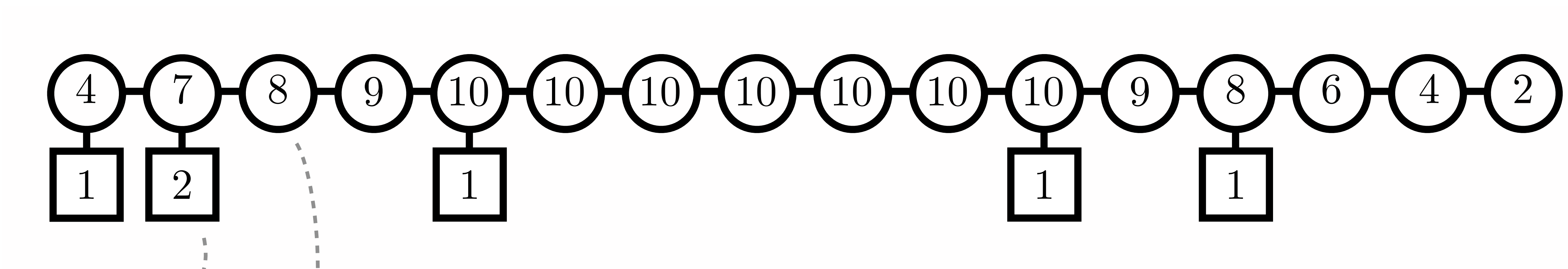

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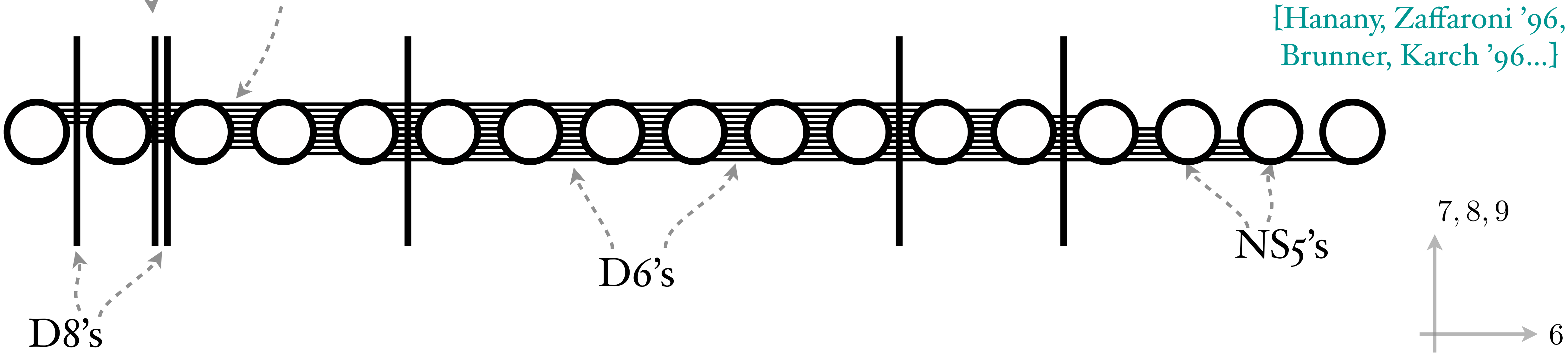

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coincident NS5s = strong coupling point; CFT?

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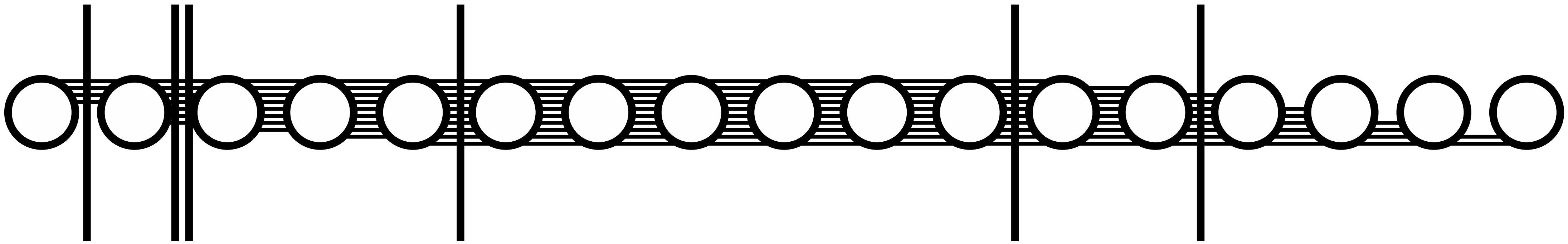

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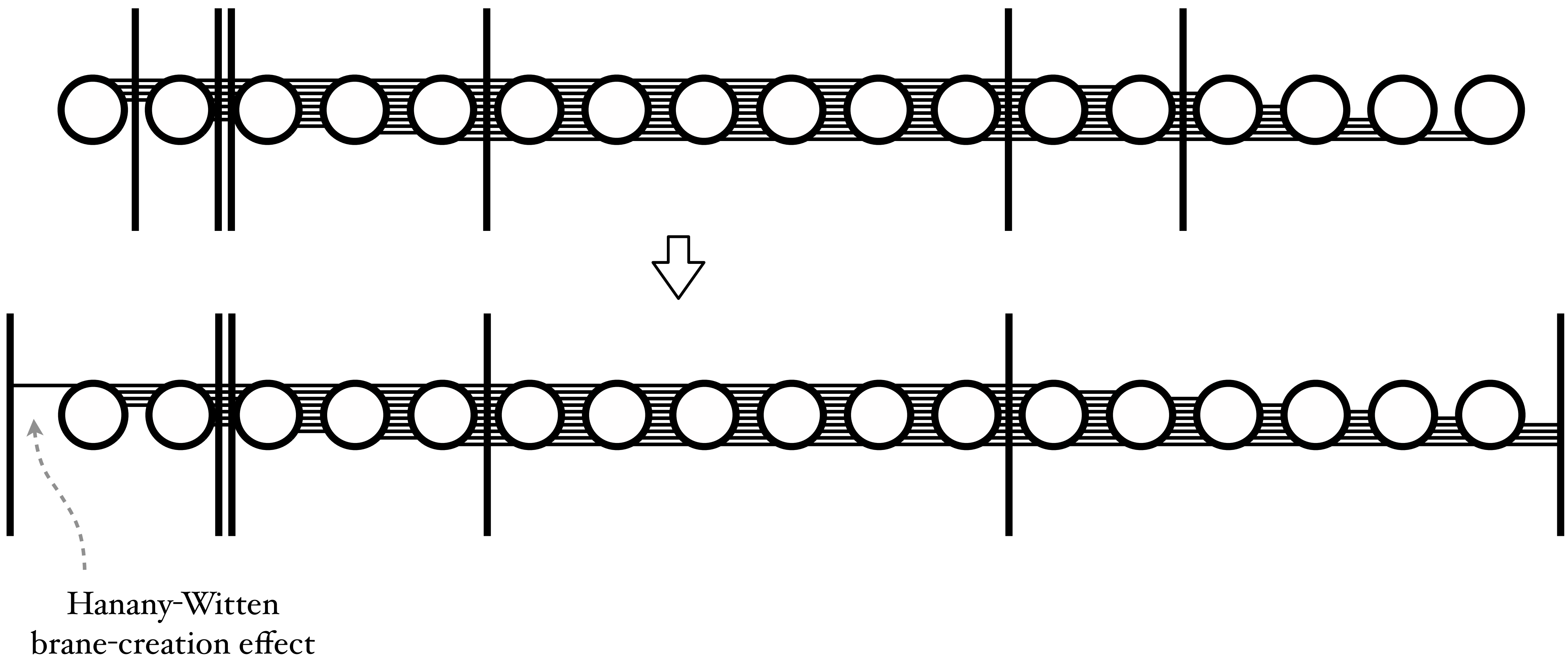

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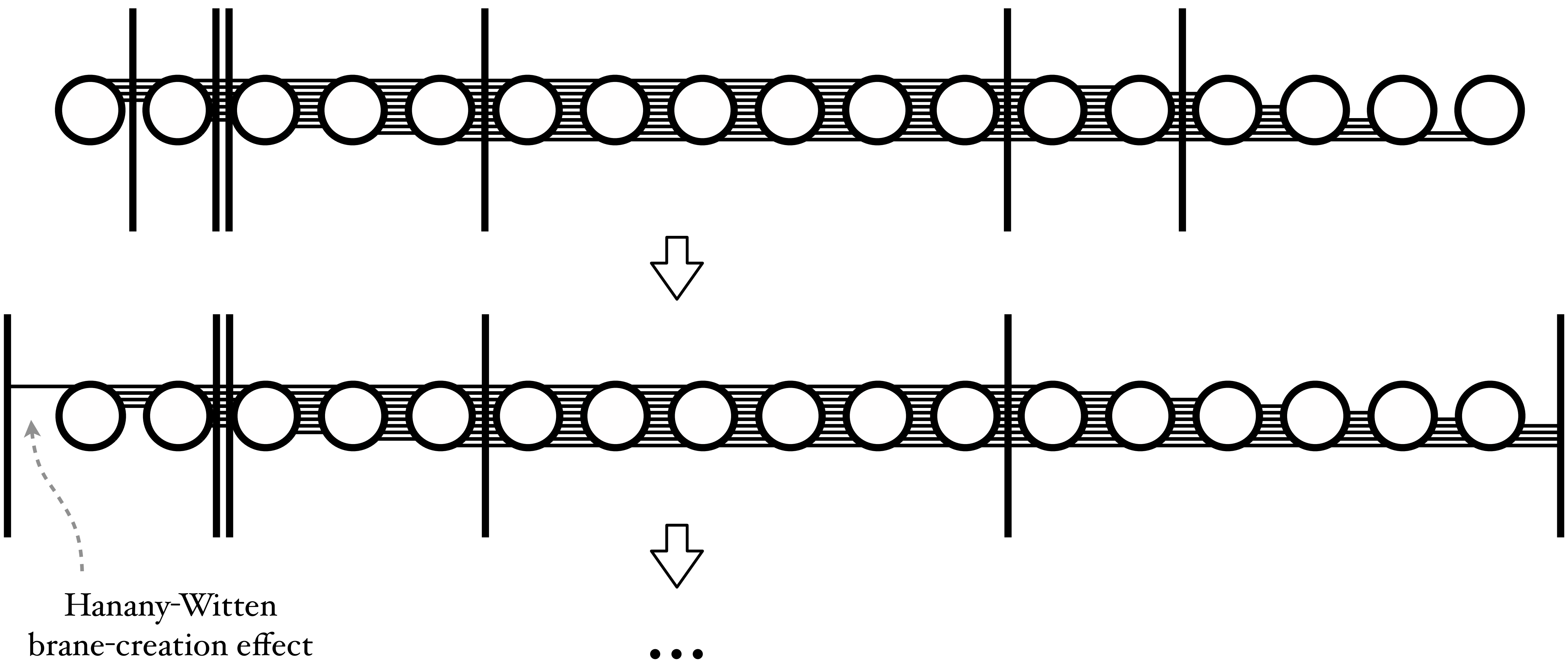

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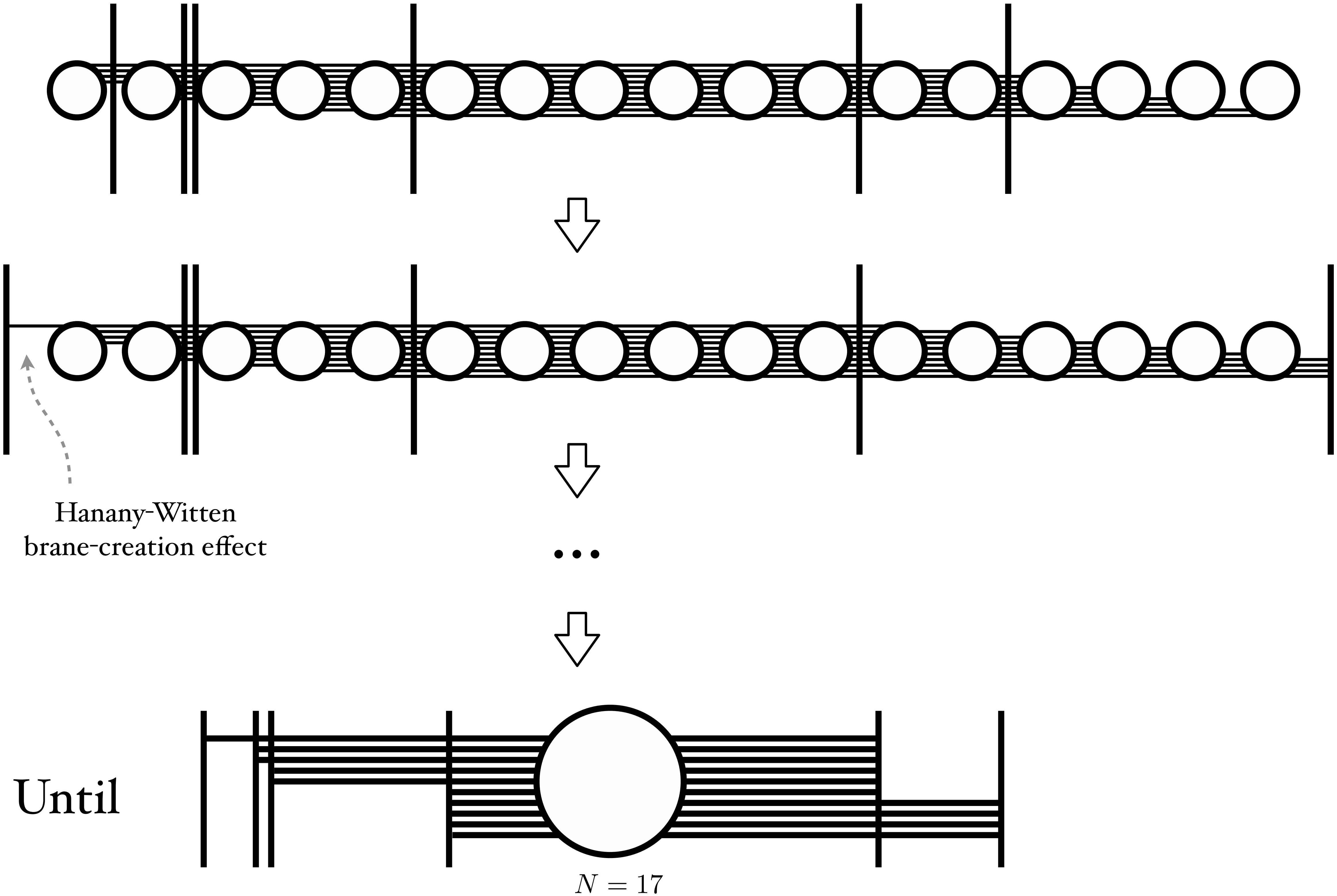

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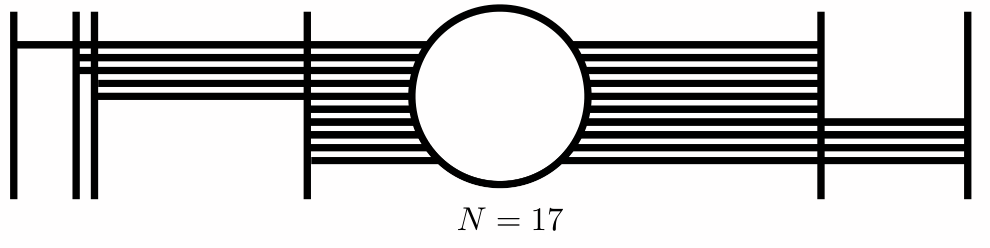

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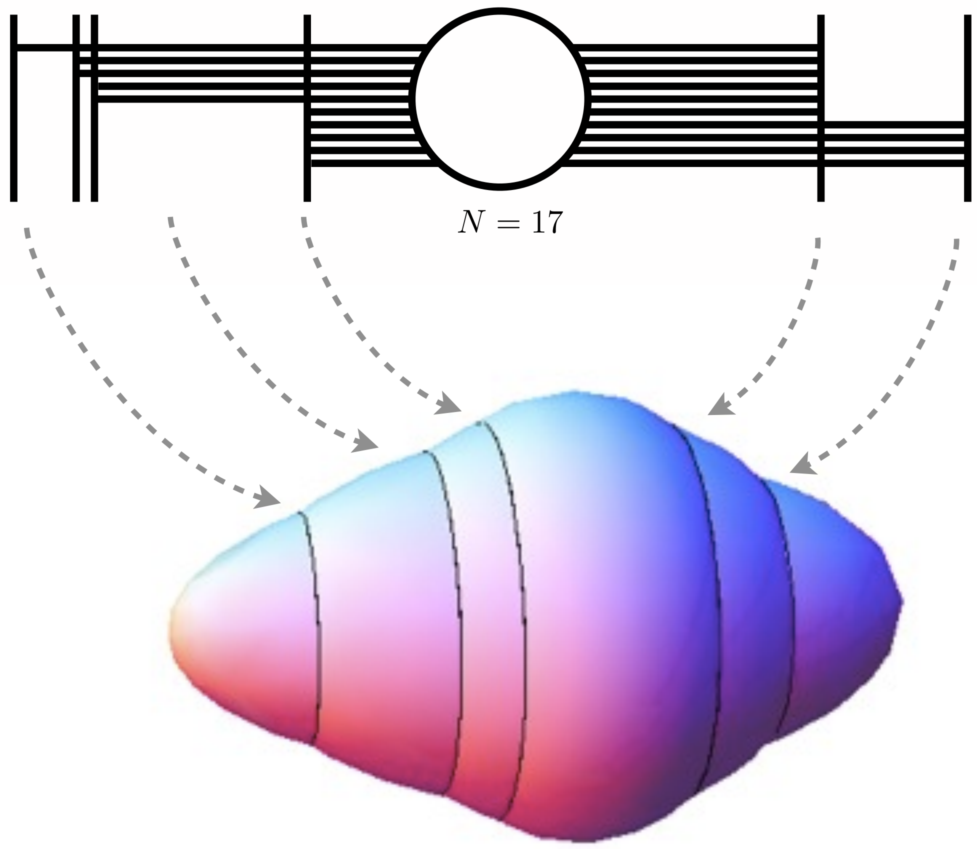
Conjecture: near-horizon limit gives our AdS7 solutions



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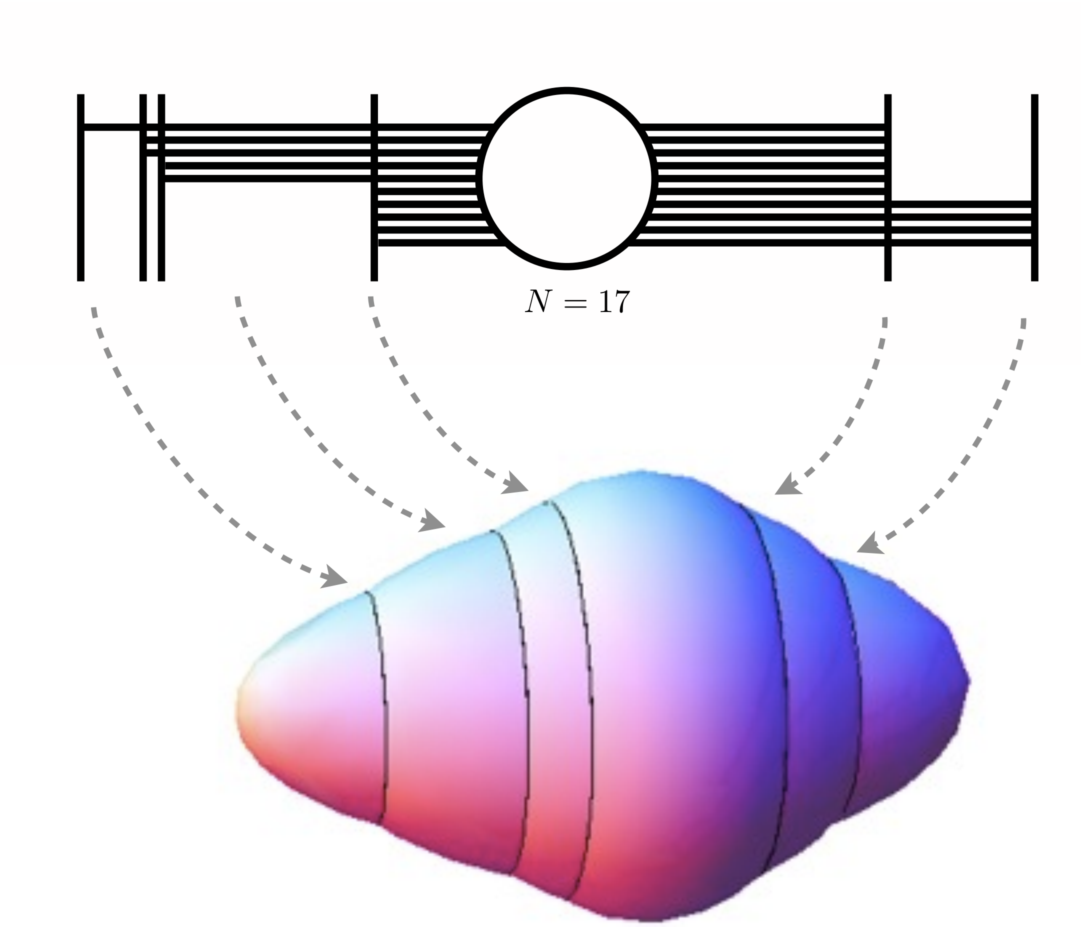
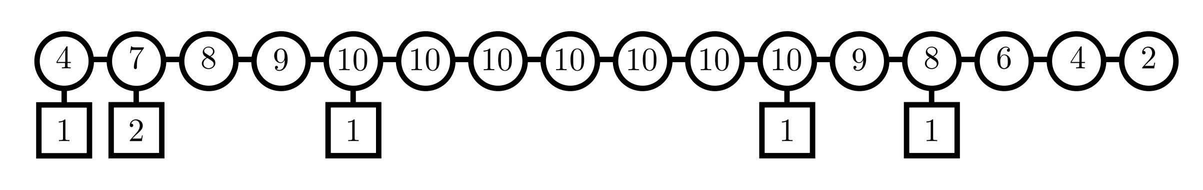


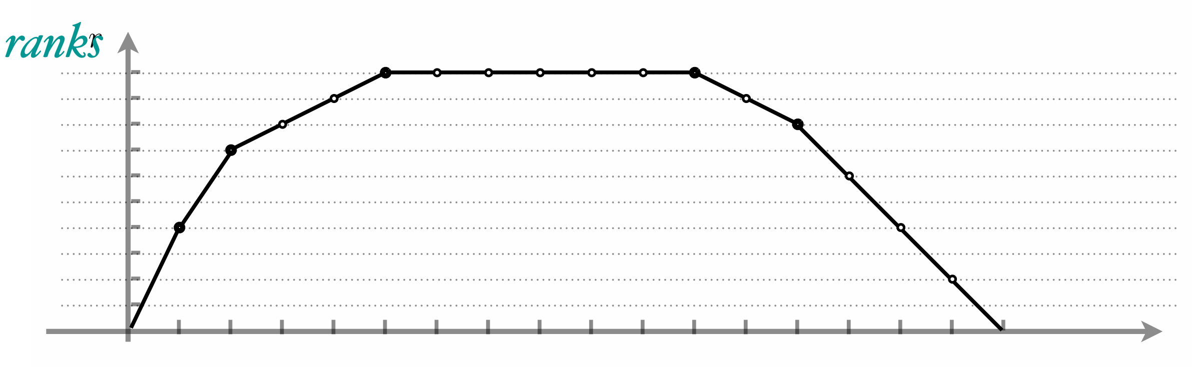
N = # NS5's ⟷ flux integer $\int_{M_3} H$

D6's ending on a D8 ⟷ D6 charge of the D8

These theories can be labeled by two Young diagrams

{combinatorics well-known
in other dimensions}





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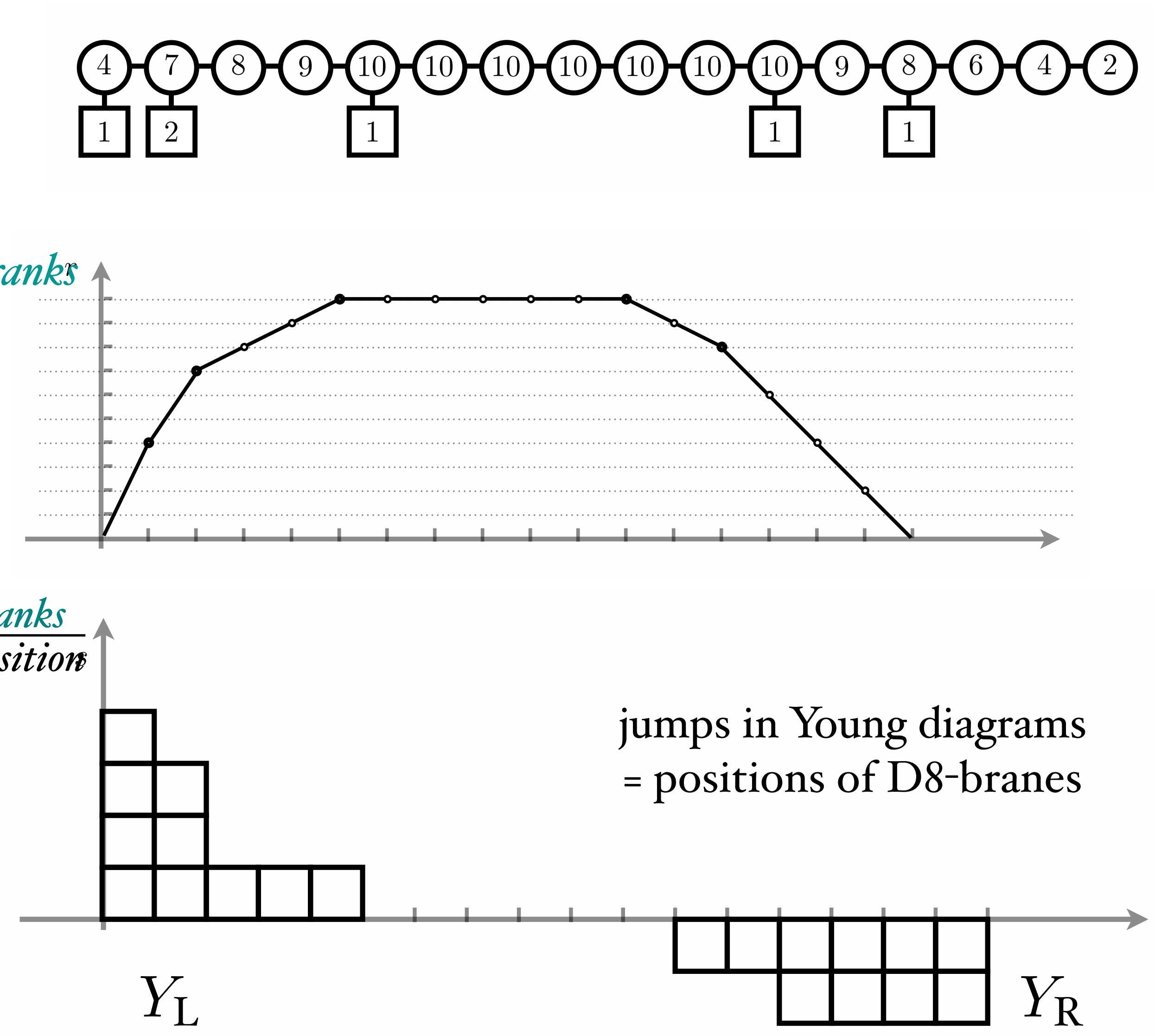

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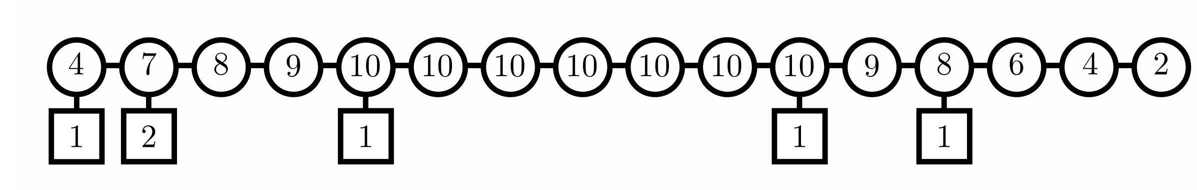
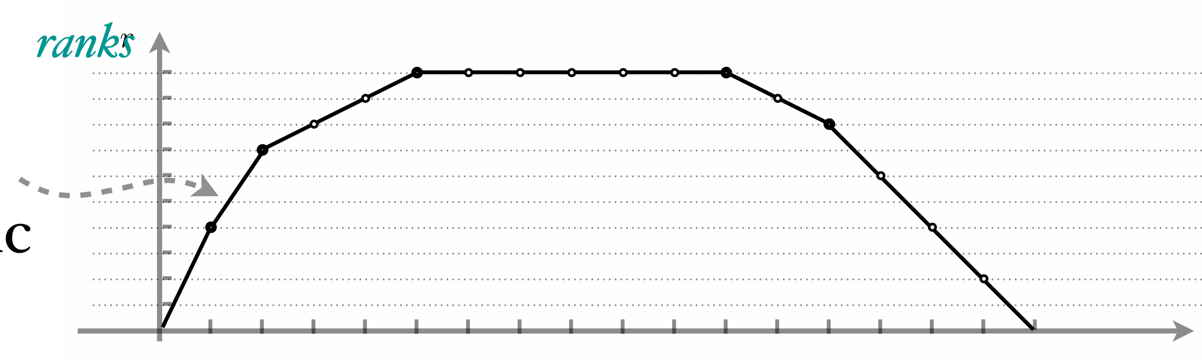
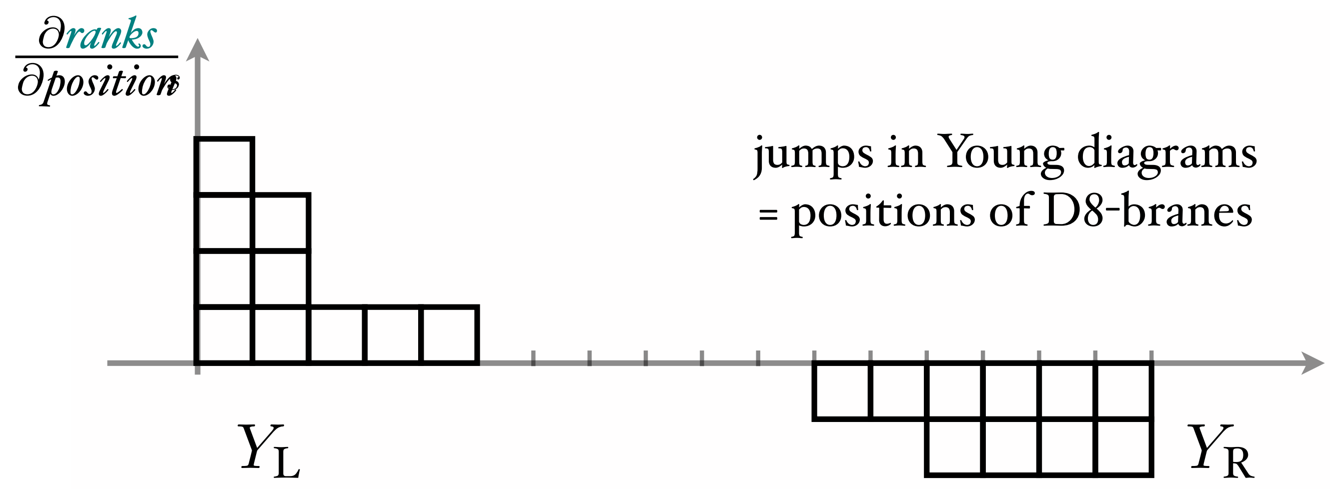
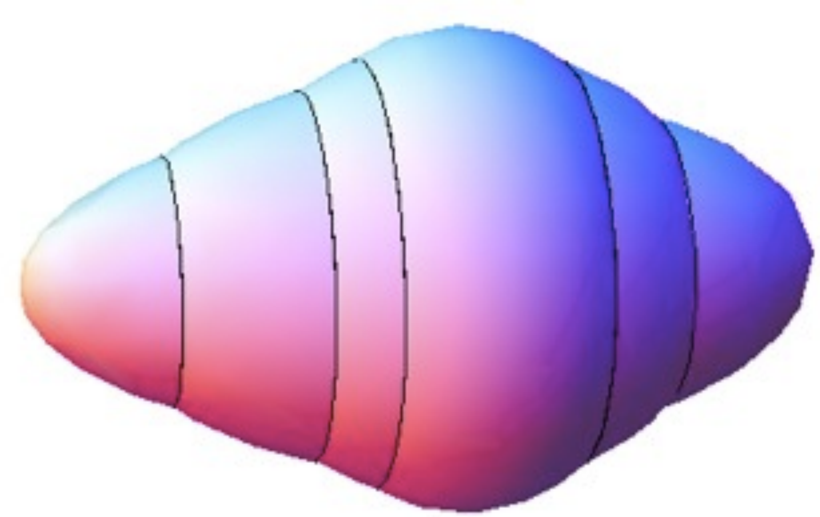


same function $\ddot{\alpha}(z)$
appearing in the metric





$$ds^2 = 8\sqrt{-\frac{\ddot{\alpha}}{\alpha}}\,ds^2_{\rm AdS_7} + \sqrt{-\frac{\alpha}{\ddot{\alpha}}}\,dz^2 + \frac{\alpha^{3/2}(-\ddot{\alpha})^{1/2}}{\sqrt{2\alpha\ddot{\alpha}-\dot{\alpha}^2}}\,ds^2_{S^2}$$



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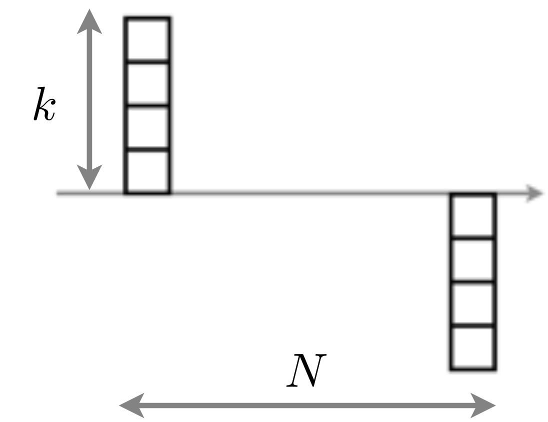

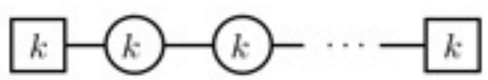

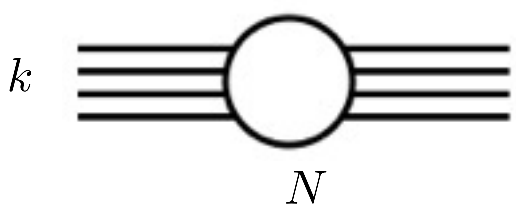

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$\mathrm{AdS}_7 \times S^4/\mathbb{Z}_k$

an orbifold of
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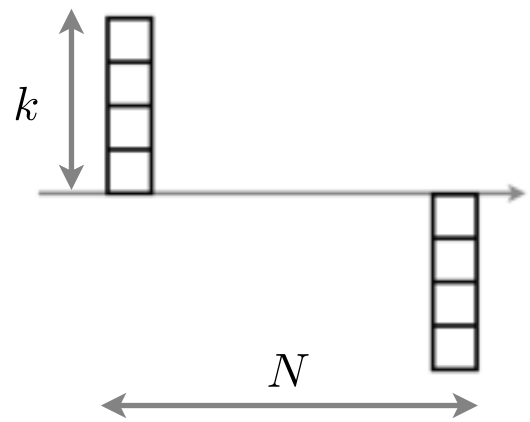

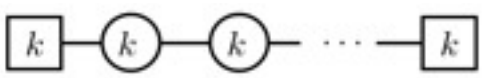

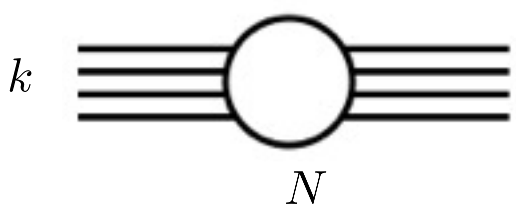

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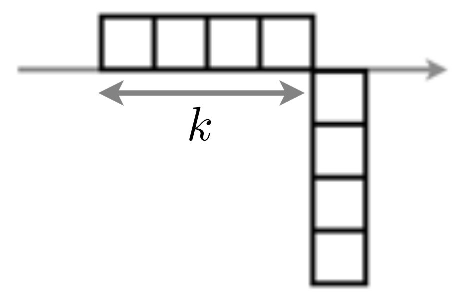

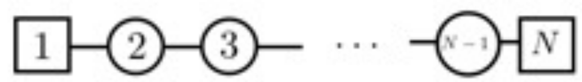

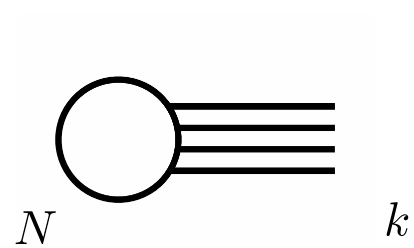

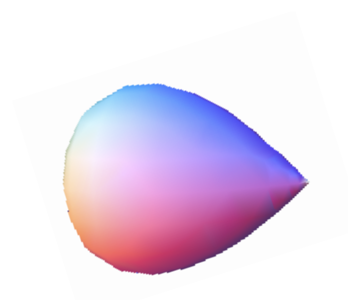

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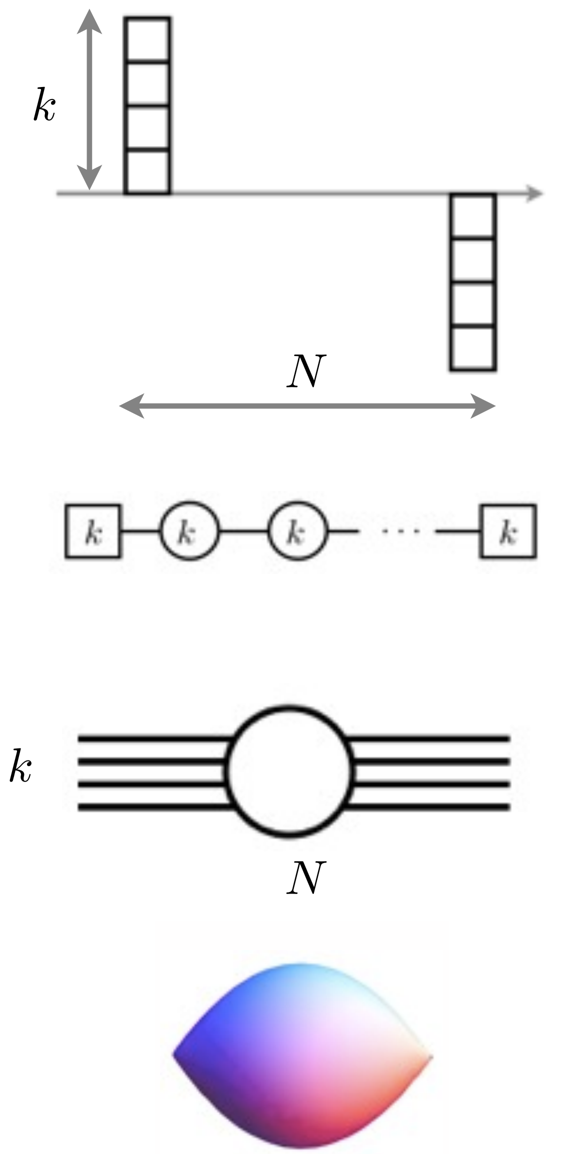

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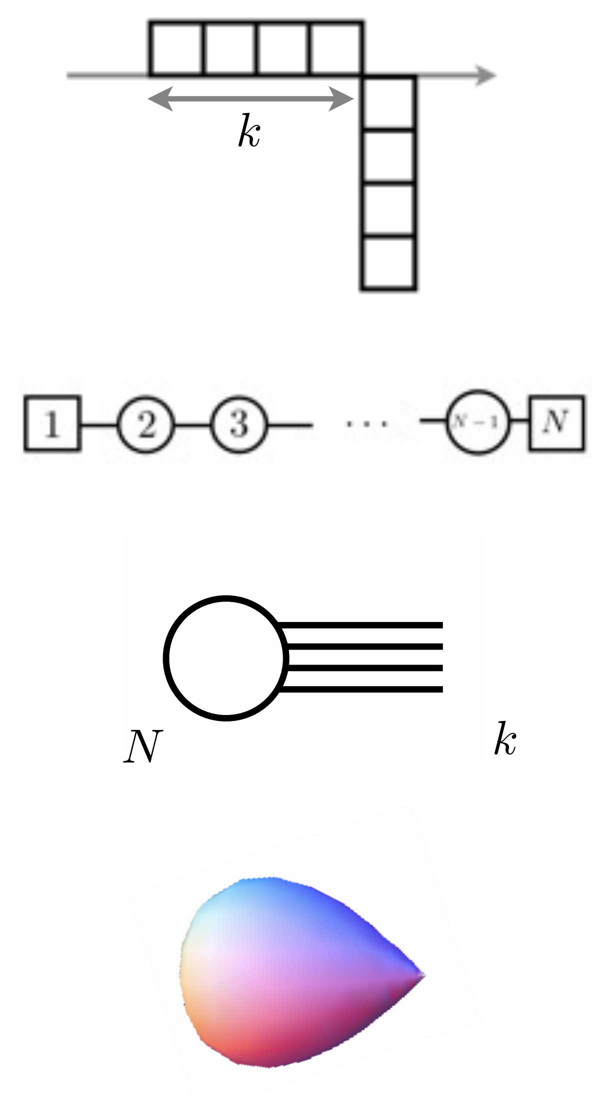

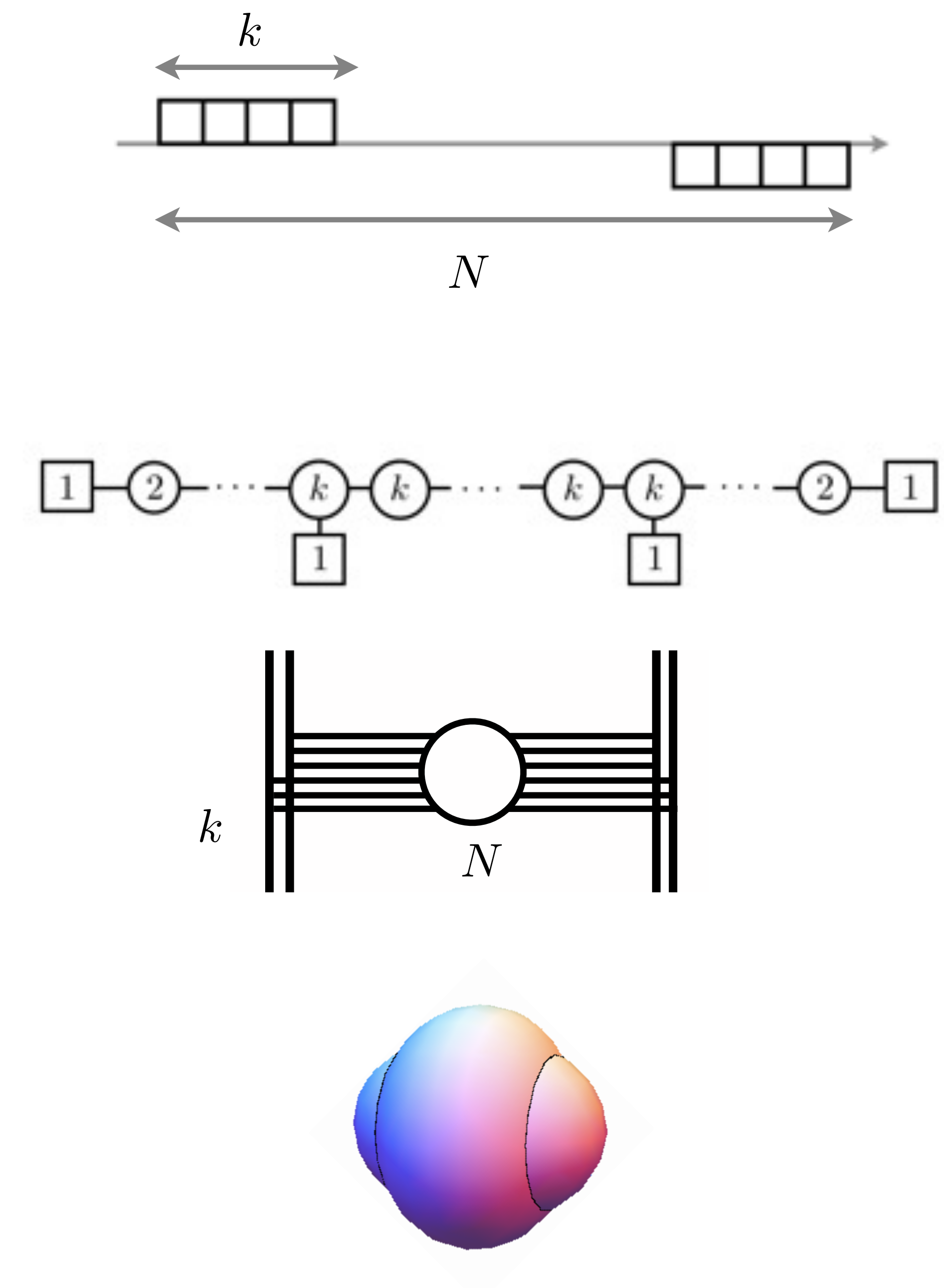

Anomaly match

[Cremonesi, AT, to appear]

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[Cordova, Dumitrescu, Intriligator '15]

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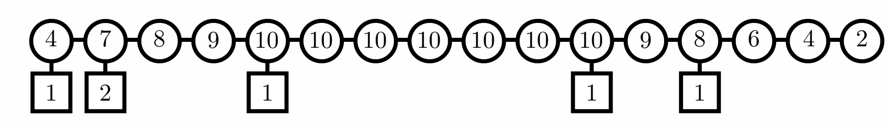

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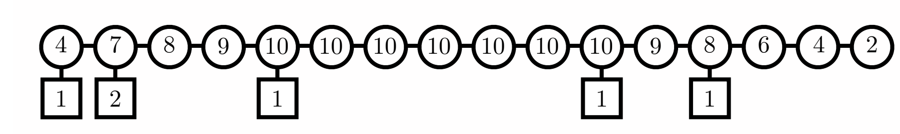
$\wr$

(# gauge groups)^3



This reproduces the famous cubic scaling.

Example:

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It matches with holographic computation:

$$a = \frac{R^5_{\text{AdS}}}{G_{\text{N},7\text{d}}}$$

[Henningson, Skenderis '98]

in IIA
[string frame]

$$a = \frac{3}{56\pi^4} \int_{M_3} e^{5A-2\phi} \text{vol}_3$$

Another example:

$$\sum_{i,j} C^{-1}_{ij} r_i r_j = \frac{1}{180} N(4N^2-1)(N^2-1) \sim \frac{1}{45} N^5 + \ldots$$

[because $k = N$ in this case]

$$a = \frac{16}{7} \frac{4}{15} N^5 + \ldots$$

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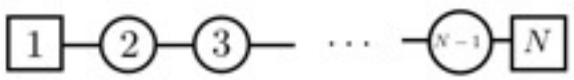

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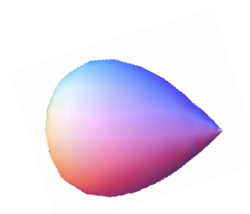

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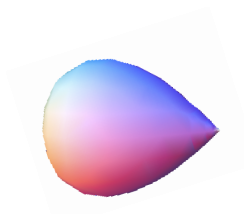

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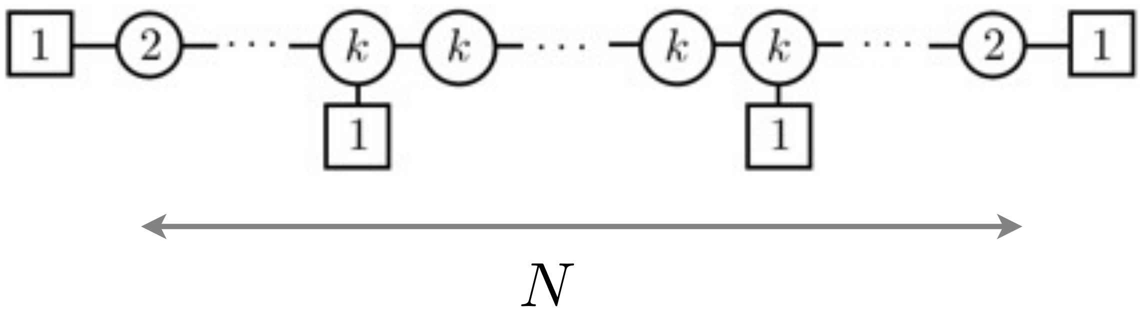

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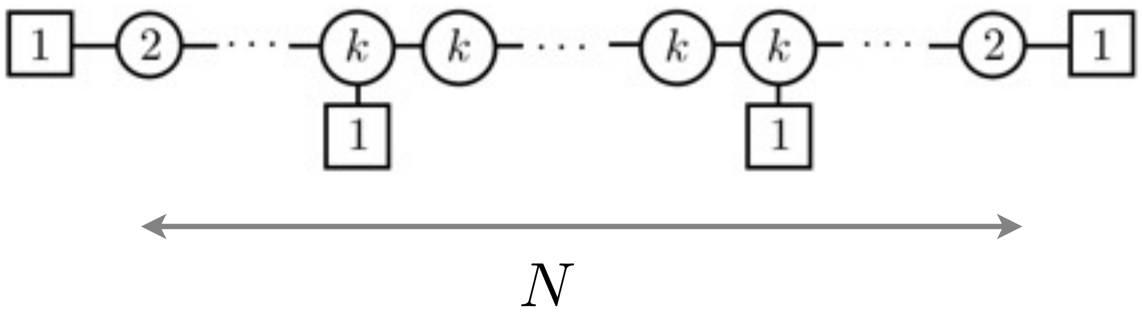

$$a \sim \frac{192}{7} \sum_{i,j} C^{-1}_{ij} r_i r_j + \ldots = \frac{16}{7} k^2 \left(N^3 - 4 N k^2 + \frac{16}{5} k^3 \right) + \ldots$$

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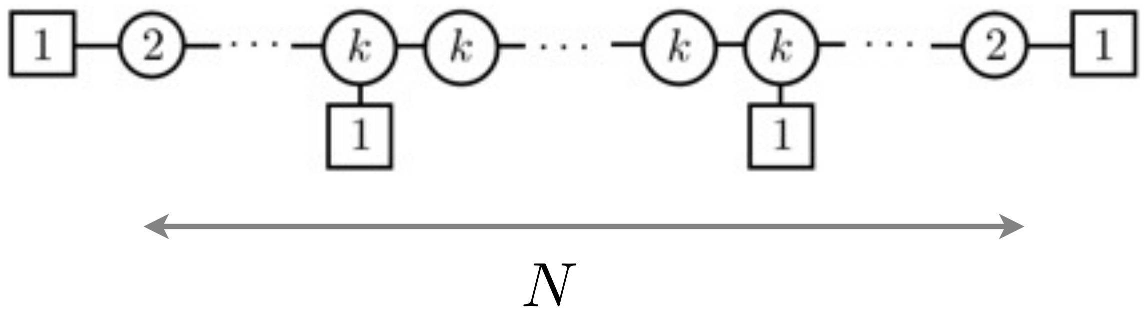

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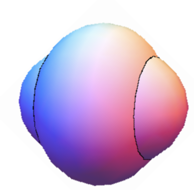

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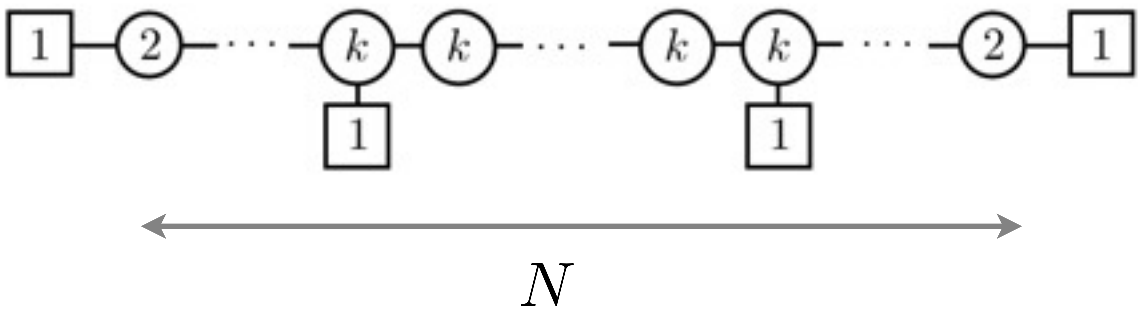

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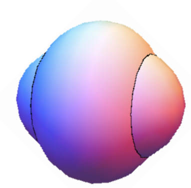

✓

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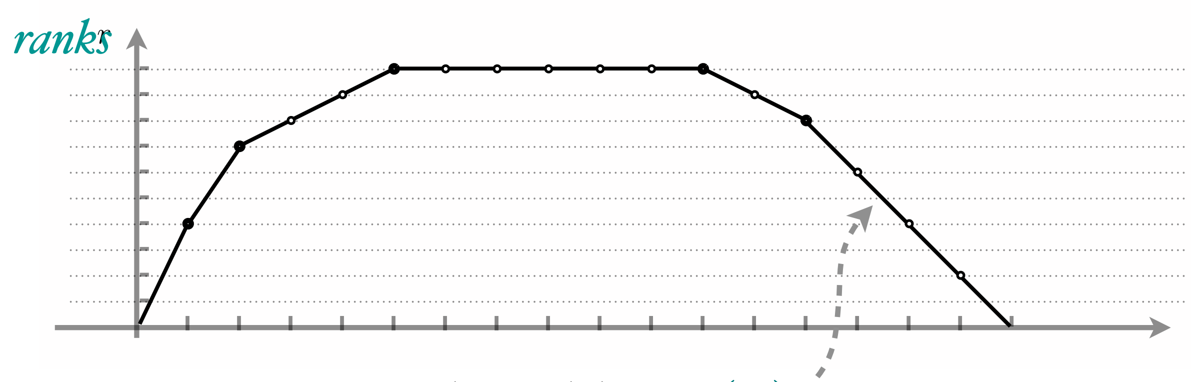

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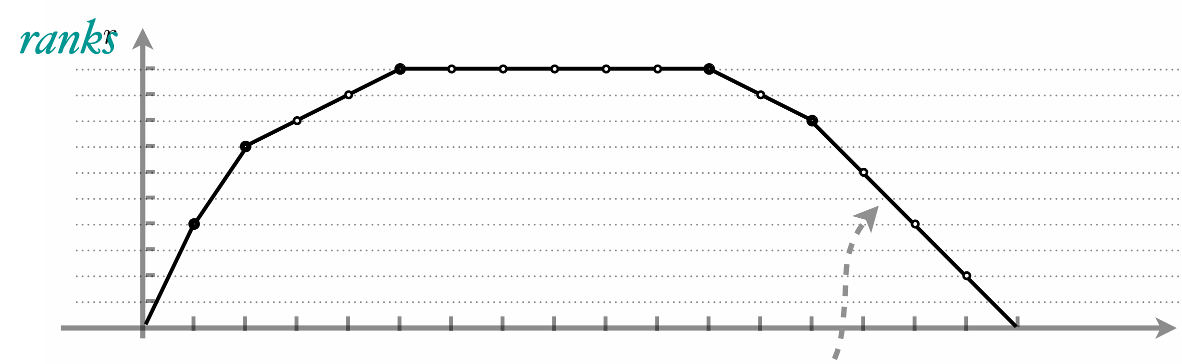

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- On the other hand: Cartan is "discrete double derivative"

$$C = \begin{pmatrix} 2 & -1 & 0 & \dots \\ -1 & 2 & -1 & \dots \\ 0 & -1 & 2 & \ddots \\ \vdots & \vdots & \ddots & \ddots \end{pmatrix} \qquad C_{ij} = 2\delta_{ij} - \delta_{i-1,j} - \delta_{i+1,j}$$

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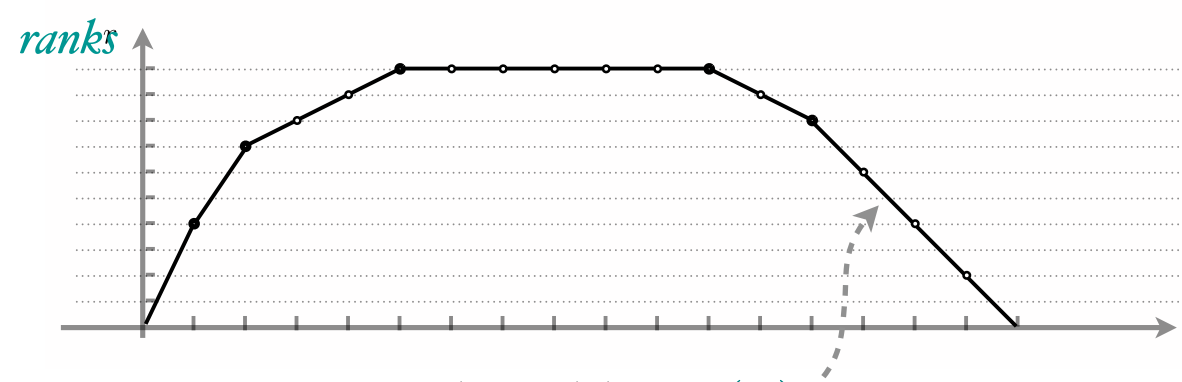

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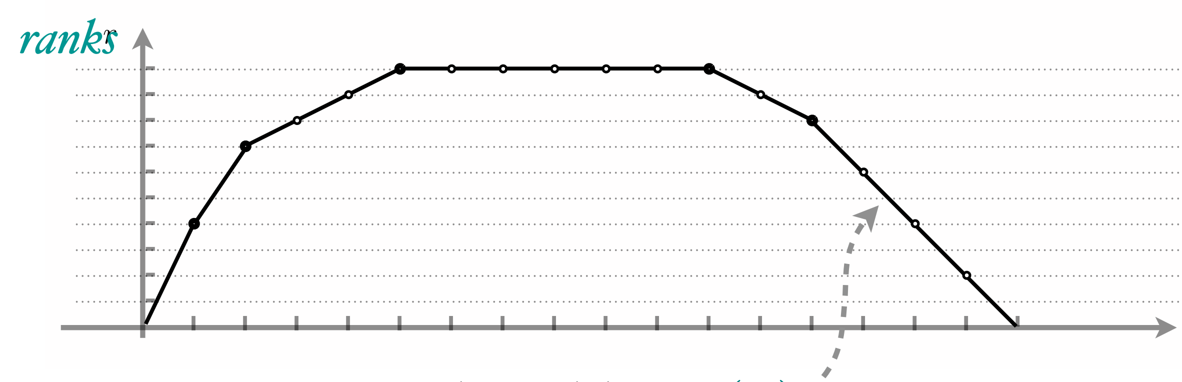

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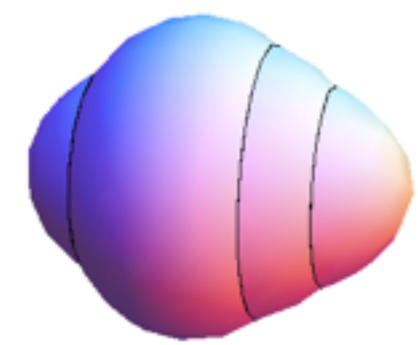
Conclusions & Extensions

- Classification of type II AdS7 solutions



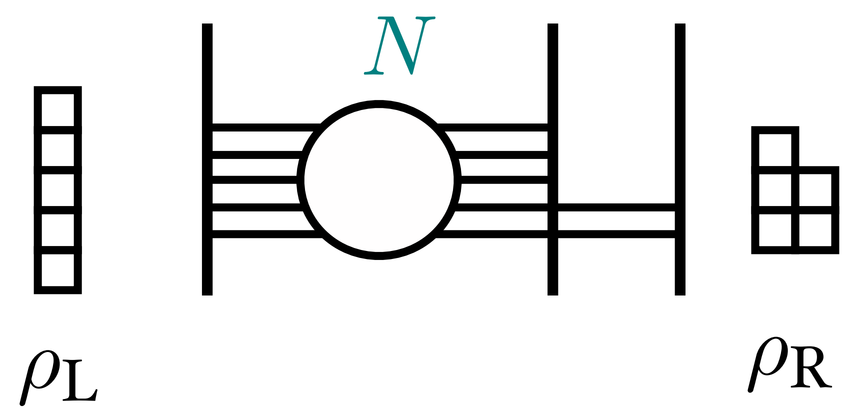
infinitely many new ones!

- Dual field theories: strong coupling points in linear $\mathrm{U}(k)$ quivers

$T^N{}_{\rho_\mathrm{L},\rho_\mathrm{R}}$

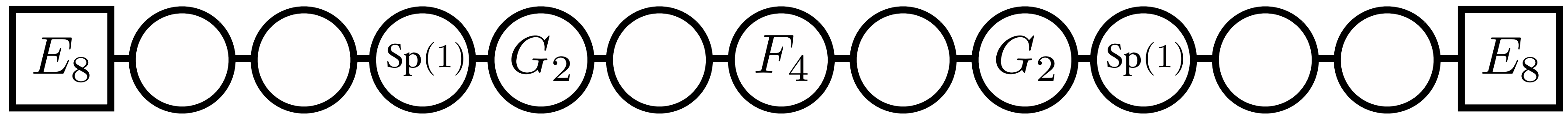
NS5-branes

pattern of D6's ending on D8's



- There are also extensions involving exceptional gauge groups

example:



[‘fractional M5-branes’]

[del Zotto, Heckman, AT, Vafa ’14]

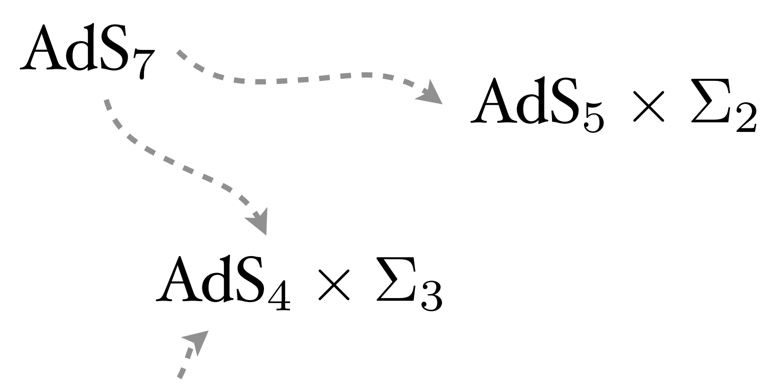
- One can also ‘compactify’

so ∞ new CFT4, CFT3...

[Apruzzi, Fazzi, Passias, AT ’15; Rota, AT ’15]

in fact there is a
consistent truncation to 7d

[Passias, Rota, AT ’15]



these are also interesting
flux compactifications

Backup Slides

Generalization:

[Apruzzi, Fazzi, Rosa, AT '13;
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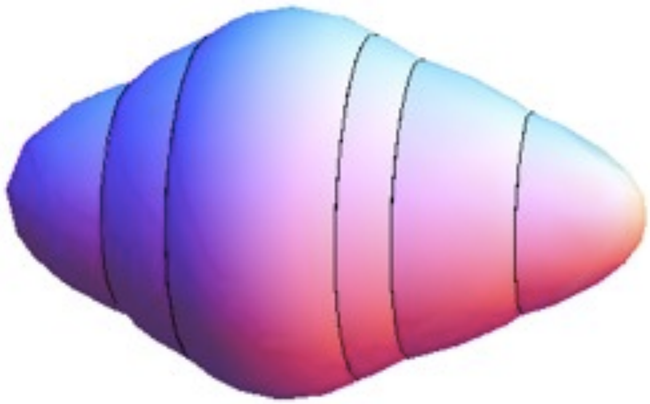
- numbers N_i of D8's, and their D6 charges μ_i



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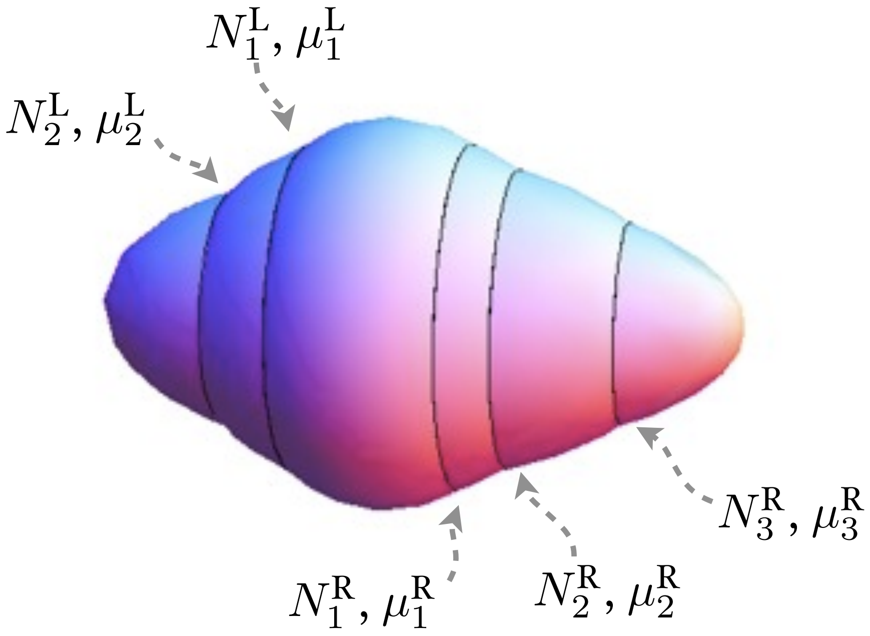

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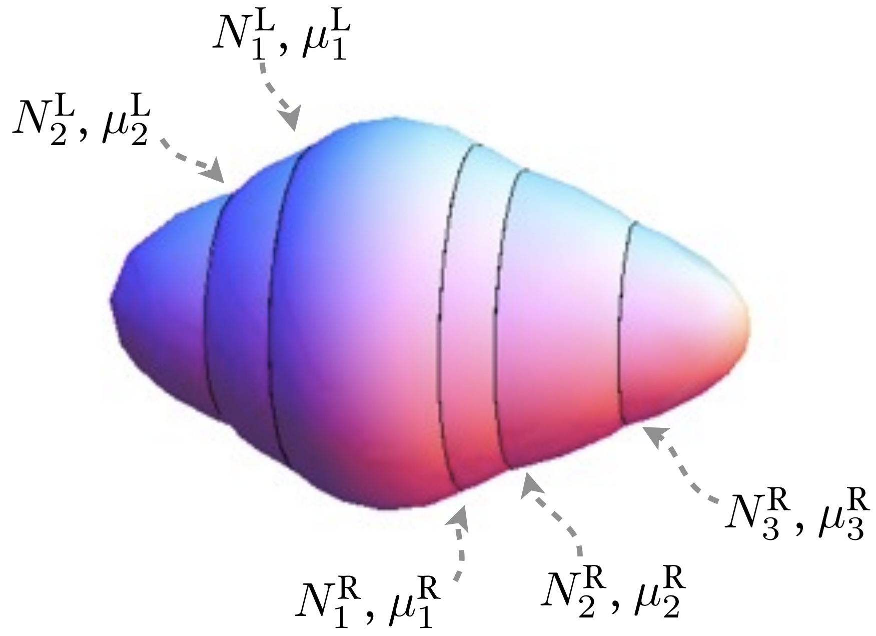

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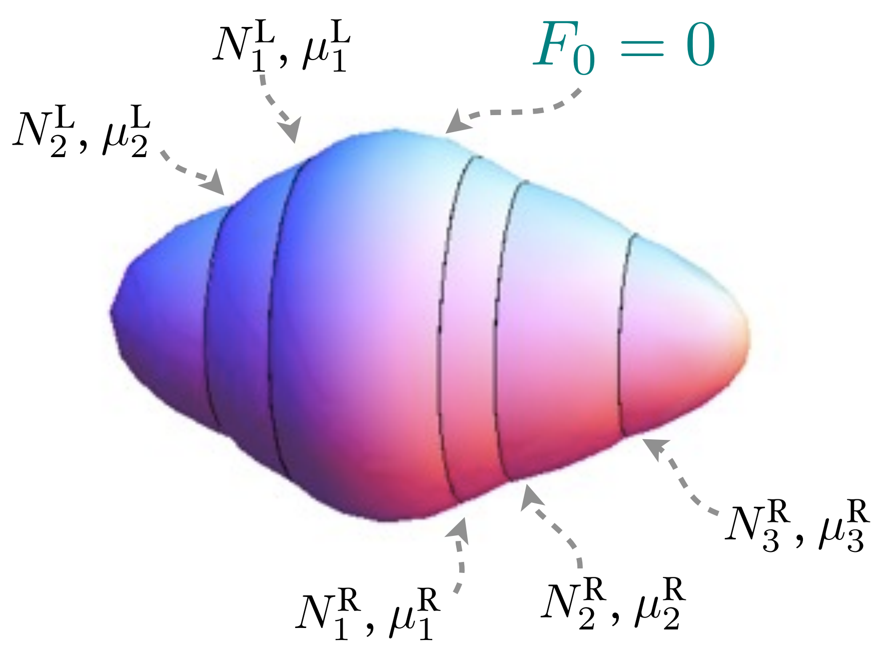

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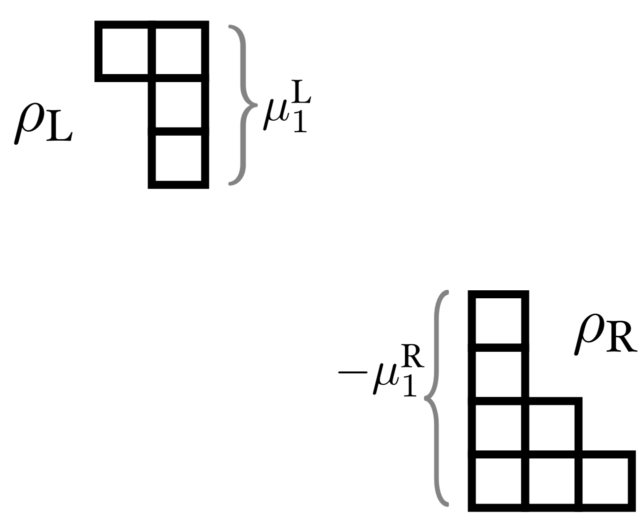

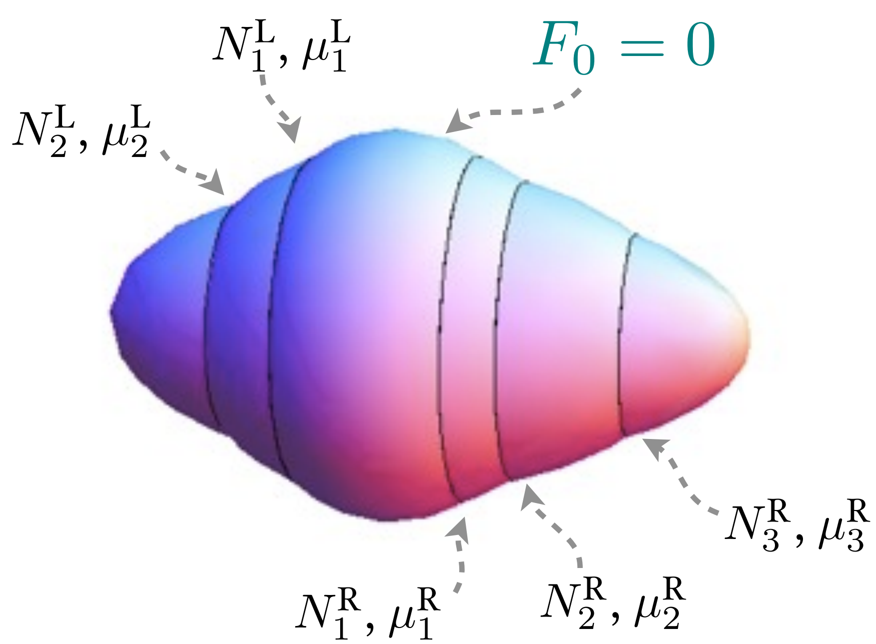

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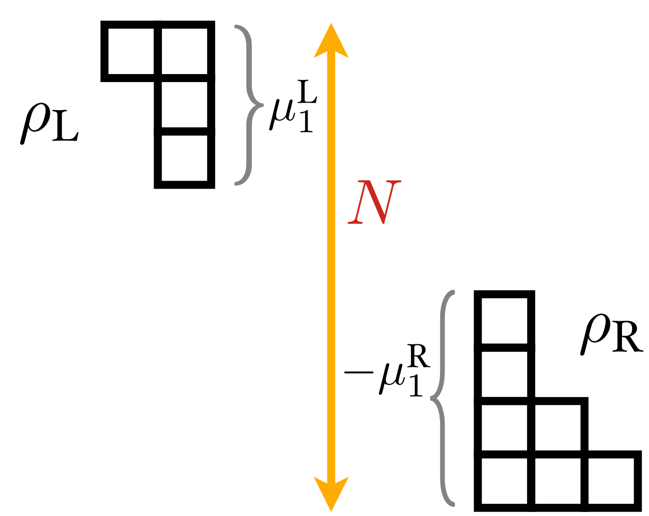
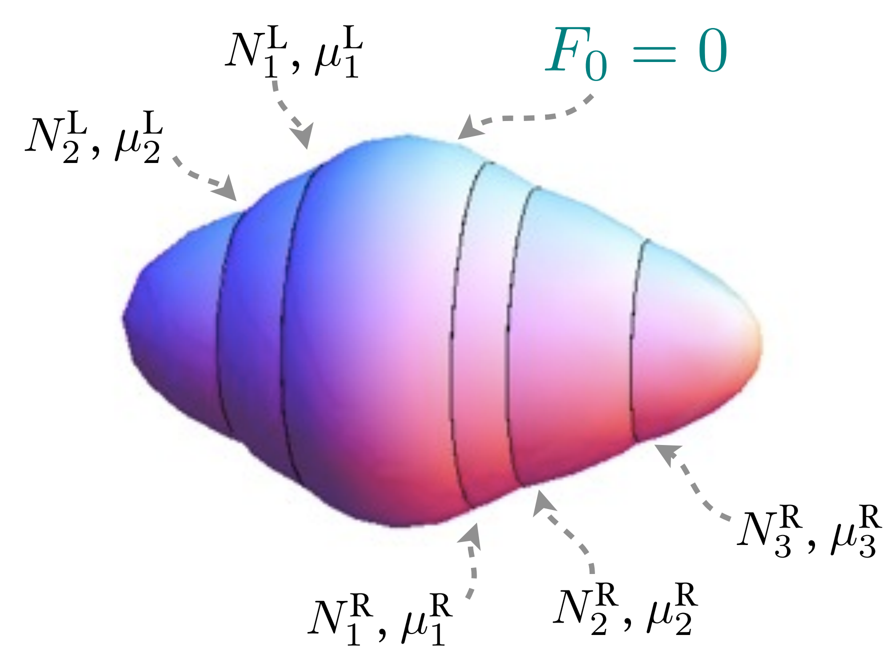
bordering $F_0 = 0$ region.





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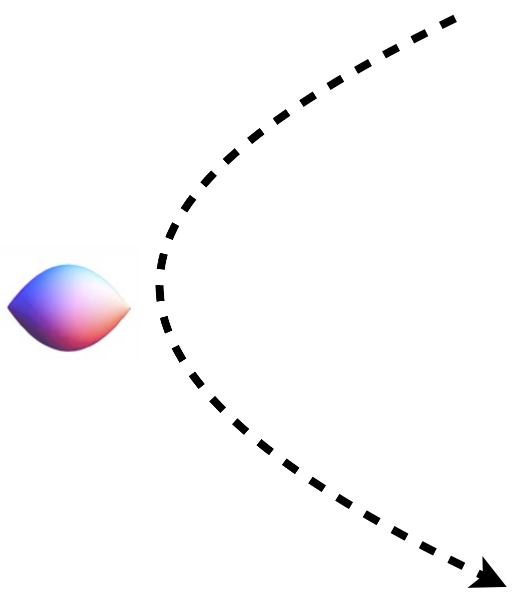

7d minimal gauged sugra

fields: $g^{(7)}_{\mu\nu}$, A^i_μ, X

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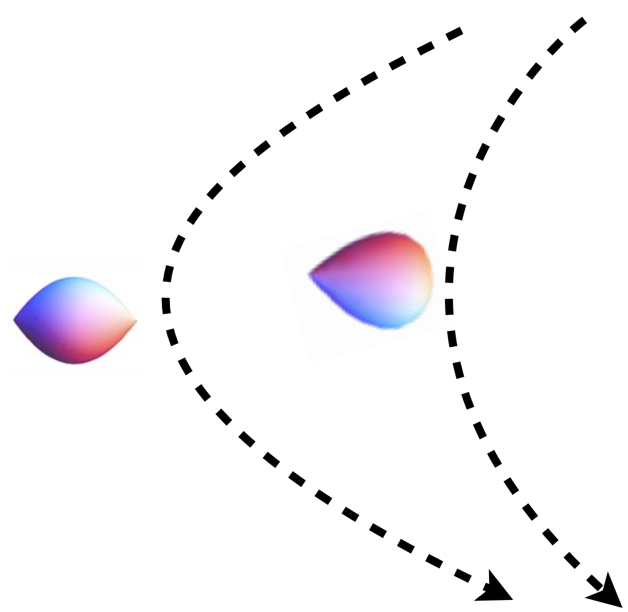

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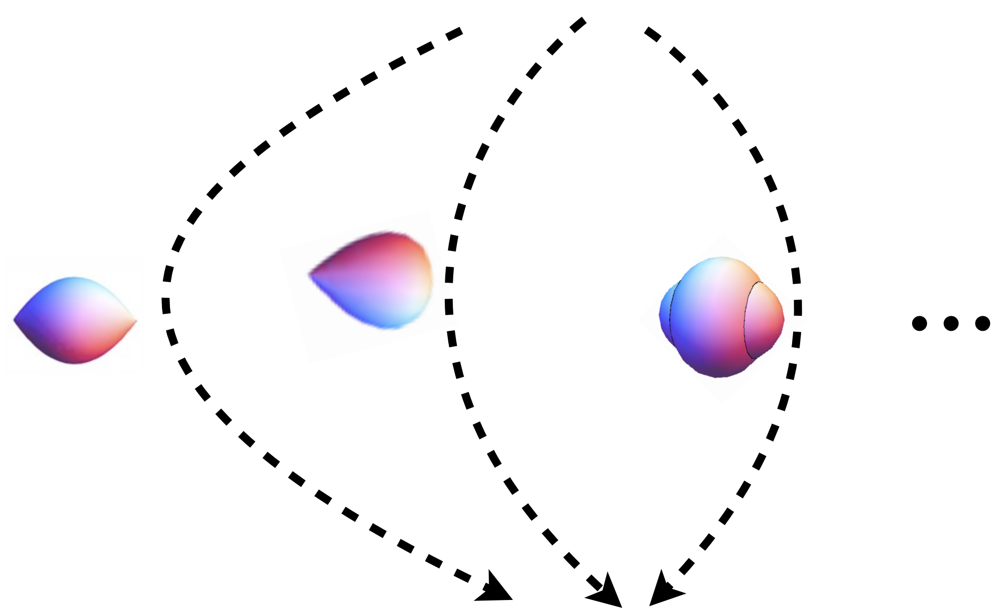

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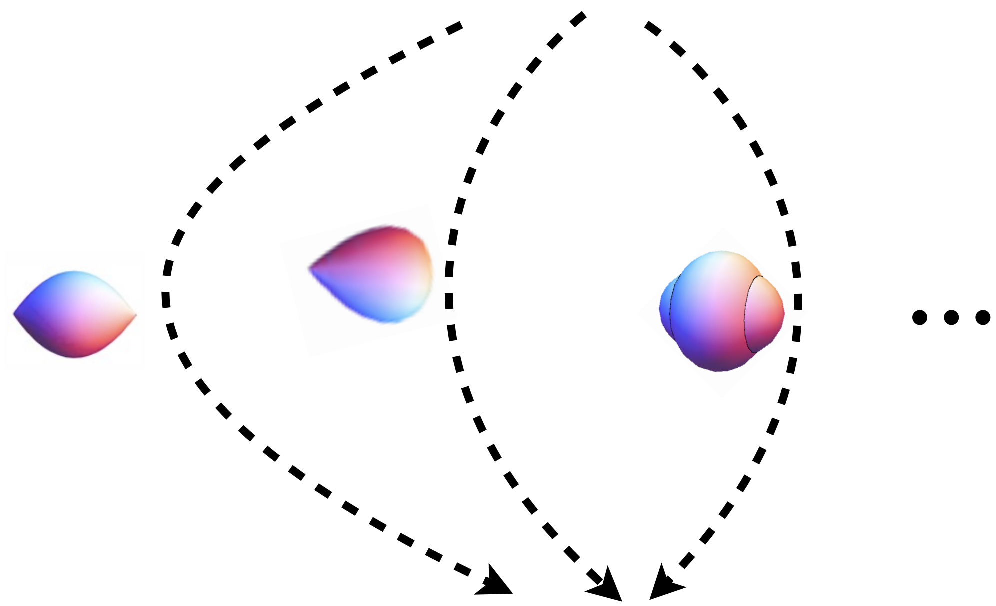

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$$e^{2A} ds^2_7 + dr^2 + \frac{v^2}{1+16(X^5-1)v^2} e^{2A} ds^2_{S^2}$$

scalar $X \cong$ an internal 'distortion'

vacuum:

$$e^{2A} ds^2_{\mathrm{AdS}_7} + dr^2 + v^2 ds^2_{S^2}$$

Many solutions that one can lift:

- $AdS_5 \times \Sigma_2$, $AdS_4 \times \Sigma_3$ solutions

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$F_0 \neq 0$, most general: $\beta \propto \left(\sqrt{\hat{y}} - 6\right)^2 \left(\hat{y} + 6\sqrt{\hat{y}} + 6b_2 - 72\right)^2$

$$\hat{y} \equiv 2b_2\left(\frac{y}{y_0} - 1\right) + 36$$

More general CFT6 from F-theory

So far we have seen chains of $SU(N)$ gauge groups

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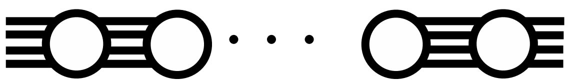
IIA



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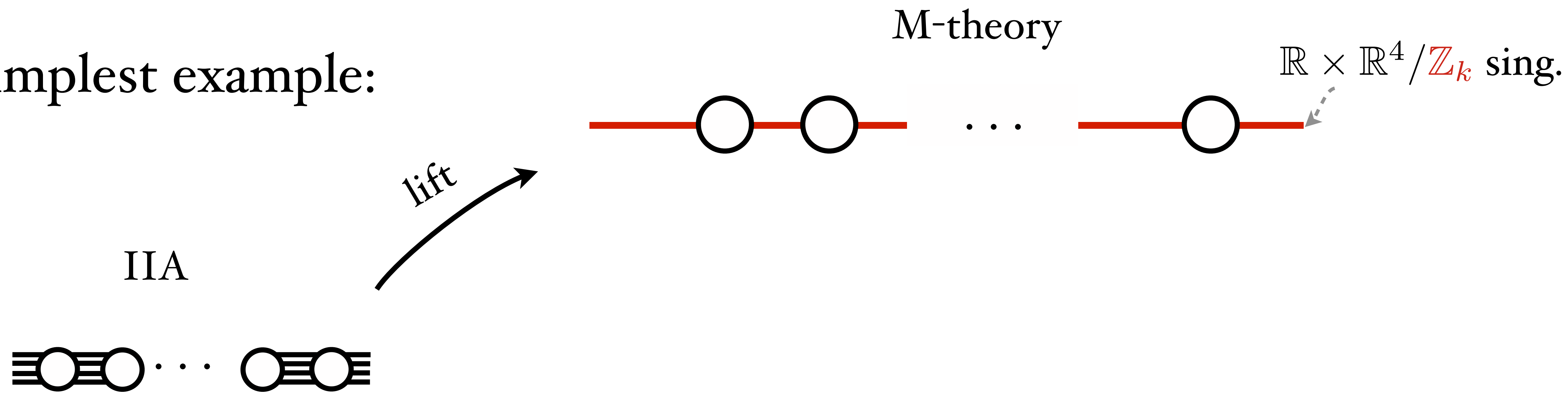

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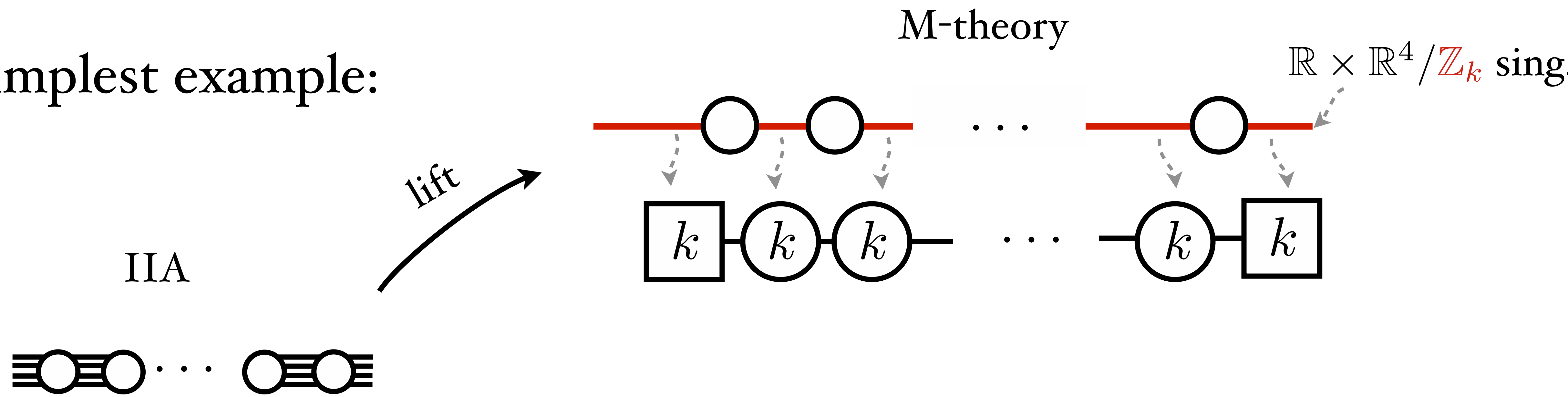

More general CFT6 from F-theory

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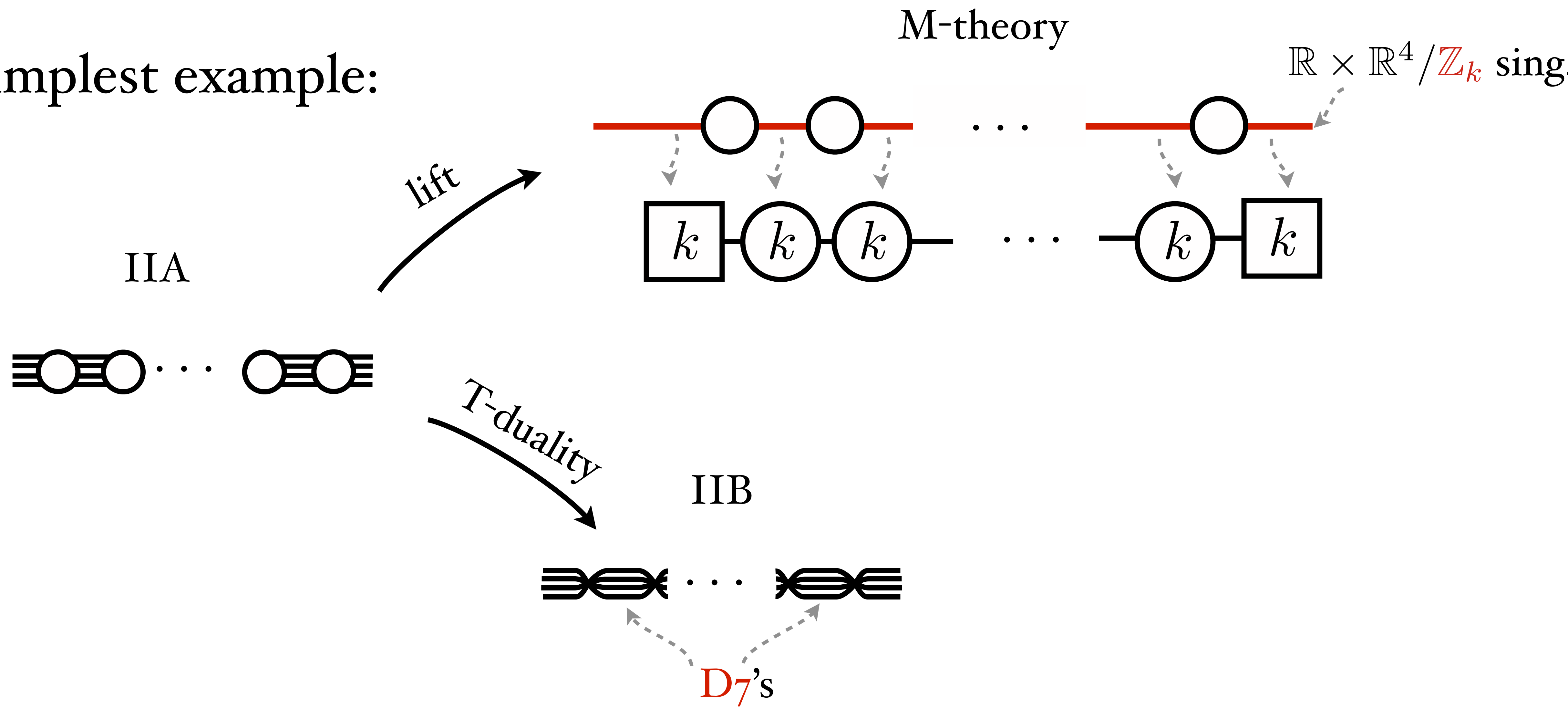

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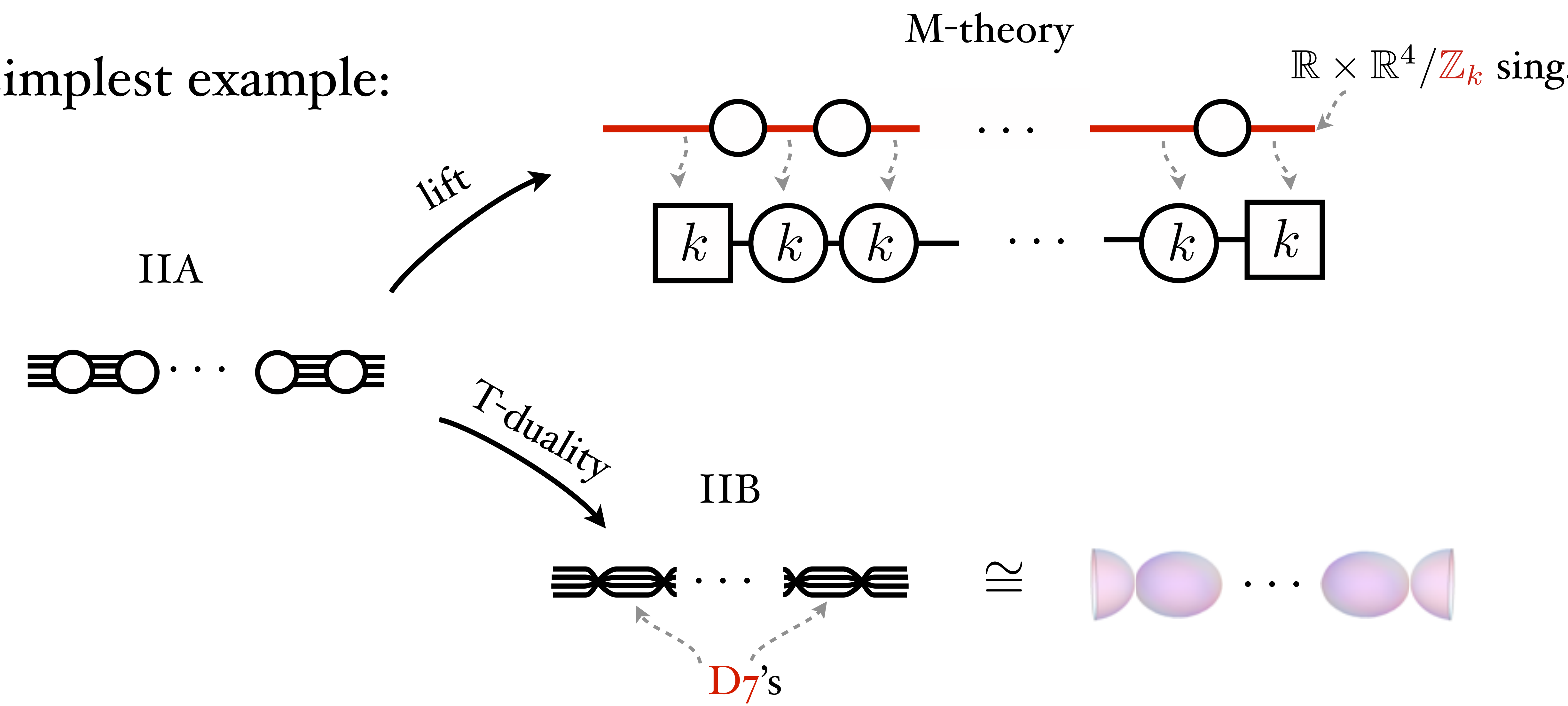

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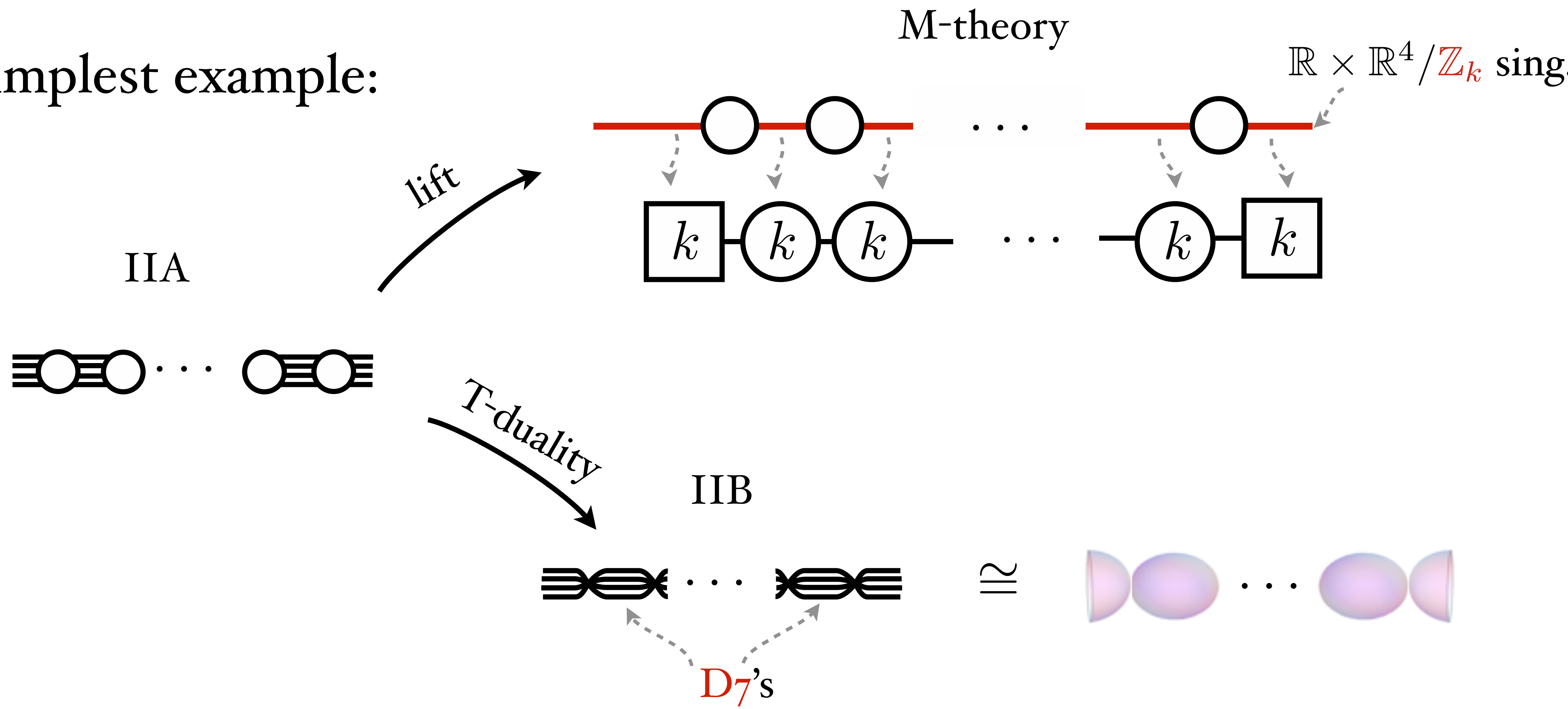

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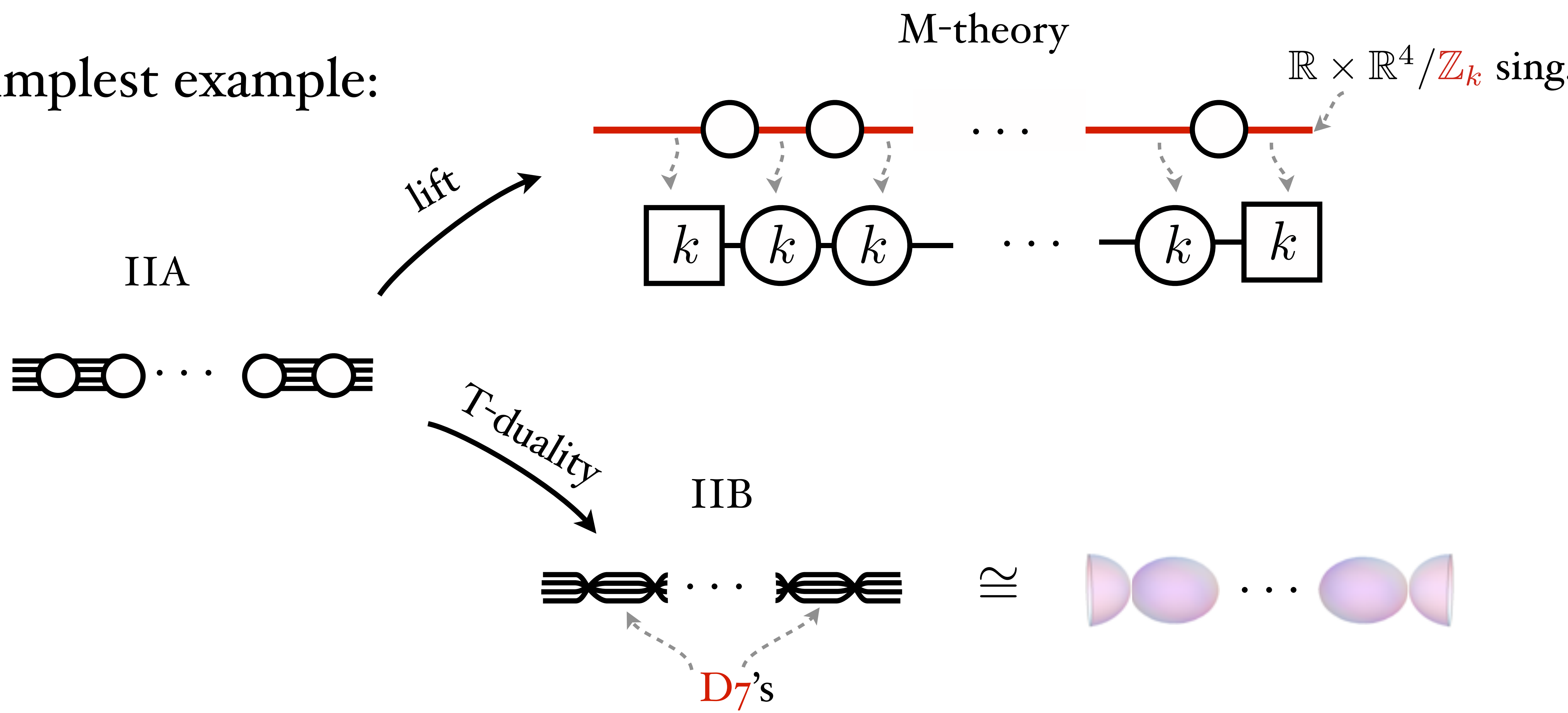

- F-theory allows to include more general gauge groups
- The D8's should be dual in F-theory to an object called "T-brane"

[del Zotto, Heckman, AT, Vafa '14]

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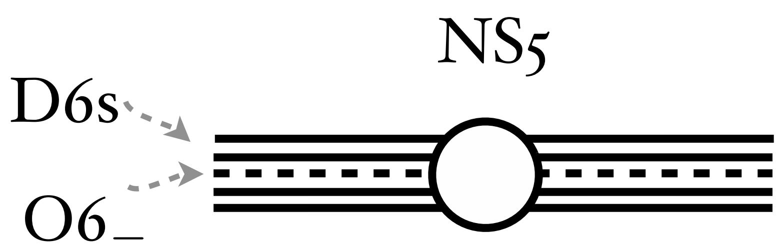

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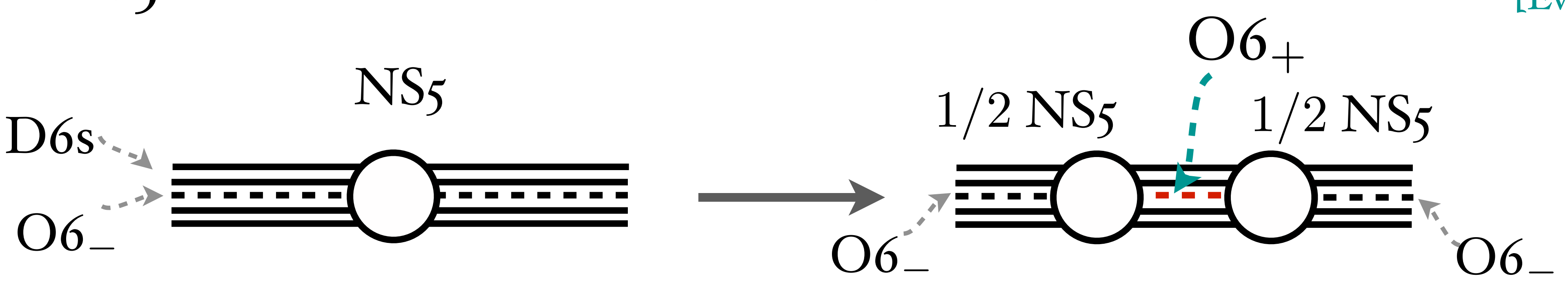

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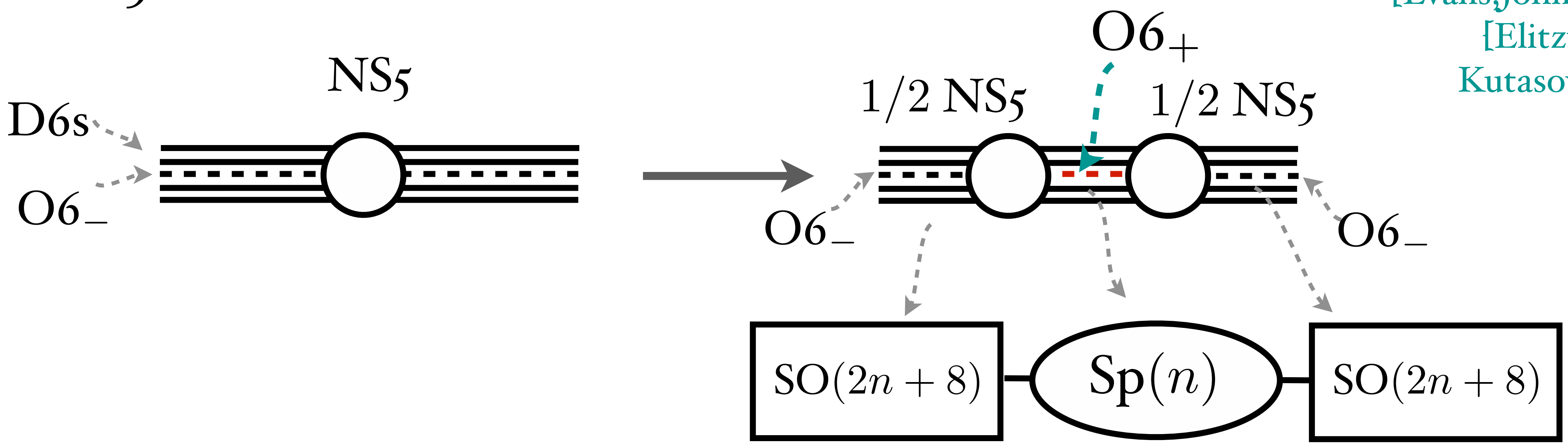

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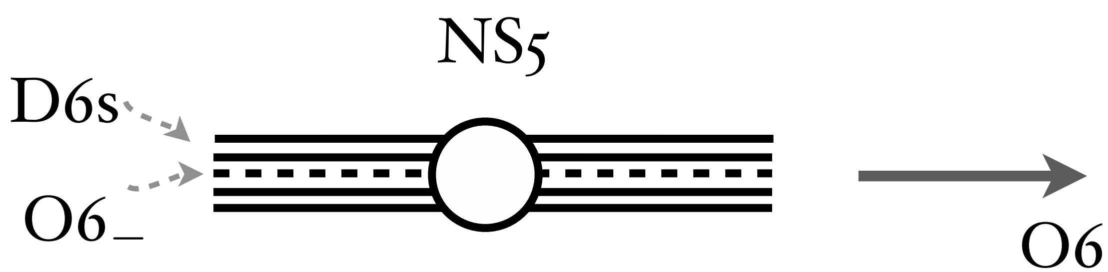

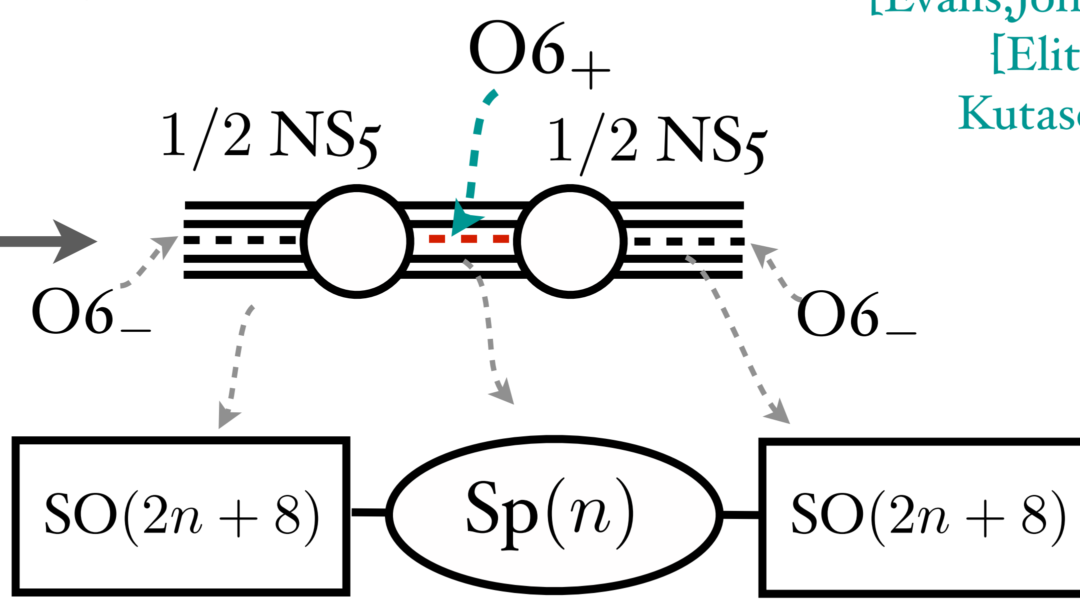

In F-theory this is
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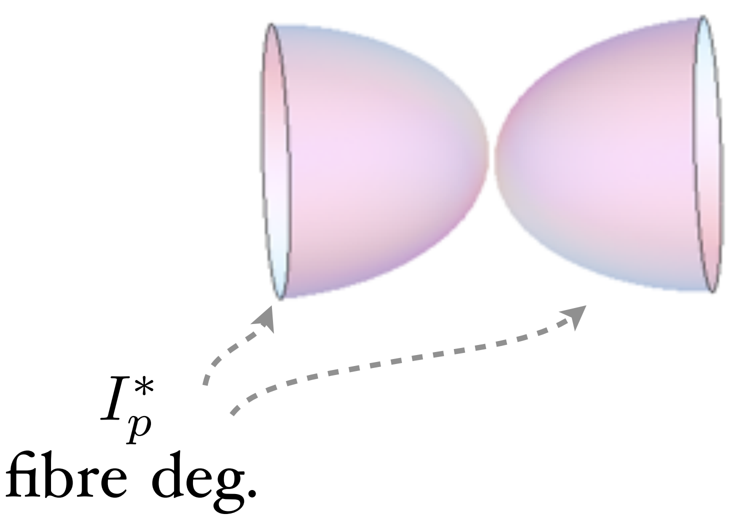

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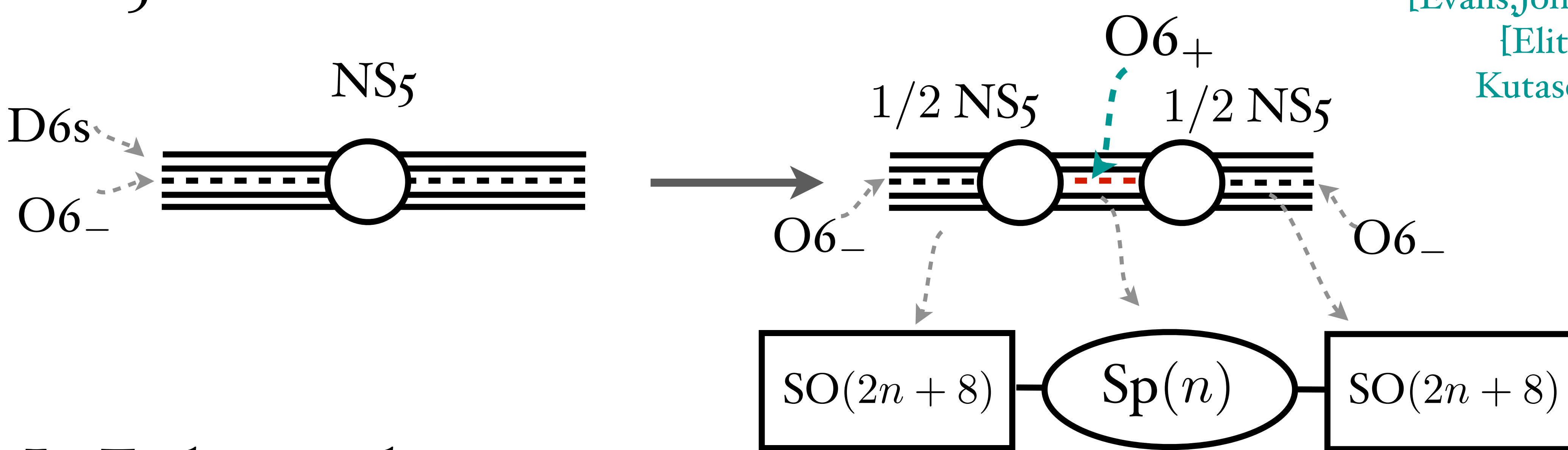

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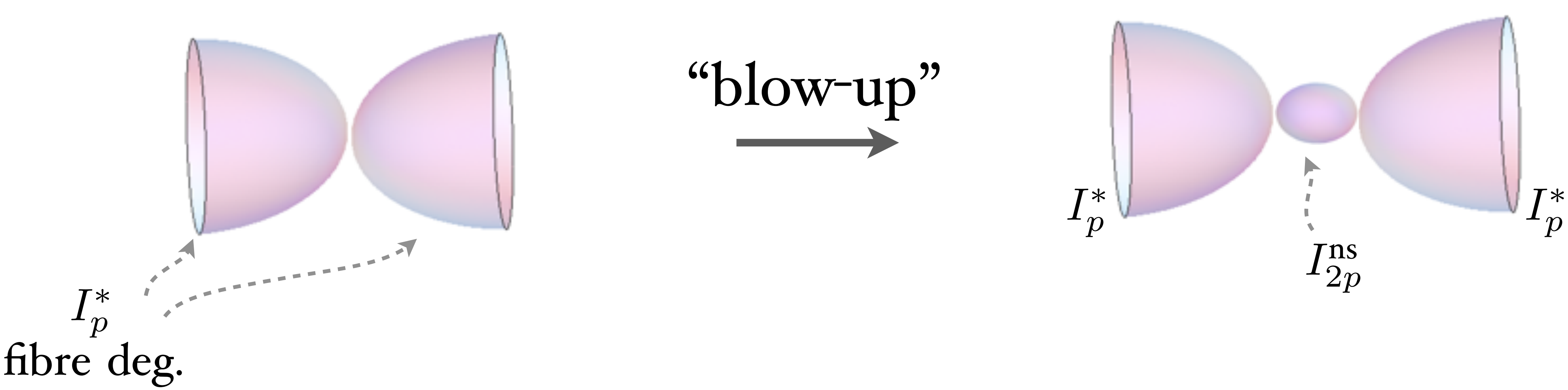

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now we need
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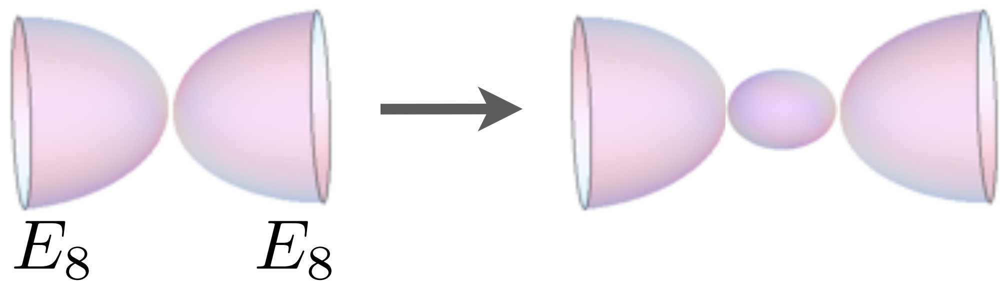

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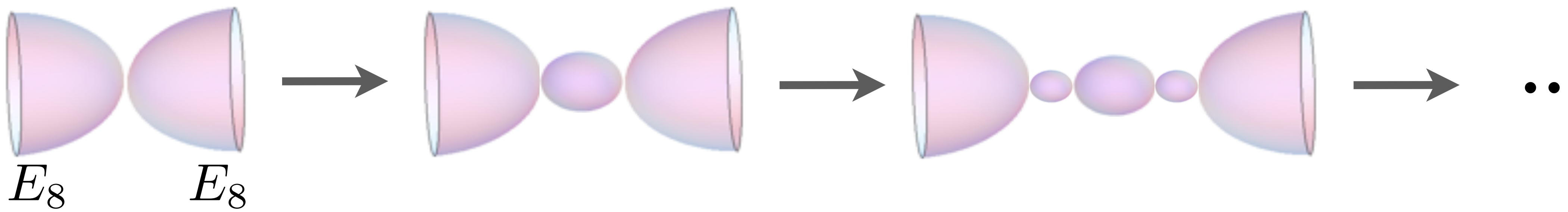

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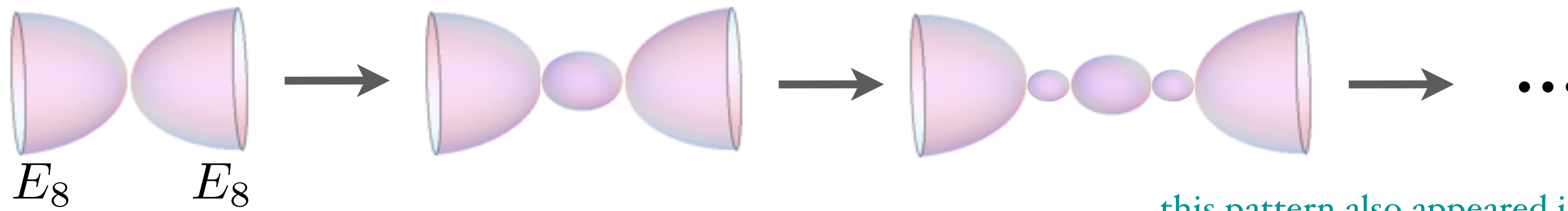

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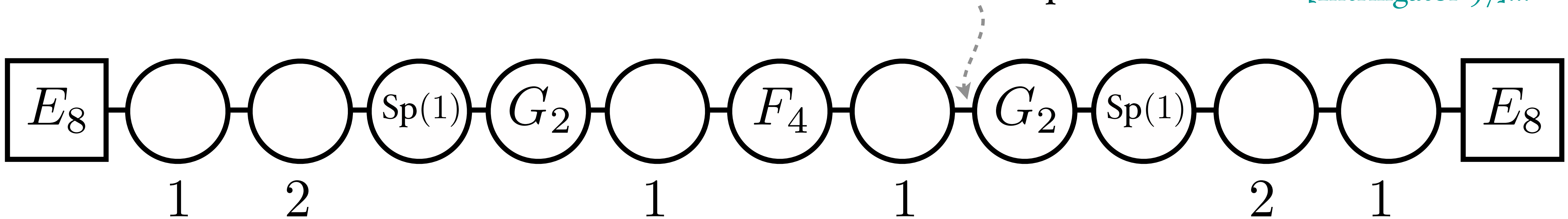
Final result: the (E_8, E_8) theory

tensor multiplets



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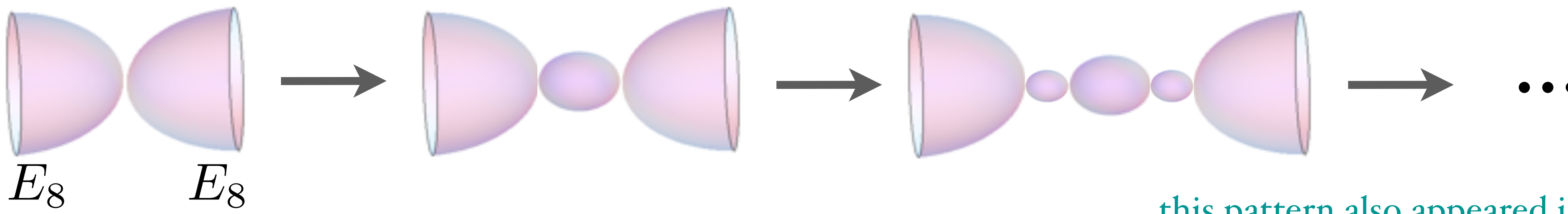

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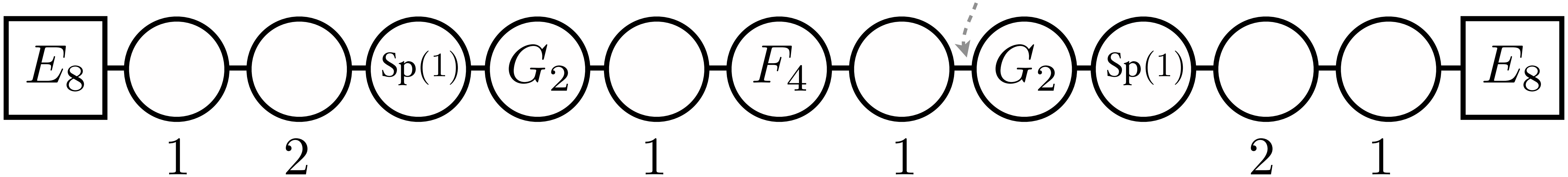

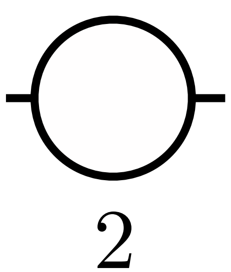

= two tensors (no gauge group)

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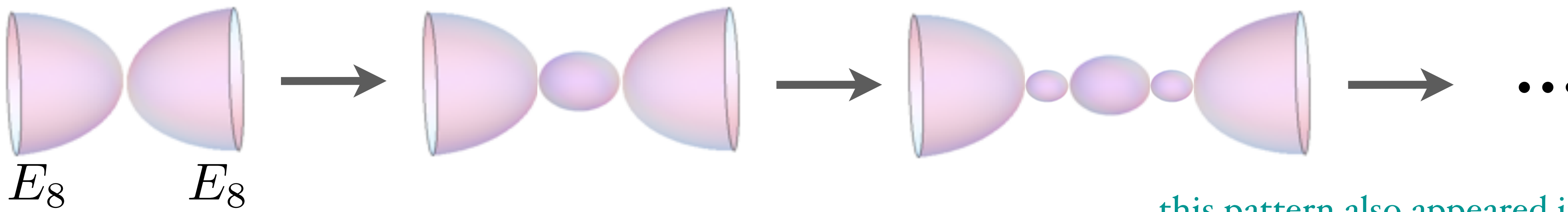

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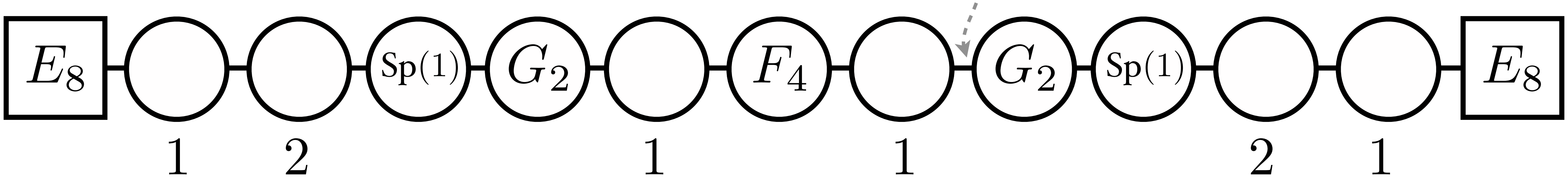

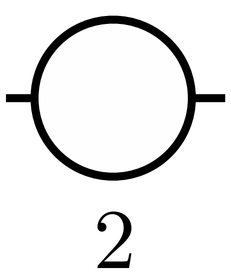

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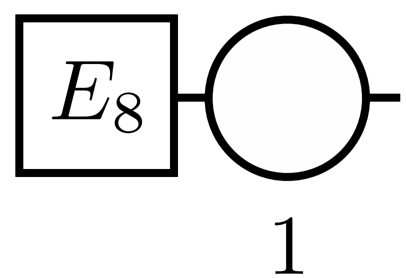

= "E-string"
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E_8 flavor symmetry

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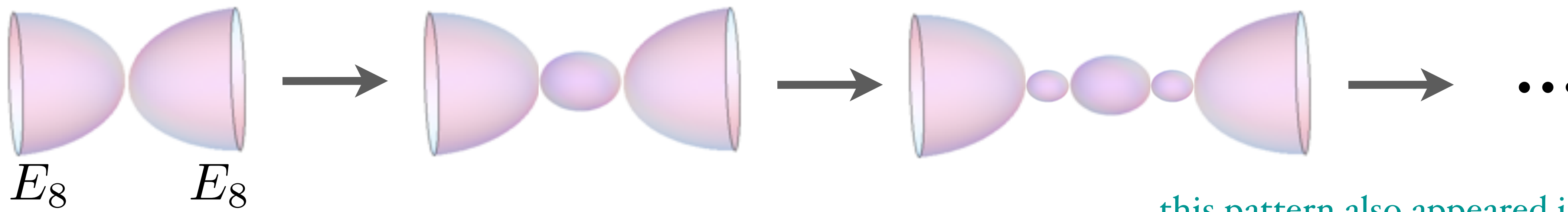

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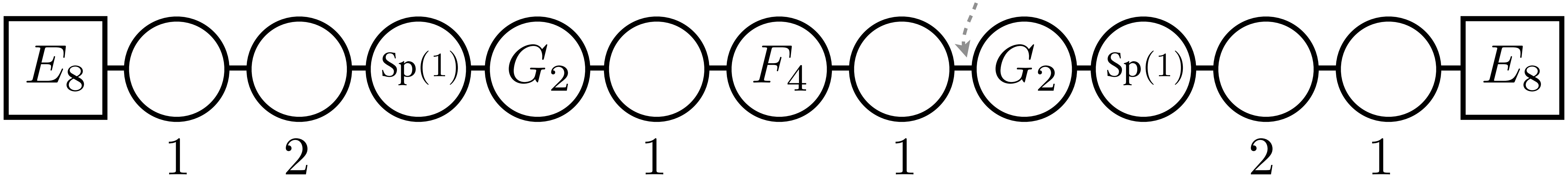

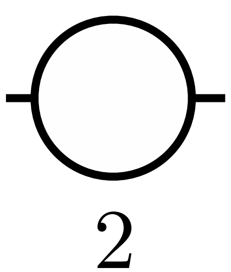

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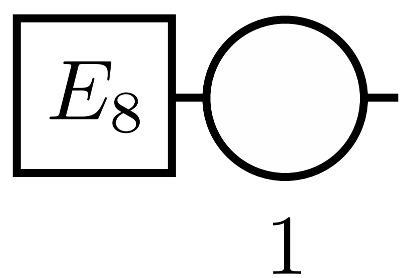

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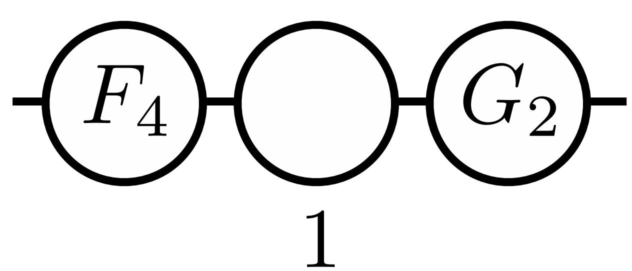
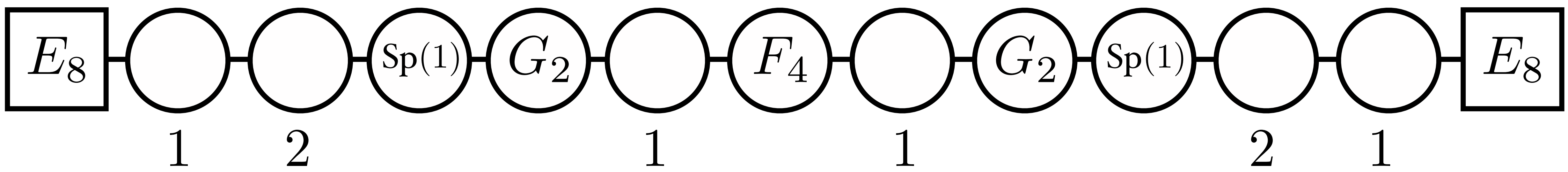


= again "E-string" where $F_4 \times G_2 \subset E_8$ has been gauged

Final result: the (E_8, E_8) theory



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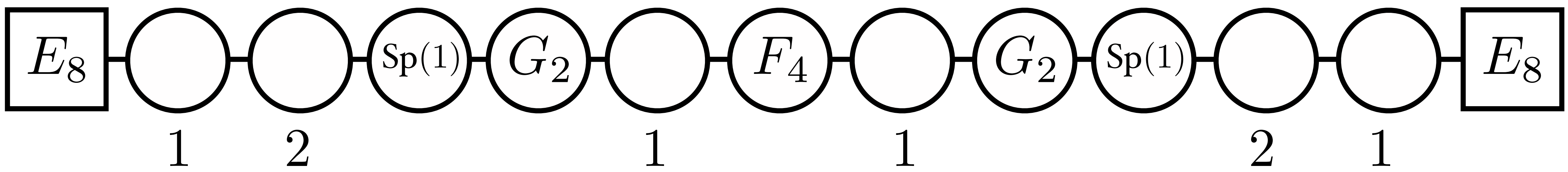

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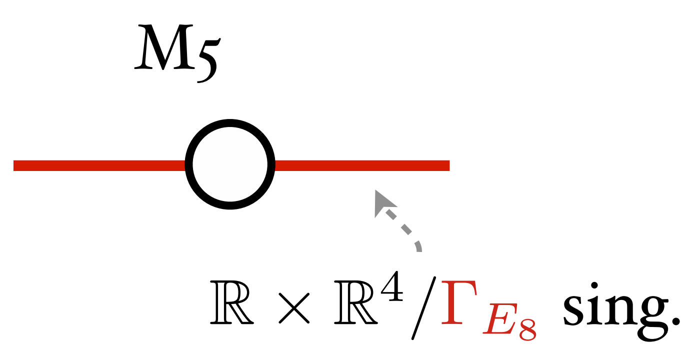

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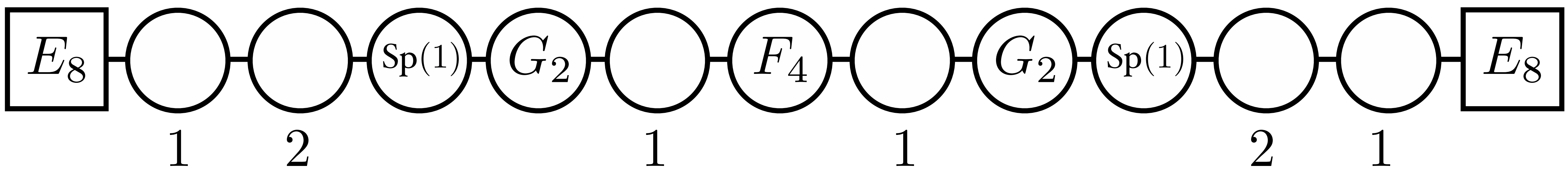

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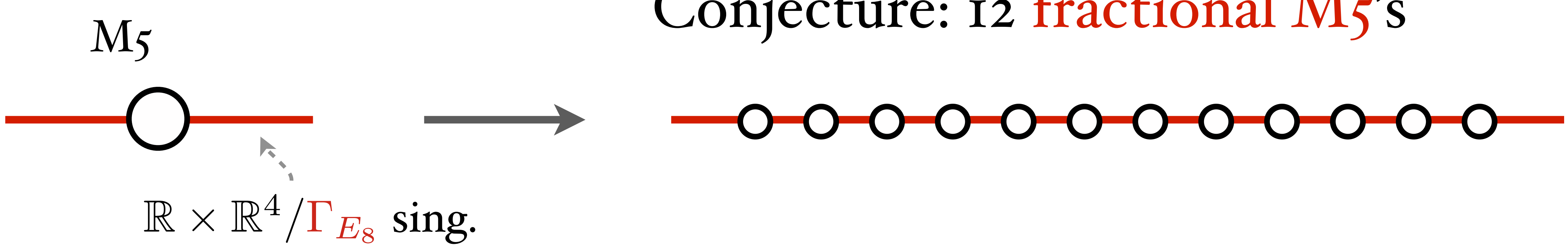
Conjecture: 12 fractional M5's



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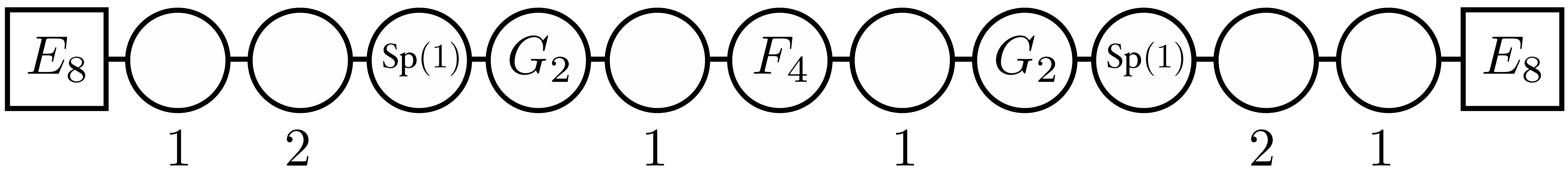

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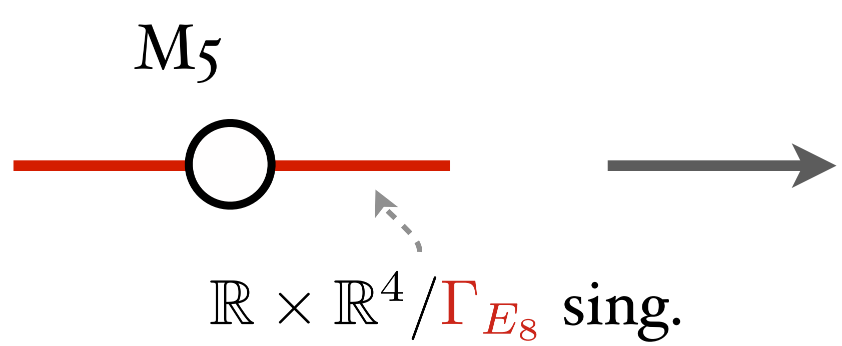

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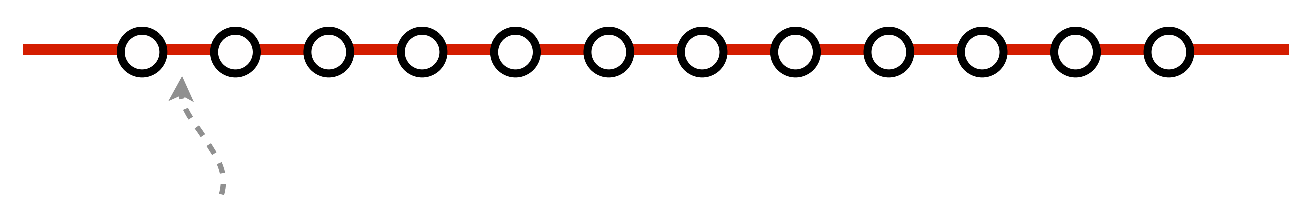

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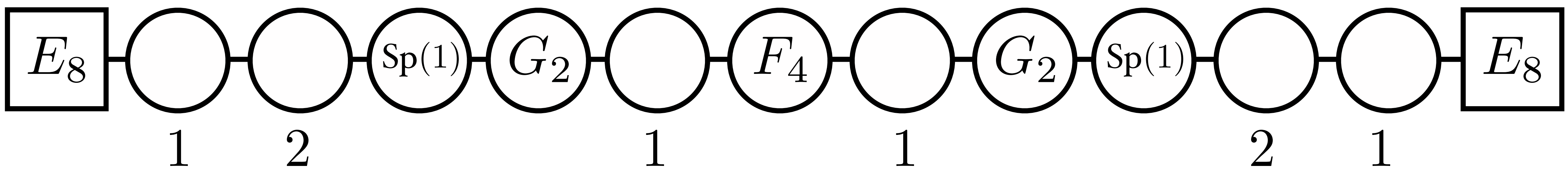

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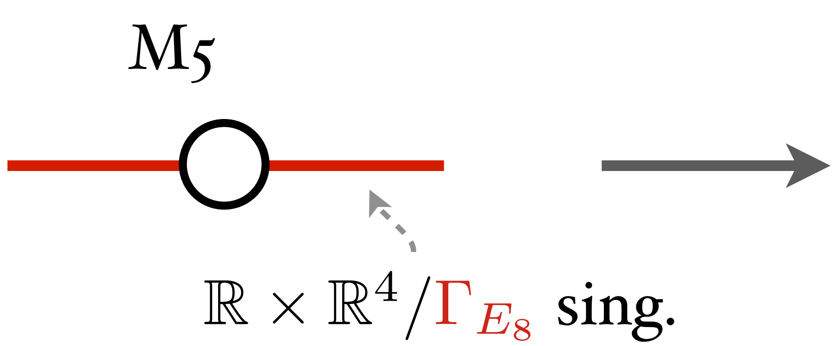

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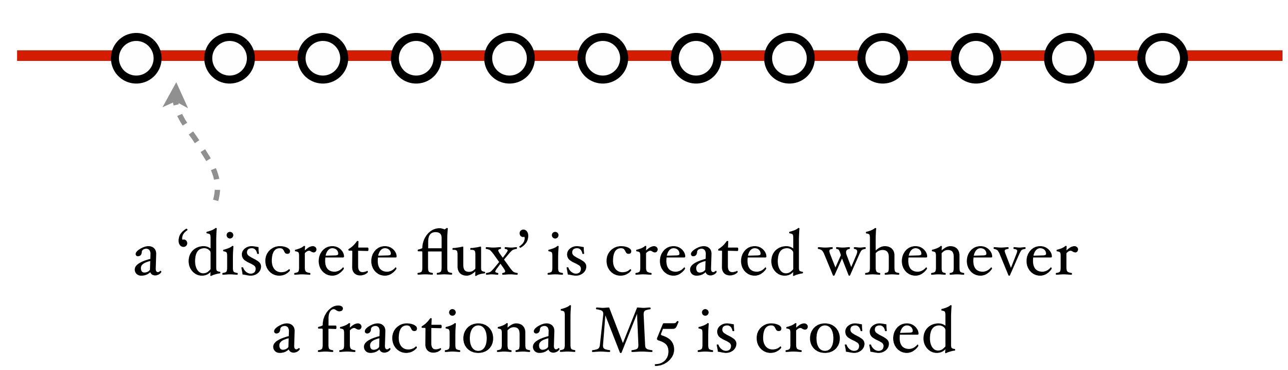

for a nice alternative explanation
[Ohmori, Shimizu, Tachikawa, Yonekura '15]