5d/6d SCFTs on Tao diagrams II

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Based on the collaboration with

Hirotaka Hayashi, Sung-Soo Kim, Kimyeong Lee, Masato Taki

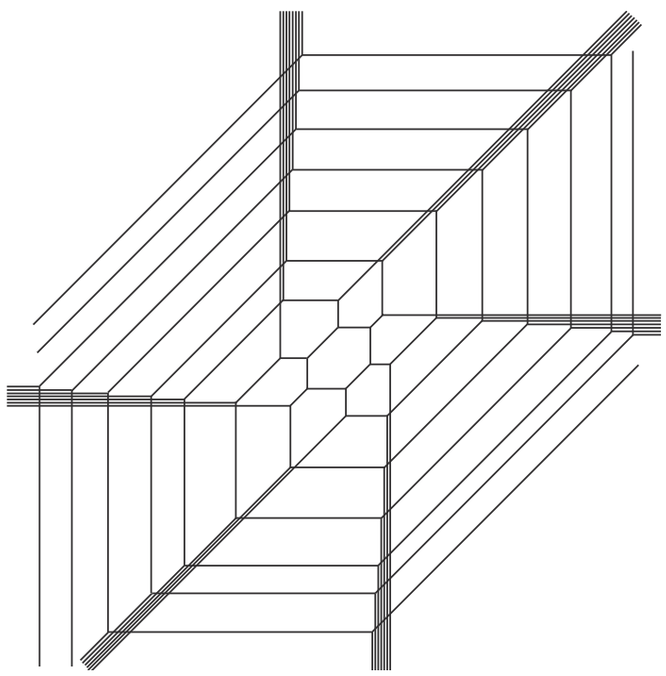
arXiv:1504.03672, 1509.03300, 1505.04439

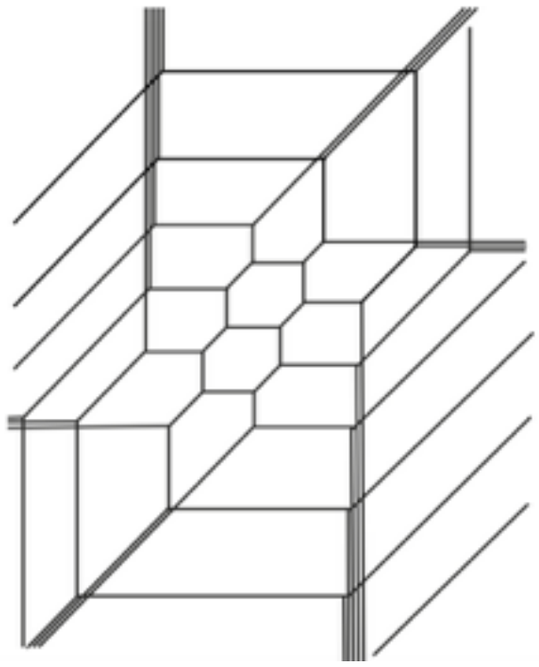
§1 Review of the previous talk+α [Conjecture on UV fixed point]

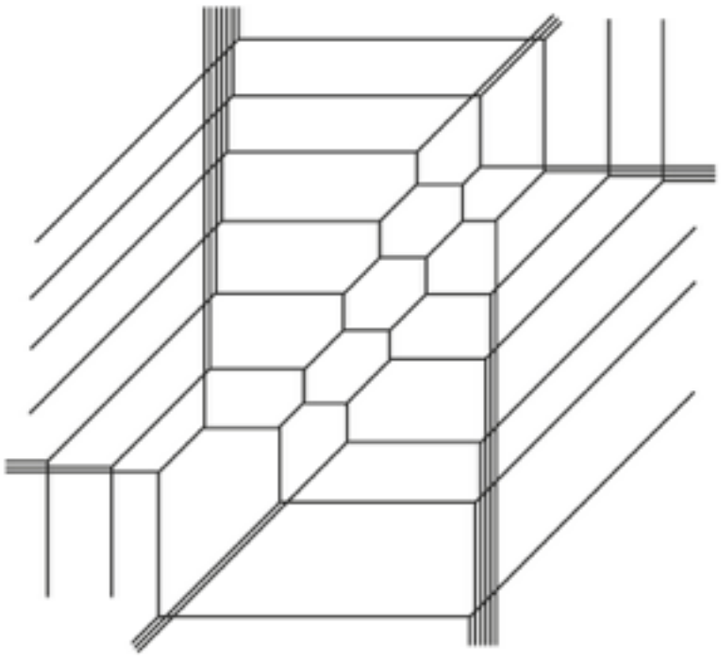
Conjecture

"Tao diagram": ➡ 6D UV fixed point

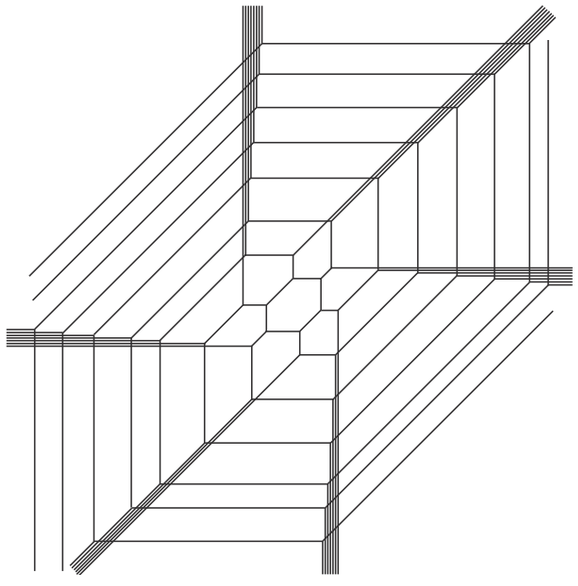
Examples of **Tao diagrams**



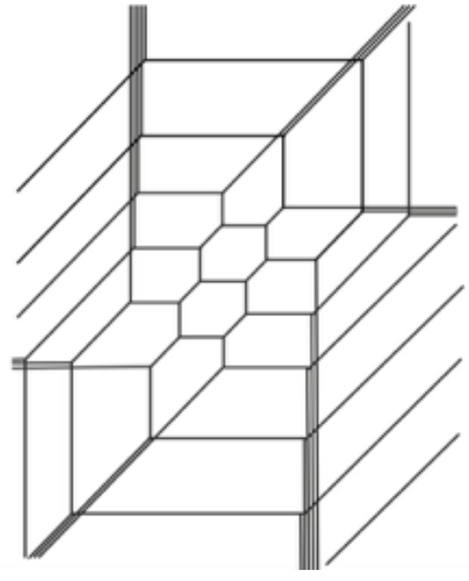




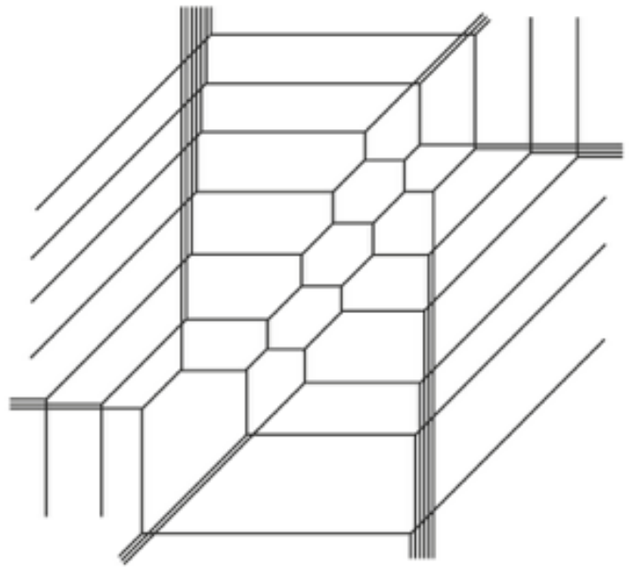
$$5\text{d } \mathcal{N}=1,\ SU(N),\ N_f = 2N+4$$



$N=2$

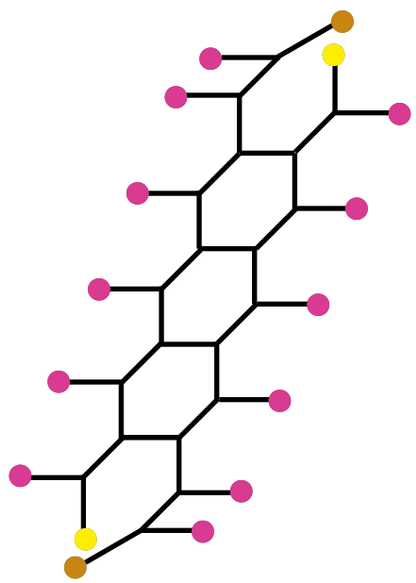


$N=3$

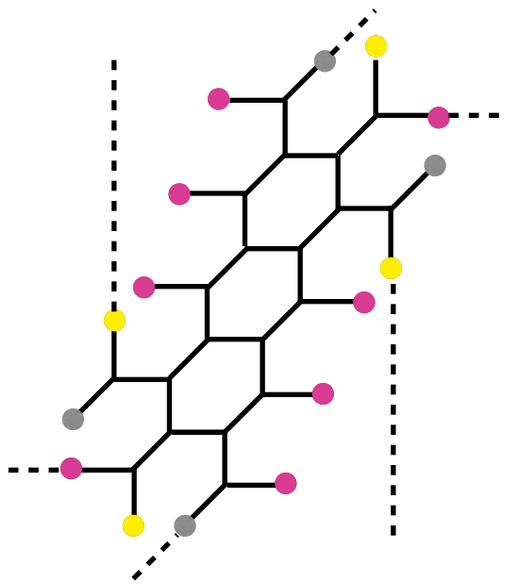


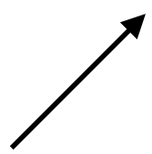
$N=4$

...



$SU(4), N_f = 12$





Conjecture

$5\mathrm{d}\ \mathcal{N}=1,\ SU(N),\ N_f=2N+4$ **has a 6d UV fixed point**

Conjecture

$5\mathrm{d}\ \mathcal{N}=1,\ SU(N),\ N_f=2N+4$ **has a 6d UV fixed point**

M5-brane probing D_{N+2} singularity

“(D_{N+2}, D_{N+2}) conformal matter”

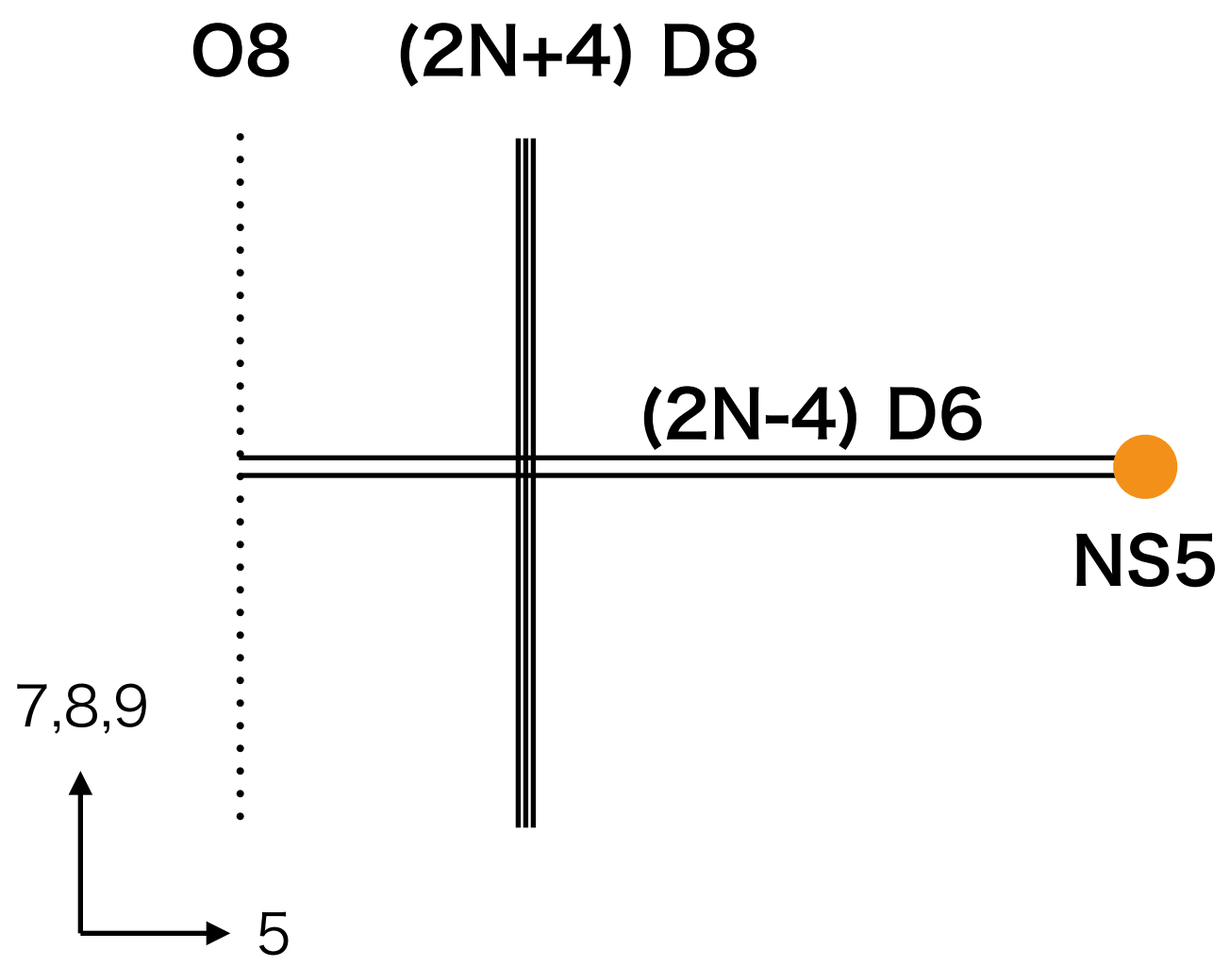
Del Zotto - Heckman - Tomasiello - Vafa ’14

§2 Evidence for the conjecture

M5-brane probing D_{N+2} singularity

Tensor branch
(≒ Coulomb branch)

$$6\mathrm{d}\ \mathcal{N}=(1,0)\ Sp(N-2)\ \text{gauge theory}$$
$$N_f = 2N+4,\ \text{w/tensor multiplet}$$

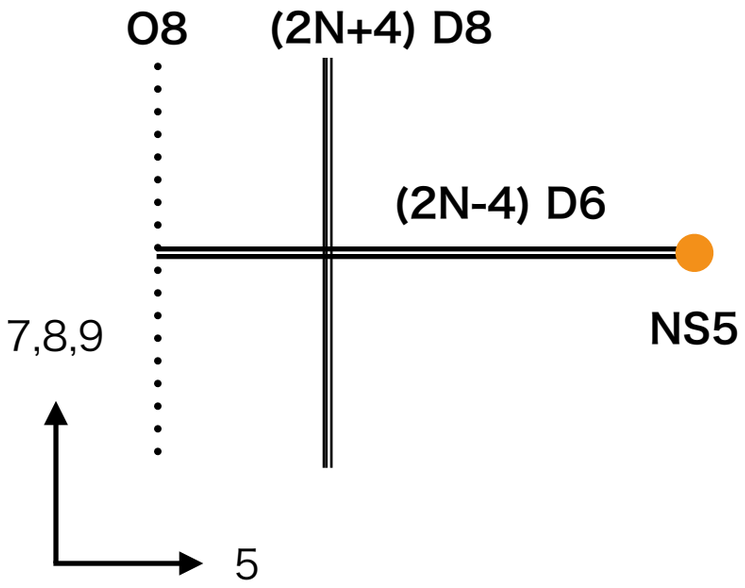


S^1

	0	1	2	3	4	5	6	7	8	9
D6-brane	×	×	×	×	×	×	×			
NS5-brane	×	×	×	×	×		×			
D8-brane	×	×	×	×	×		×	×	×	×
O8-plane	×	×	×	×	×		×	×	×	×

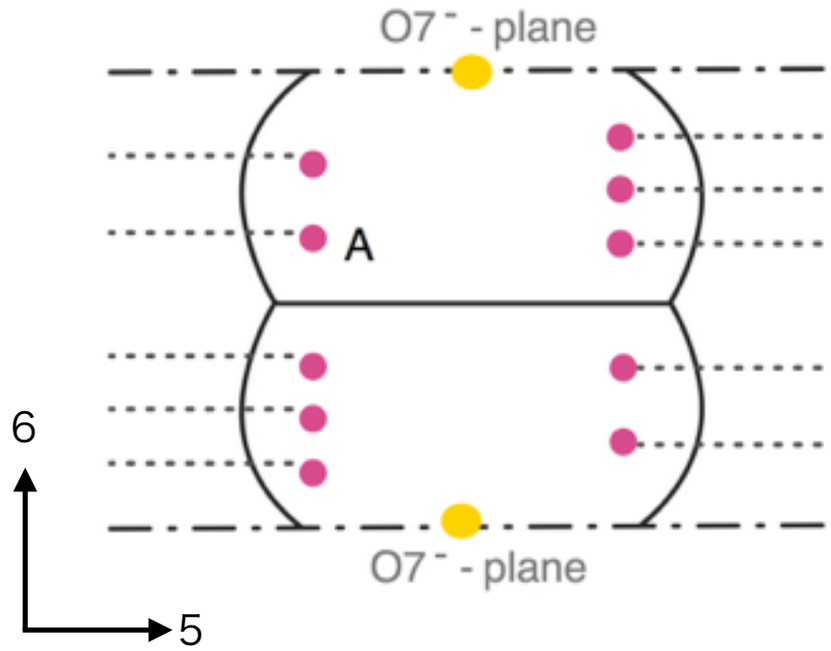
Brunner, Karch '97, Hanany, Zaffaroni '97

Diagramatic “Derivation”



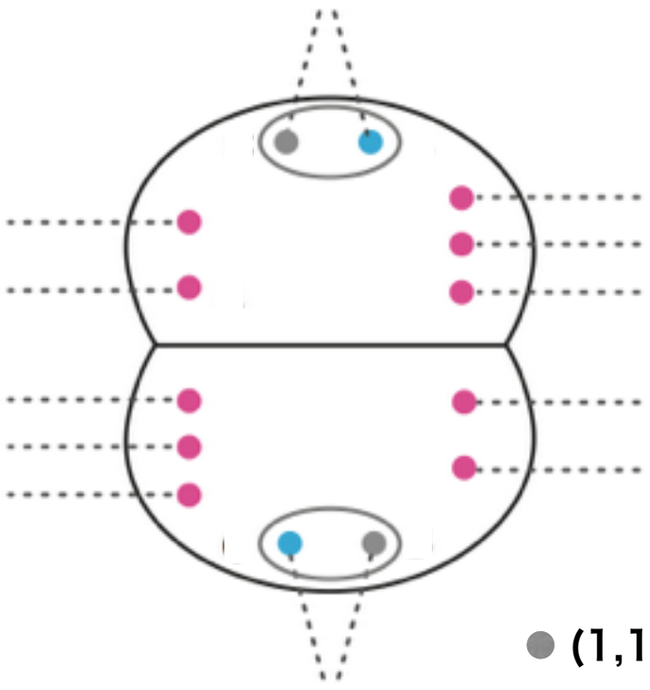
T-duality

(N=3)



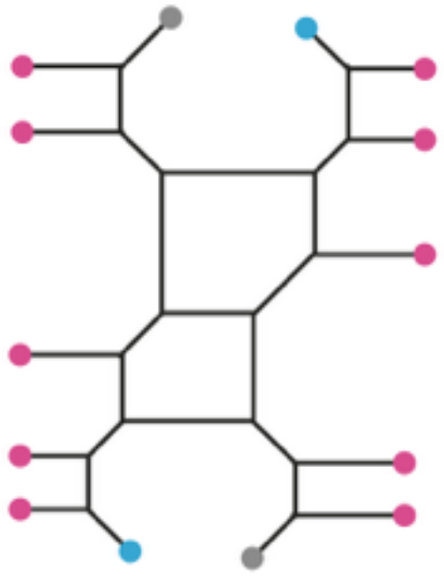
O7⁻ -plane
= (1,1) 7-brane
+ (1,-1) 7-brane

Sen ‘96



(1,1) 7-brane
(1,-1) 7-brane

$$5\mathrm{d}\ SU(N)\ N_f = 2N + 4$$

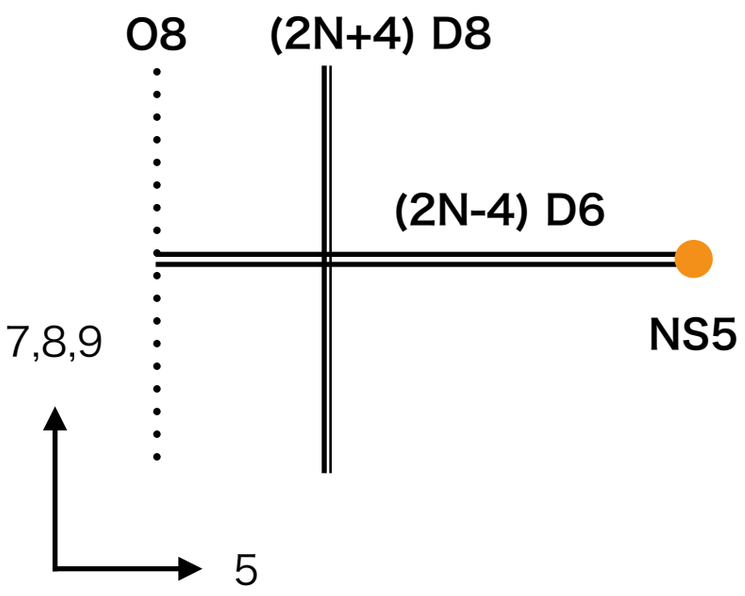


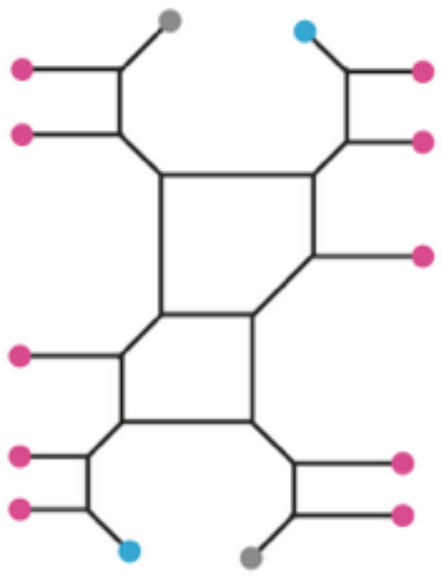
Hanany-Witten
transition

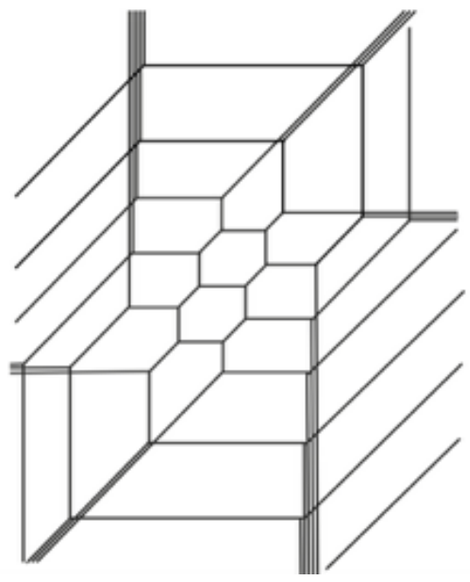
M5-brane probing D_{N+2} singularity

$$5\mathrm{d}\ SU(N)\ N_f = 2N + 4$$

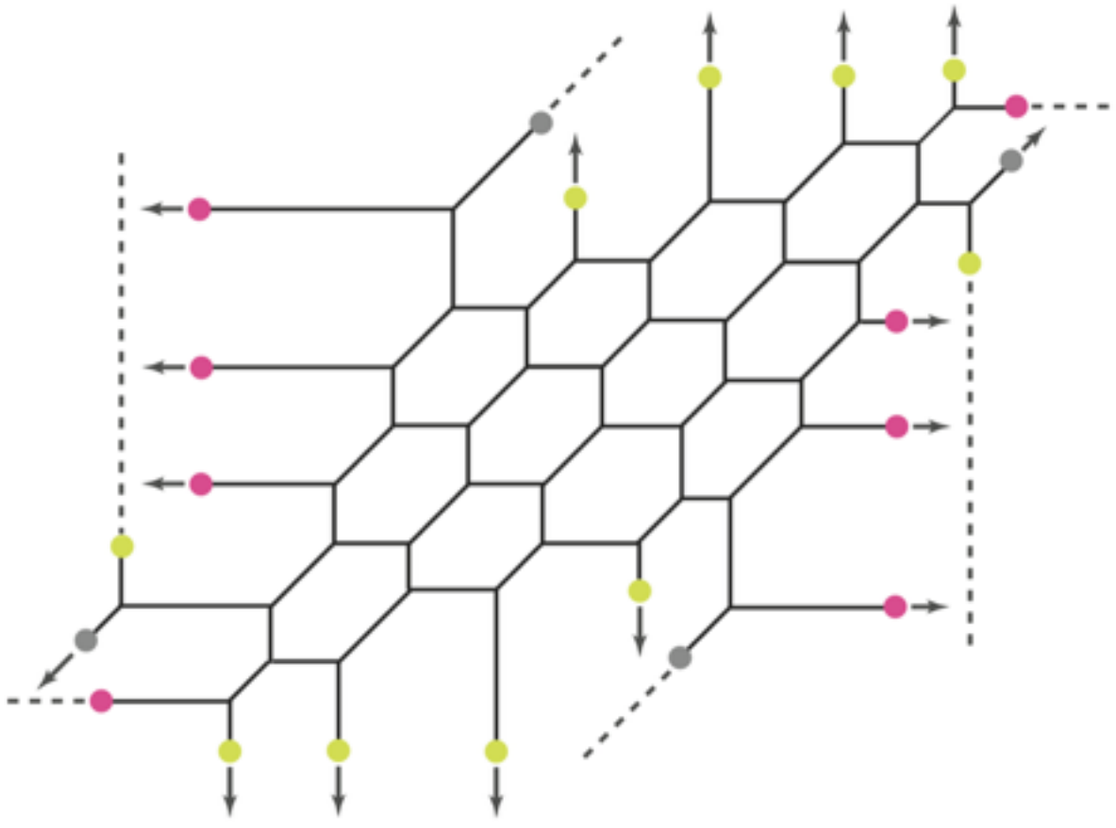
Tao diagrams

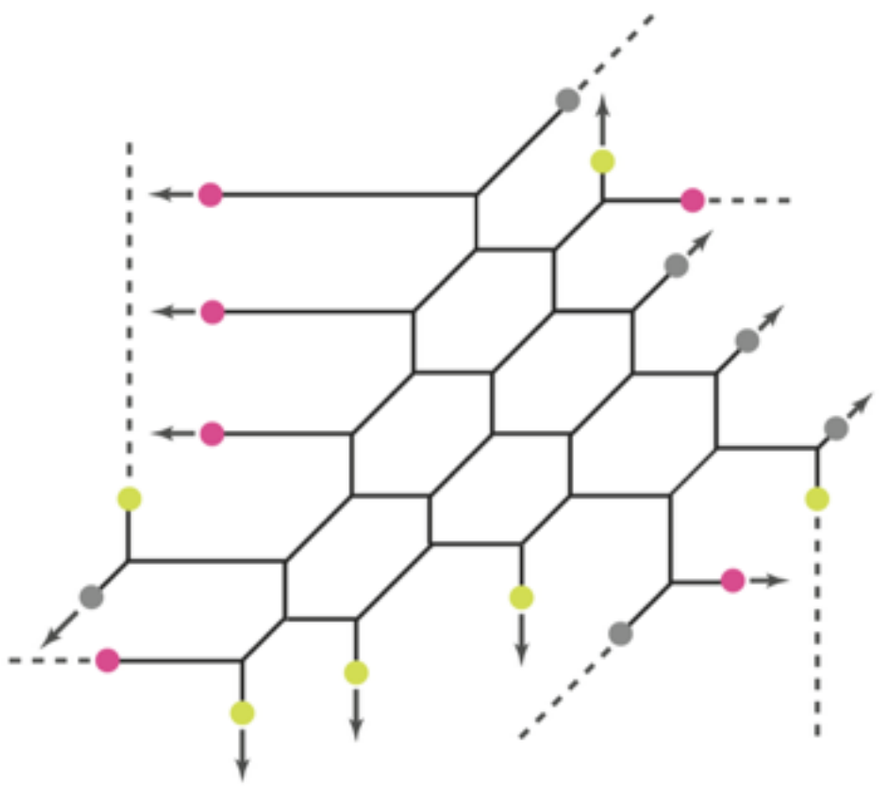


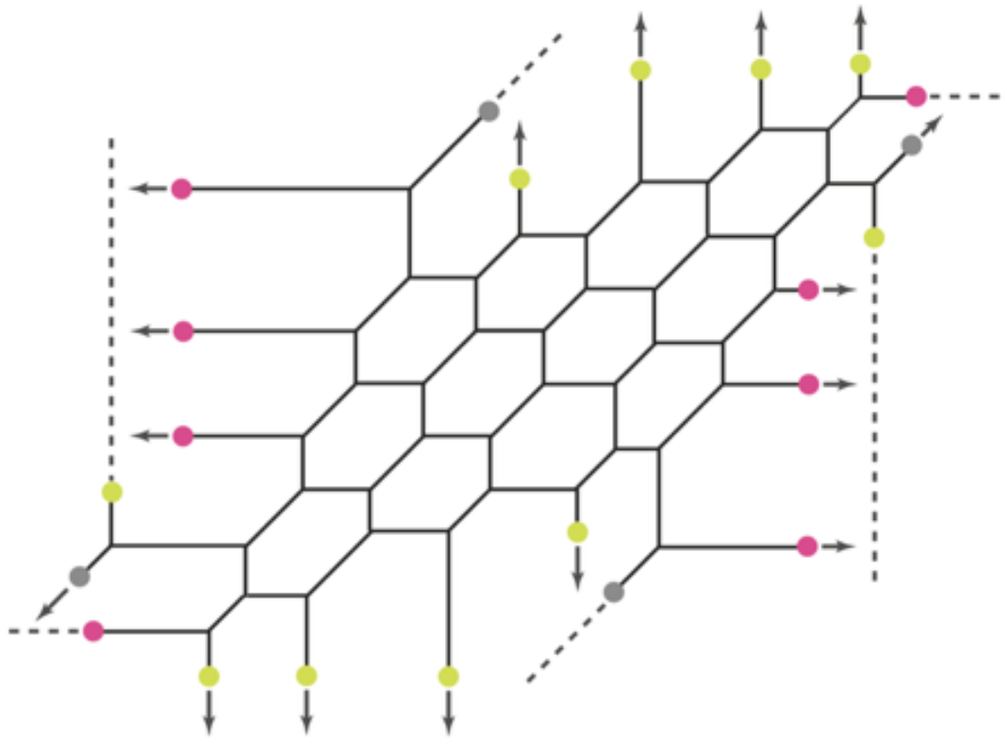




What about still other types of Tao diagrams?







$$k$$

$$5\mathrm{d}\ [N+2]-SU(N)-\cdots-SU(N)-[N+2]$$

’15 Yonekura

$$k=2n+1$$

$$6\mathrm{d}\ Sp(N')-SU(2N'+8)-SU(2N'+16)-\cdots-SU(2N'+8(n-1))-[2N'+8n]$$

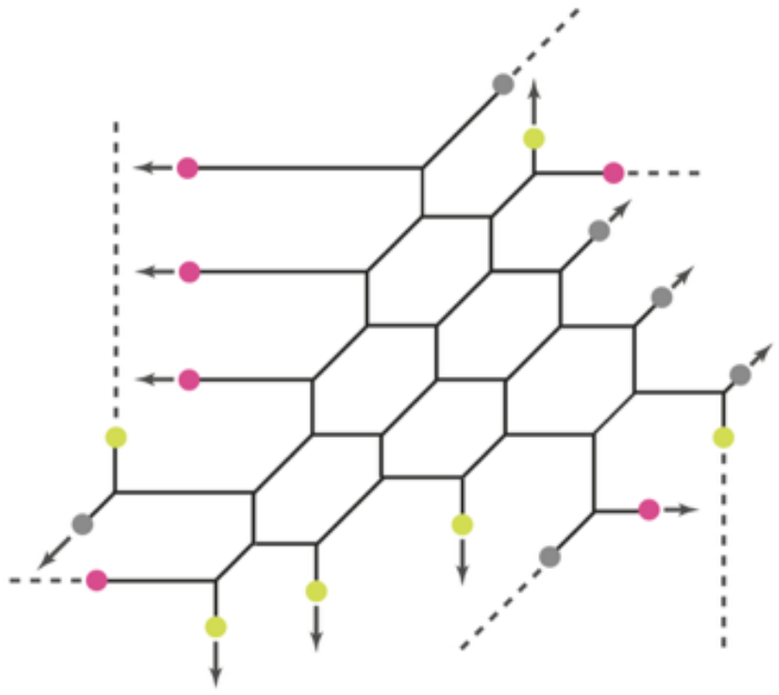
$$N'=N-2n$$

$$k=2n$$

$$6\mathrm{d}\ [A]-SU(N')-SU(N'+8)-SU(N'+16)-\cdots SU(N'+8(n-1)-[N'+8n+8]$$

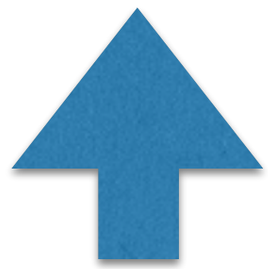
$$N'=2(N-2n+1)$$

hypermultiplet in antisymmetric representation



$$5\text{d } [N+3] - SU(N) - SU(N-1) - SU(N-2) - \cdots - SU(3) - SU(2) - [3]$$

(“Tao-nization” of 5d T_N)



’15 Zafrir

’15 Ohmori, Shimizu

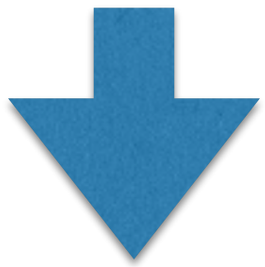
$$\begin{aligned}
N = 3n: &\quad 6\text{d } SU(0) - SU(9) - \cdots - SU(9n) - [9n+9] \\
N = 3n+1: &\quad 6\text{d } SU(3) - SU(12) - \cdots - SU(3+9(n-1)) - [3+9n] \\
N = 3n+2: &\quad 6\text{d } \left[\tfrac{1}{2}\right]_{\Lambda^3} - SU(6) - SU(15) - \cdots - SU(6+9(n-1)) - [6+9n]
\end{aligned}$$

§3 “UV dualities”

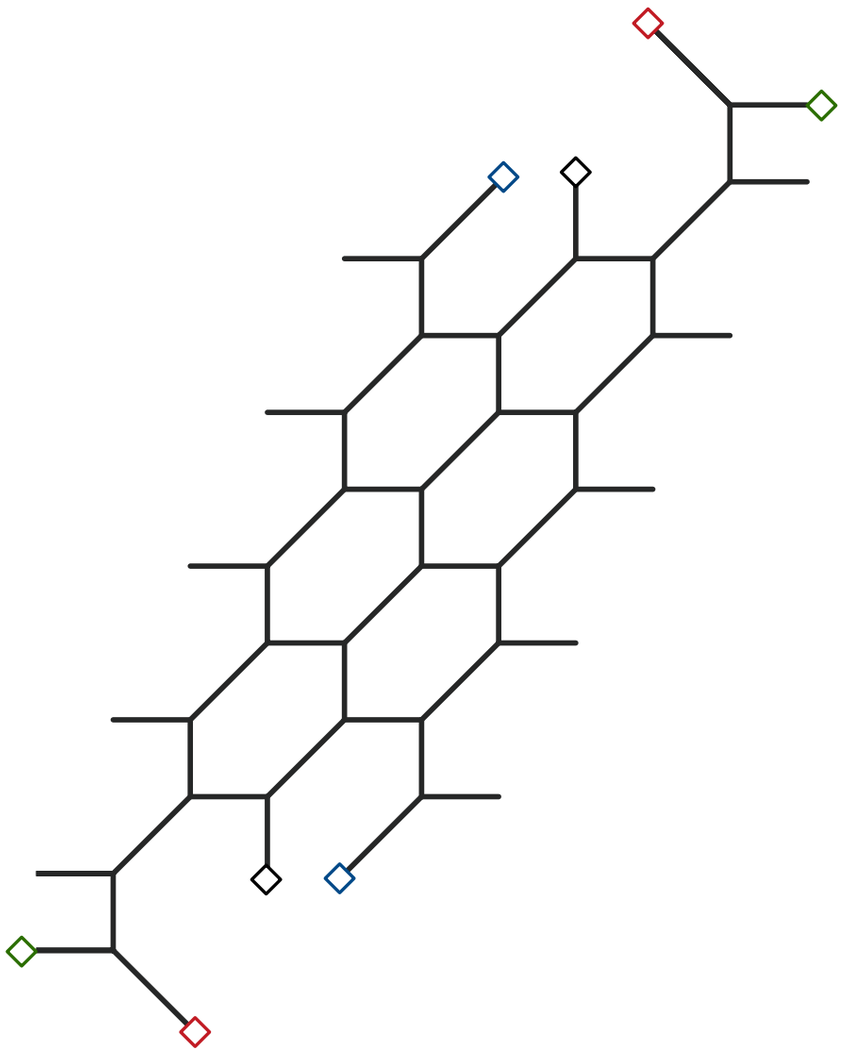
Multiple 5d gauge theories

has

an identical 6d UV fixed point



UV Dualities

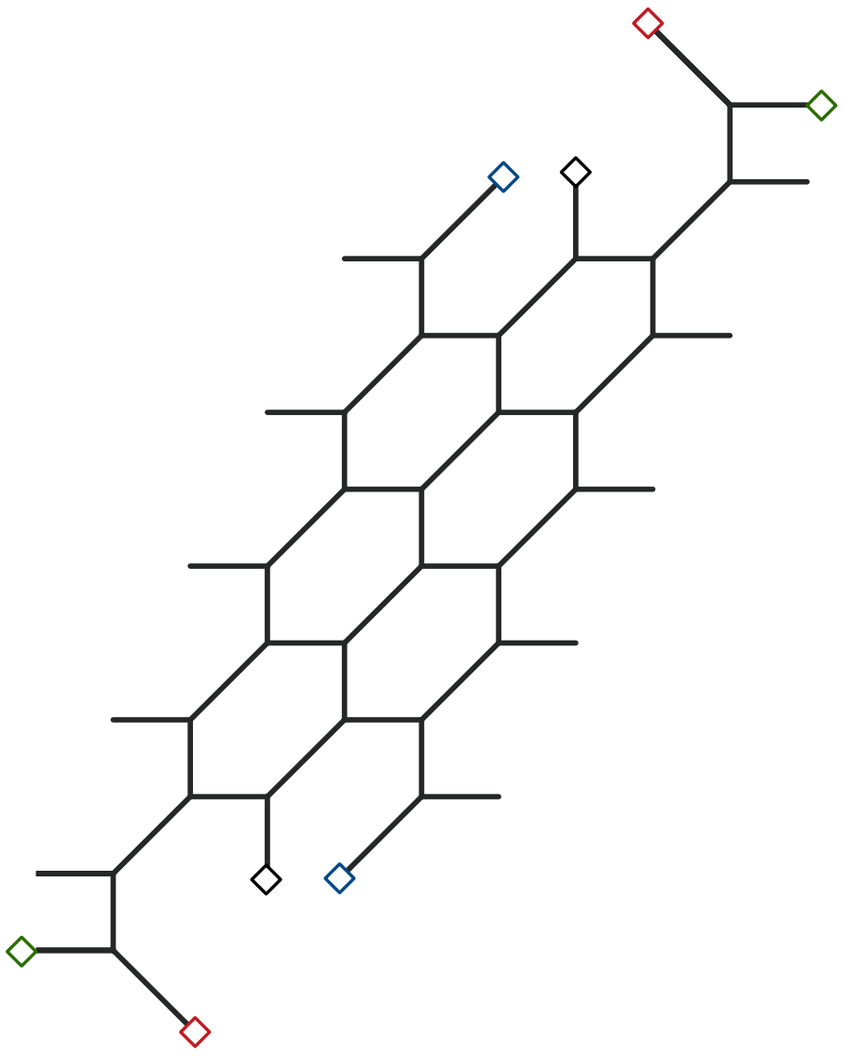


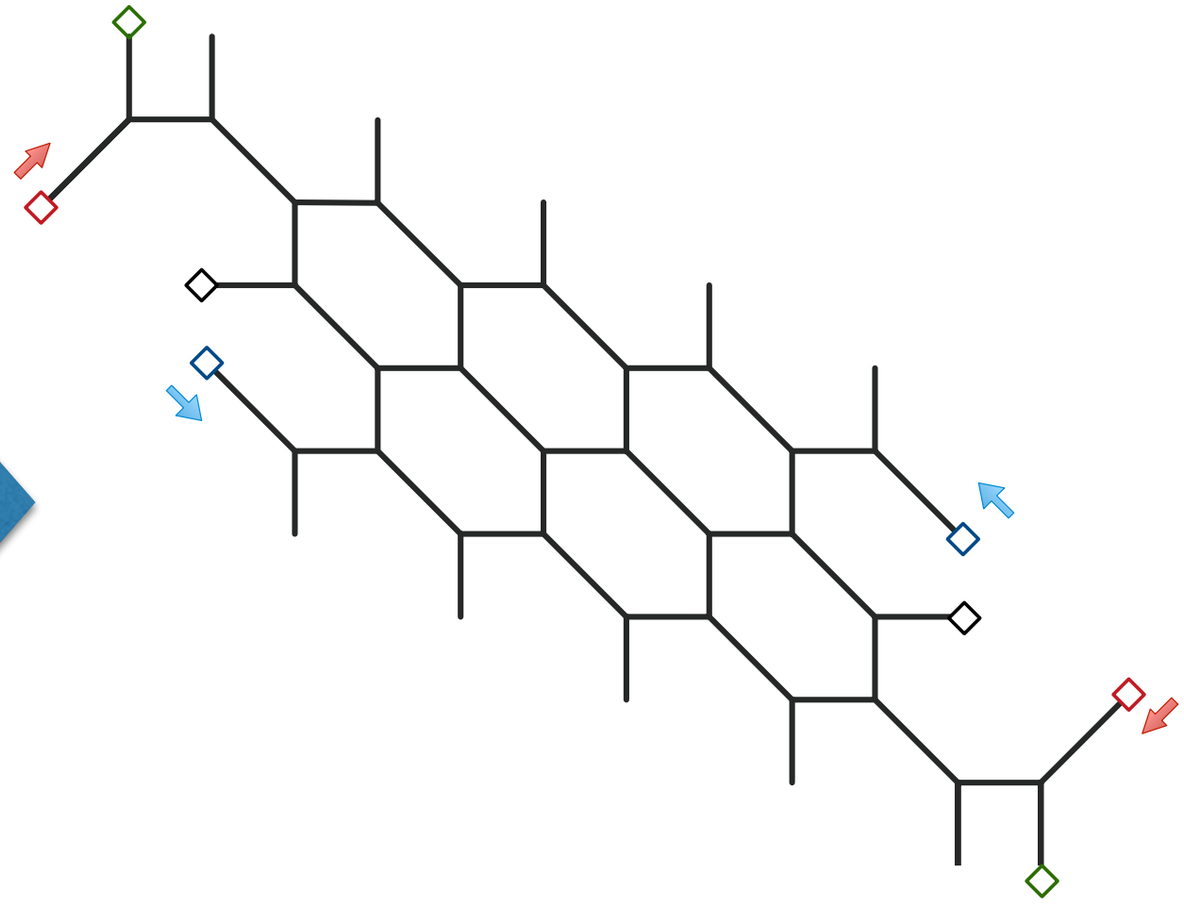
5d [6]-SU(4)-SU(4)-[6]

↑

6d [A]-SU(6)-[14]

S-duality



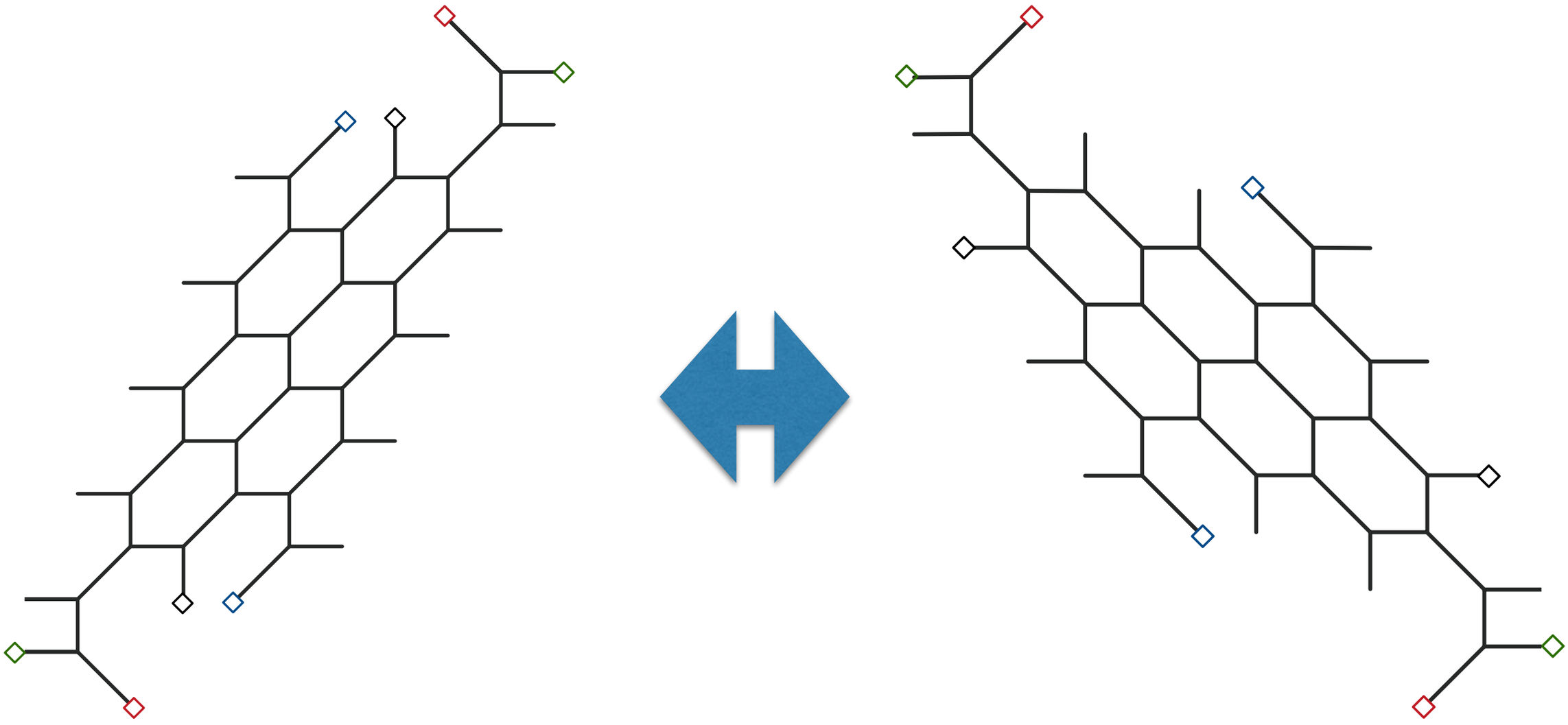


5d [6]-SU(4)-SU(4)-[6]

6d [A]-SU(6)-[14]

5d (?)-SU(3)-SU(3)-SU(3)-(?)

S-duality

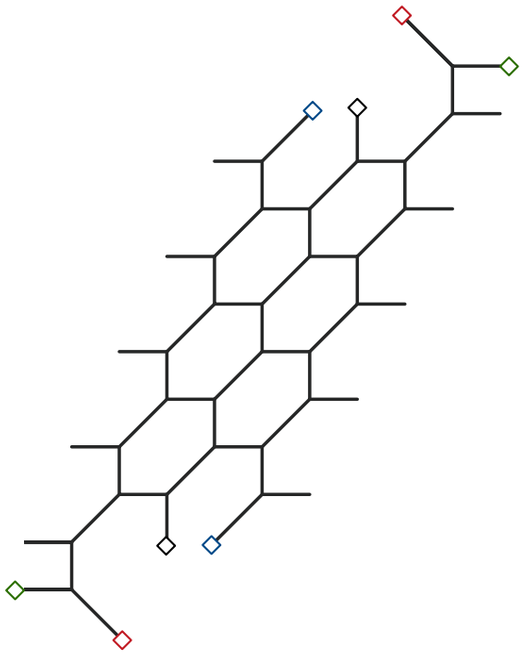


5d [6]-SU(4)-SU(4)-[6]

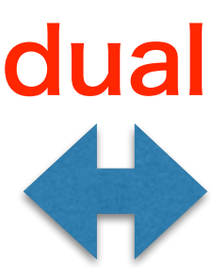
5d [5]-SU(3)-SU(3)-SU(3)-[5]

6d [A]-SU(6)-[14]

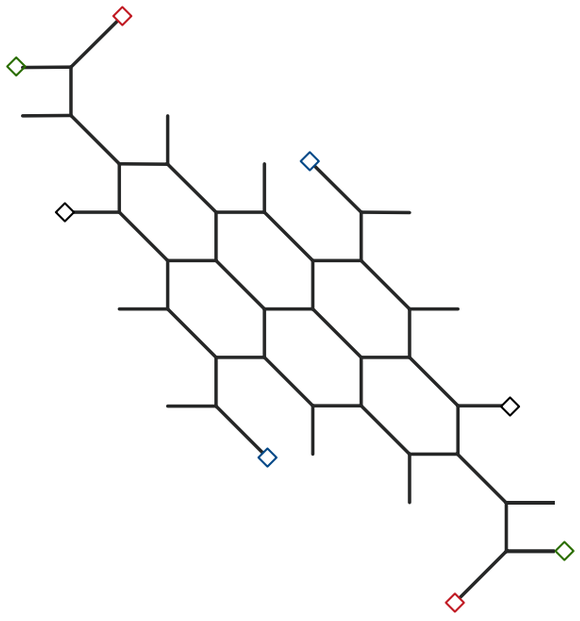
[6]-SU(4)-SU(4)-[6]



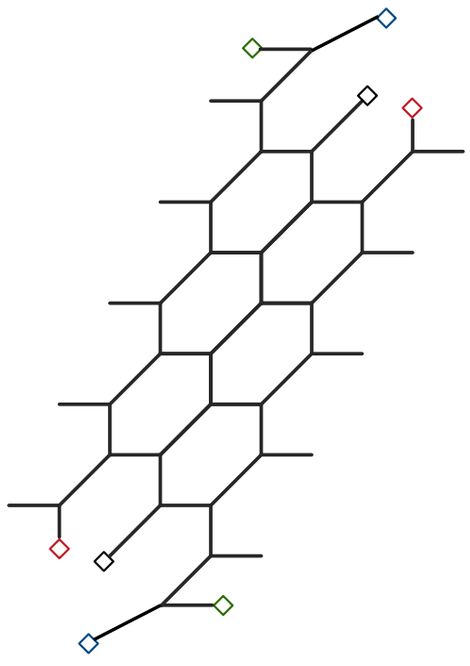
S-duality



[5]-SU(3)-SU(3)-SU(3)-[5]



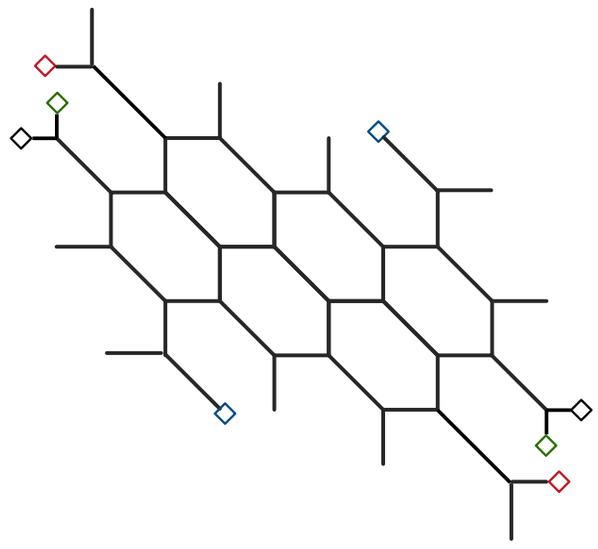
Mass deformation



S-duality

[1] [1]

[3] - SU(2) - SU(3) - SU(3) - SU(2) - [3]



6d SU(6) 14 flavor, antisym. tensor + tensor mult.

5d [5]-SU(3)-SU(3)-SU(3)-[5]

5d [6]-SU(4)-SU(4)-[6]

5d [3] - SU(2) - SU(3) - SU(3) - SU(2) - [3]
[1] [1]

All possible values of “gauge theory parameters”

§4 Conclusion

Tao diagrams indicate 6d UV fixed points.

Multiple 5d theories have identical 6d UV fixed point.

Comments on the previously known classification

5d SU(N>3) theories [Intriligator-Morrison-Seiberg '97]

"All" UV complete theories were claimed to be classified.

Comments on
the previously known classification

5d SU(N>3) theories [Intriligator-Morrison-Seiberg '97]

$$N_f = \underbrace{0, 1, \cdots, 2N}, \underbrace{2N+1, 2N+2, 2N+3, 2N+4}$$

5d SCFT

"dead" (Landau pole)

Comments on
the previously known classification

5d SU(N>3) theories [Intriligator-Morrison-Seiberg '97]

$$N_f = \underbrace{0, 1, \cdots, 2N}, \underbrace{2N+1, 2N+2, 2N+3}, \underbrace{2N+4}$$

[Bergman, Zafrir '14]

Previously known 5d SCFT

This talk

Overlooked for 20 years

Classification by Intriligator - Morrison - Seiberg

$$\text{Im } \tau_{\text{eff}}(a) > 0 \quad \text{for } \forall a$$

			flavor	Chern-Simons level
$5d$	$SU(N)$	$(N > 2)$:	$N_f \leq 2N$	$\kappa \leq 2N - N_f$

No UV fixed point for product gauge group

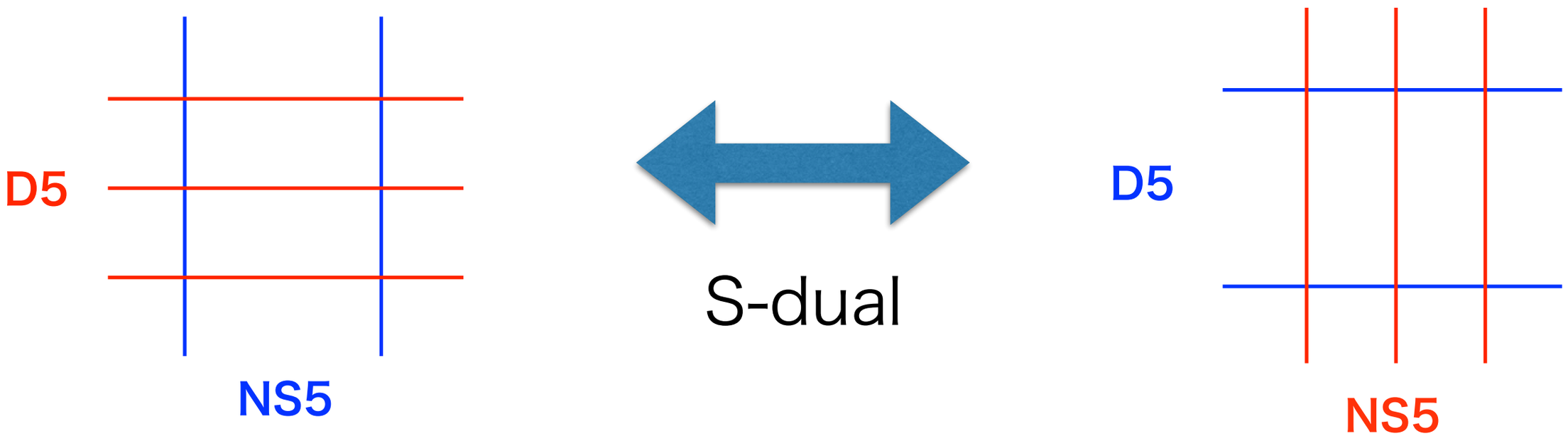
VS

Our conjecture

$5d$	$SU(N)$	:	$N_f \leq 2N + 4,$	$\kappa \leq 2N + 4 - N_f$

Some quiver gauge theories have UV fixed point

Conflict between their classification and web diagram



$SU(3) \quad N_f = 6$

$[2] - SU(2) - SU(2) - [2]$

Intriligator-Morrison-Seiberg

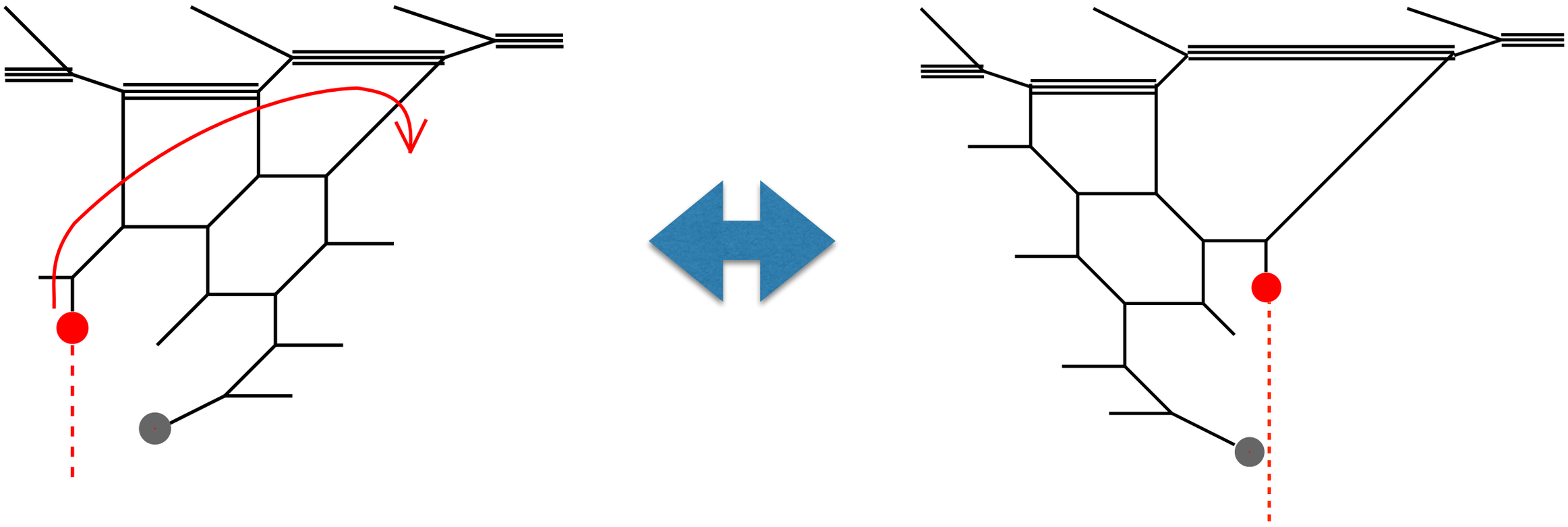
5d UV fixed point

No UV fixed point

?!

“Distribution duality”

5d $[N_1]$-$SU(M_1)$-$SU(M_2)$-$[N_2]$ 5d $[N_1+3]$-$SU(M_1+1)$-$SU(M_2-1)$-$[N_2-3]$



“Mass deformation in the S-dual frame”

(Flavor decoupling limit → Dual theories with 5d fixed point)