New 4d Lagrangians From 6d RG-Flows

Evyatar Sabag

Technion

Razamat, Sabag, Zafrir – 1907.04870
Razamat, Sabag – to appear

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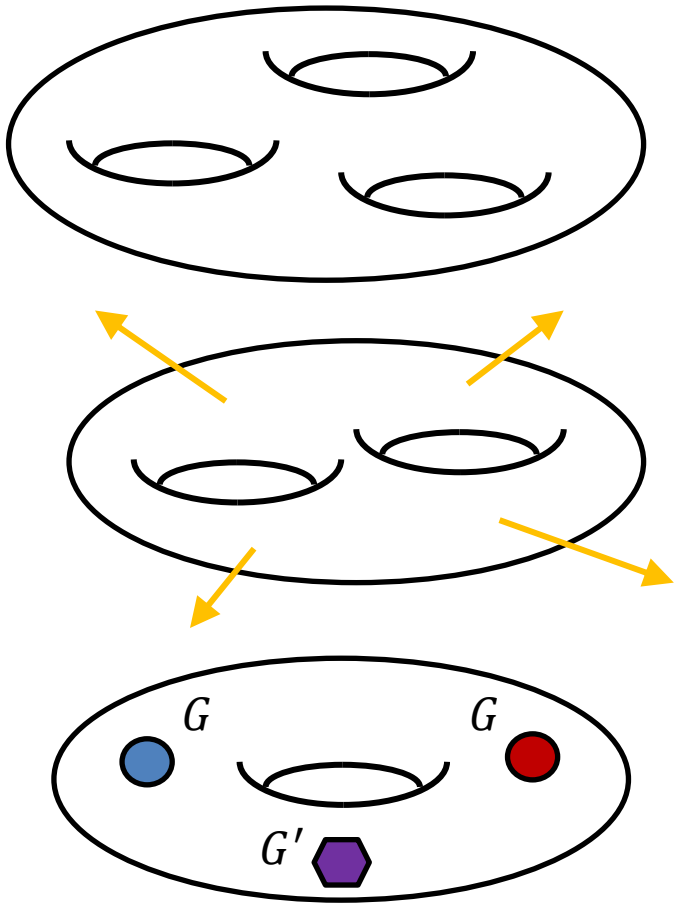
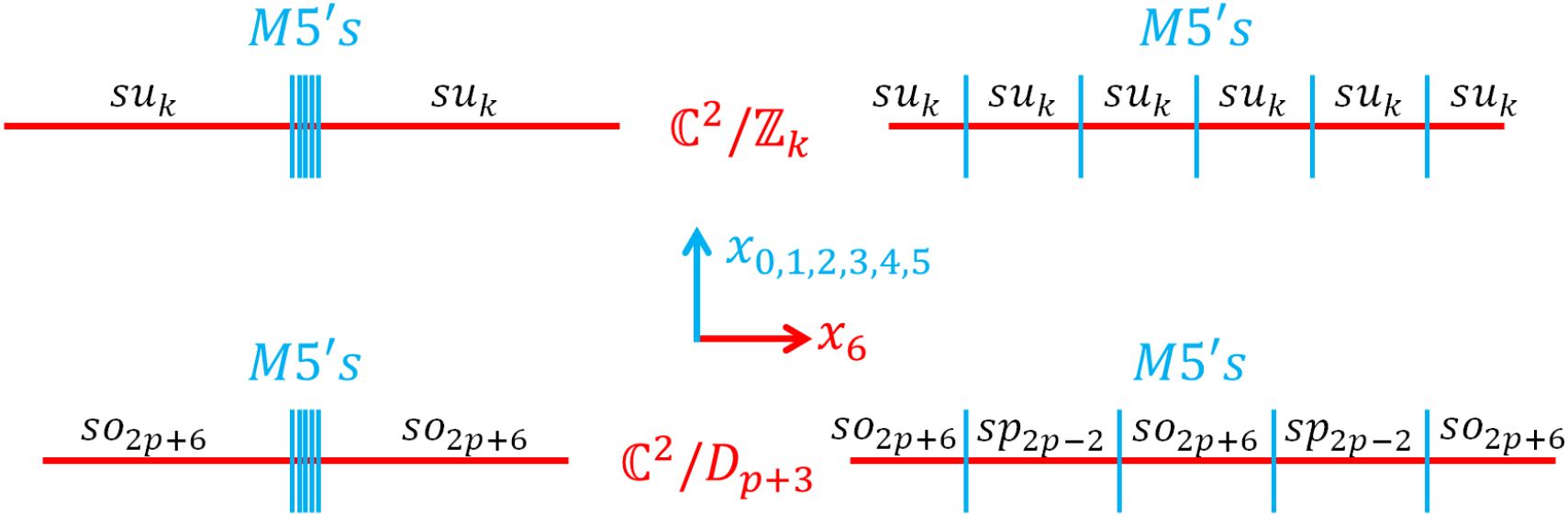
Compactification from 6d to 4d

- One can generate classes of 4d $\mathcal{N}=1$ SCFTs by Compactifying 6d (1,0) SCFTs on a Riemann surface
  - Closed Riemann surface
  - Give fluxes to $U(1)$ subgroups of the 6d global symmetry
  - Riemann surfaces with punctures (boundaries)



6d (1,0) SCFTs

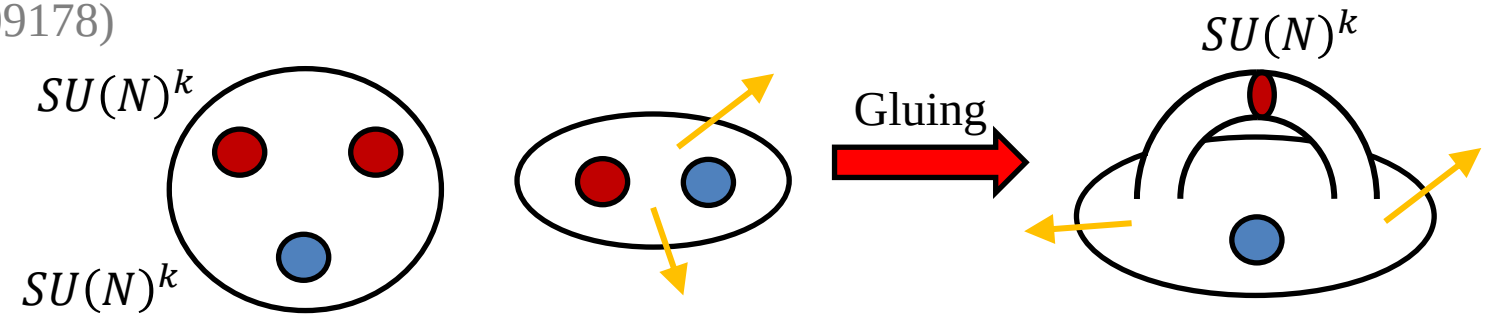
- Focusing on SCFTs described by a stack of M5-branes probing a $\mathbb{C}^2/\Gamma_{ADE}$ singularity



- Separating the M5-branes along the singularity line we find the tensor branch description from which we can read the quiver
  - M. Del Zotto J. J. Heckman, A. Tomasiello, C. Vafa. 1407.6359

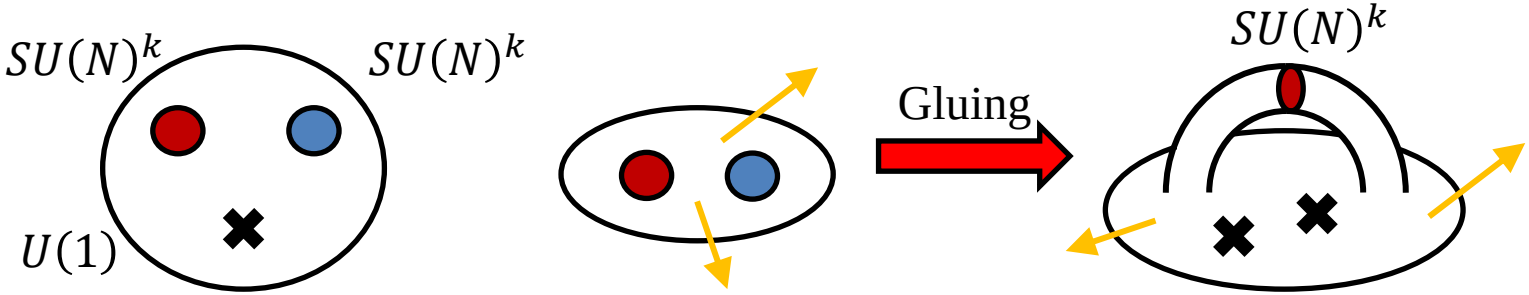
Known 4d Lagrangians

- Class S_k - Compactification of the 6d SCFT described by N M5's probing a $\mathbb{Z}_k$ singularity
  - $\boldsymbol{k = 1}$ (Class S) $\boldsymbol{N = 2, 3}$ and $\boldsymbol{k = N = 2}$**:** All theories are known (D. Gaiotto 0904.2715, A. Gadde et al. 1003.4244, S. S. Razamat et al. 1610.09178)



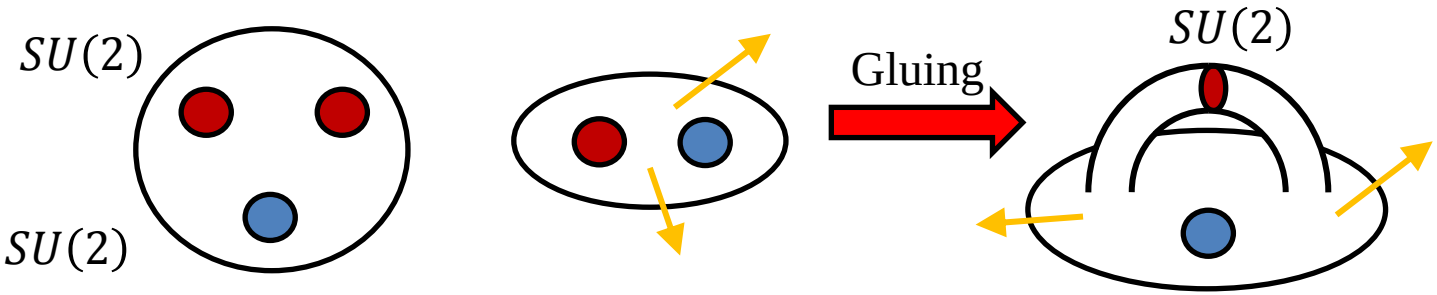
  - **Other Cases:** Free trinions and flux tubes are known

D. Gaiotto et al. 1503.05159

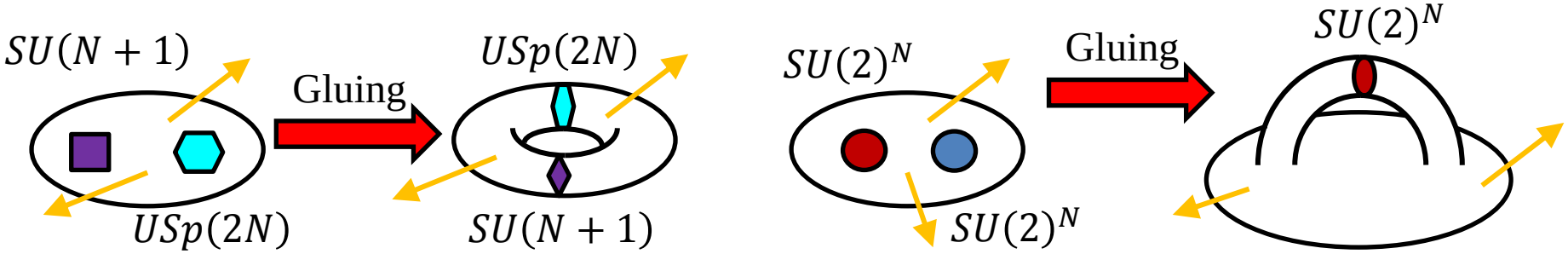


Known 4d Lagrangians

- Minimal class S_D - Compactification of 6d SCFT described by ***one*** M5 probing a D_{N+3} singularity
  - $\boldsymbol{N = 1}$**:** All theories with partial 6d symmetry rank are known (H. Kim, S. S. Razamat, C. Vafa, G. Zafrir 1709.02496)

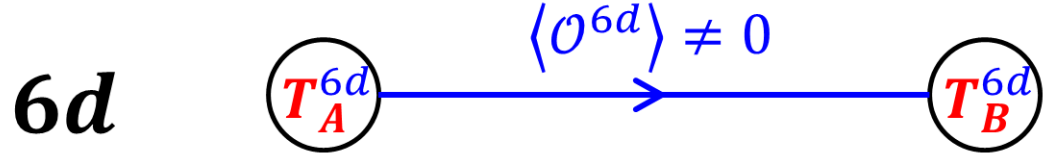


  - $\boldsymbol{N > 1}$**:** Only flux tubes are known (H. Kim et al. 1802.00620)



From 6d flows to 4d flows (1907.04870)

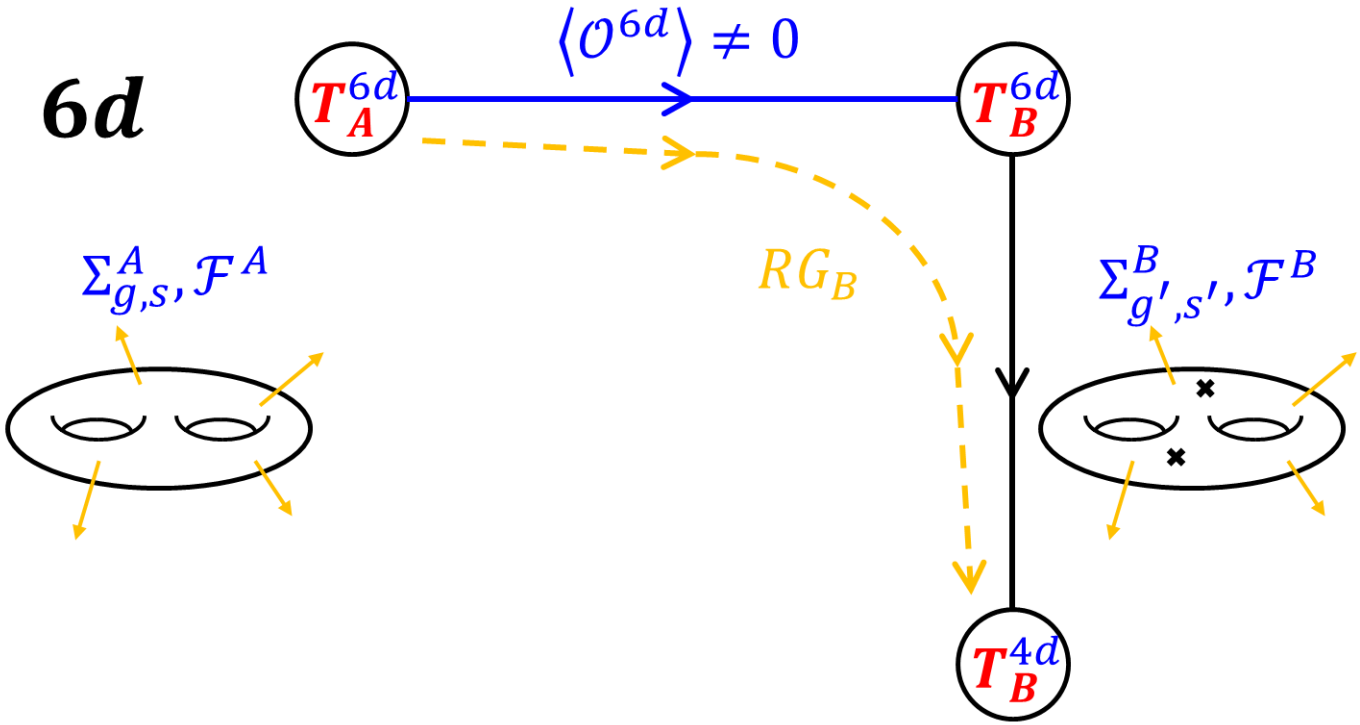
- In A-type $6d$ (1,0) SCFTs a vacuum expectation value (VEV) to an operator running from one end of the quiver to the other can lower $\mathbb{Z}_k$ to $\mathbb{Z}_{k-1}$



- If we put the 6d SCFT on a Riemann surface with fluxes and give the same VEV, it cannot remain a constant VEV due to the fluxes spatial profile and becomes space dependent

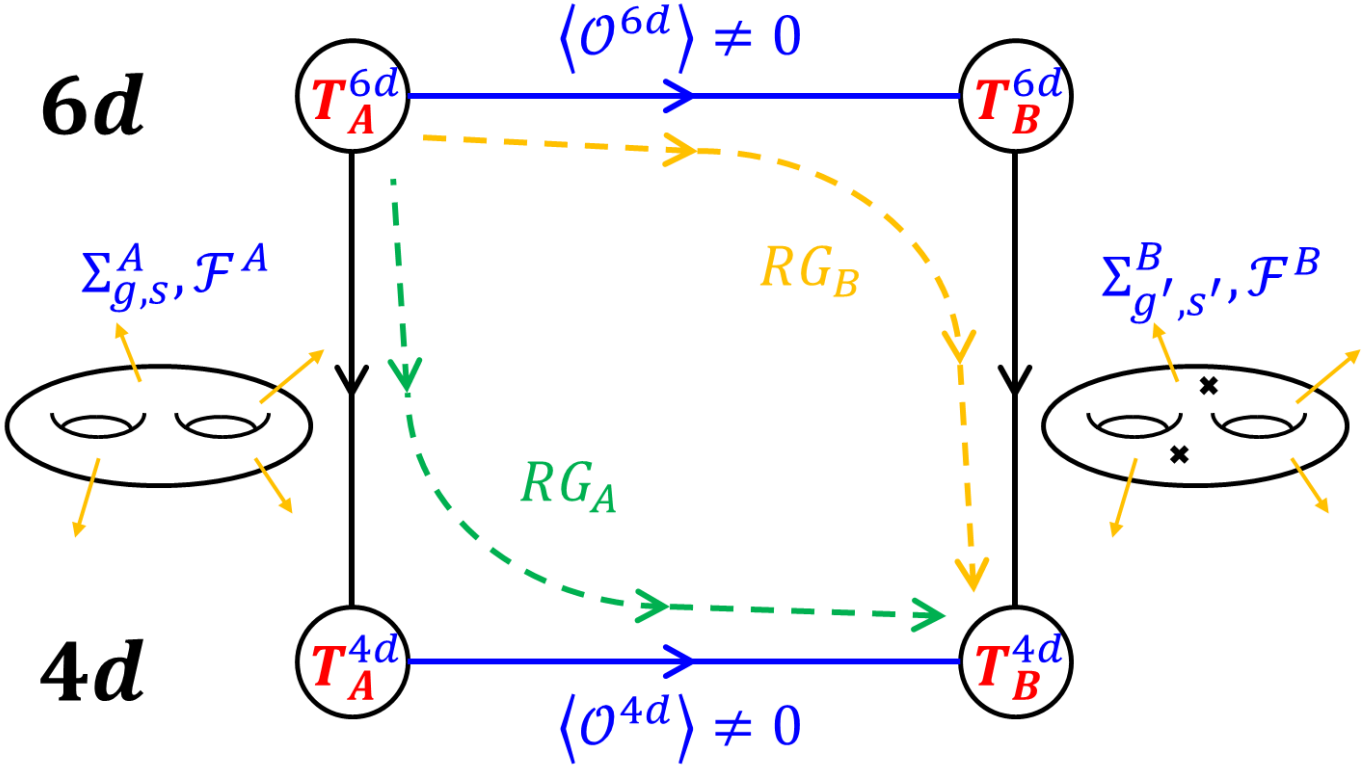
From 6d flows to 4d flows

- When taking the Riemann surface to be small, the space dependent VEV appears as additional minimal punctures on the surface



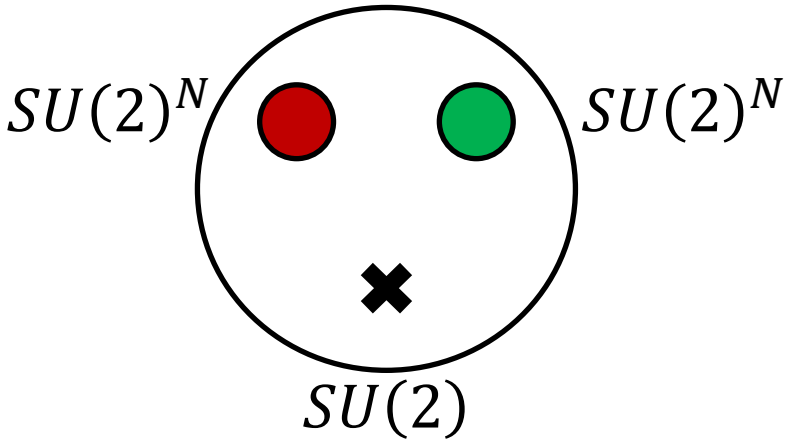
From 6d flows to 4d flows

- Changing the energy scales s.t. we first take the Riemann surface to be small and then give the VEV, we find a 4d constant VEV that can lower k and add minimal punctures when we have flux



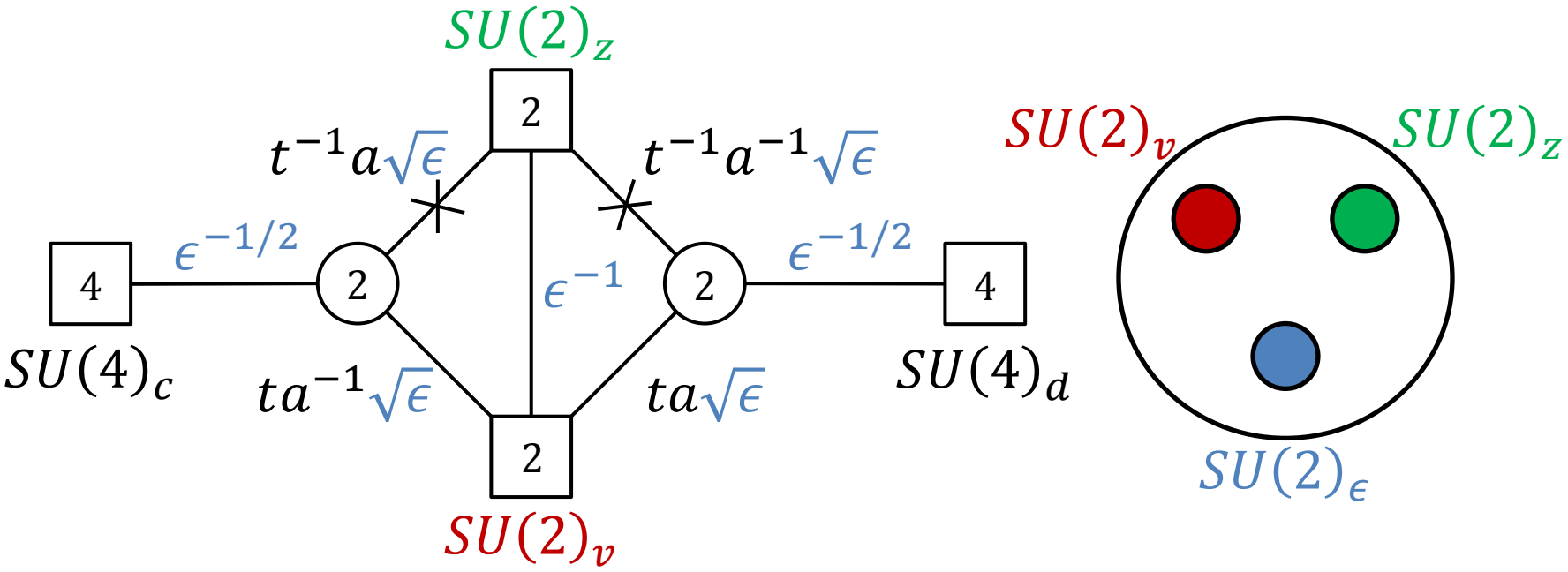
New class S_D Lagrangians

- **Main idea:** Using similar 4d flows on known class S_D models by giving VEV to an operator running from one end of the quiver to the other (in the 6d quiver)
- Using such flows on class S_D tori we find new three punctured spheres (trinions) Lagrangians



Rank 1 E-String Lagrangians

- In the case of $N = 1$ (Rank 1 E-String) this theory has three maximal punctures
  - We can generate all $N = 1$ theories of any genus, flux and punctures



Rank 1 E-String Lagrangians

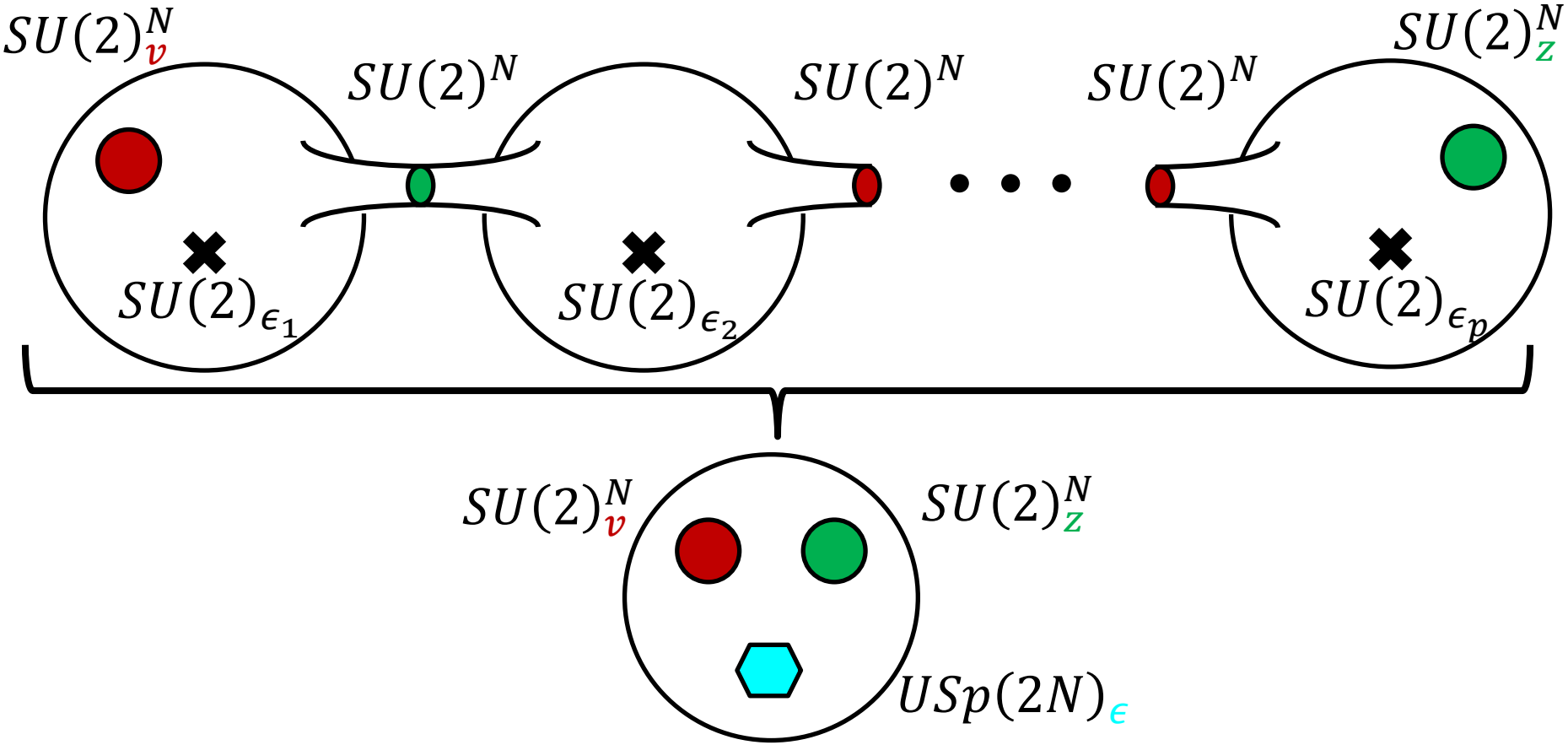
- The superconformal index forms irreps of E_8

$$I = 1 + pq\left(\mathbf{248}(g-1) + 3(g-1)\right) + \cdots$$

- E_8 is the global symmetry of the 6d SCFT
  - In 4d it appears as a subgroup of same rank
  - $E_8 \to E_7 \times U(1)_t$
    - $\mathbf{248} \to \mathbf{133} + (t^2 + t^{-2})\mathbf{56} + (1 + t^4 + t^{-4})$
  - $E_7 \to SO(12) \times U(1)_a$
    - $\mathbf{133} \to \mathbf{66} + (a^2 + a^{-2})\mathbf{32} + (1 + a^4 + a^{-4})$
    - $\mathbf{56} \to \mathbf{32}' + (a^2 + a^{-2})\mathbf{12}$
  - $SO(12) \to SU(4)_c \times SU(4)_d$
    - $\mathbf{66} \to (\mathbf{15}, \mathbf{1}) + (\mathbf{6}, \mathbf{6}) + (\mathbf{1}, \mathbf{15})$
    - $\mathbf{32} \to (\mathbf{4}, \mathbf{4}) + (\overline{\mathbf{4}}, \overline{\mathbf{4}})$
    - $\mathbf{32}' \to (\overline{\mathbf{4}}, \mathbf{4}) + (\mathbf{4}, \overline{\mathbf{4}})$
    - $\mathbf{12} \to (\mathbf{6}, \mathbf{1}) + (\mathbf{1}, \mathbf{6})$

Minimal S_D Lagrangians

- In the case of N > 1 we find something very non-trivial
  - We can glue N such trinions to generate a trinion with **three maximal punctures**

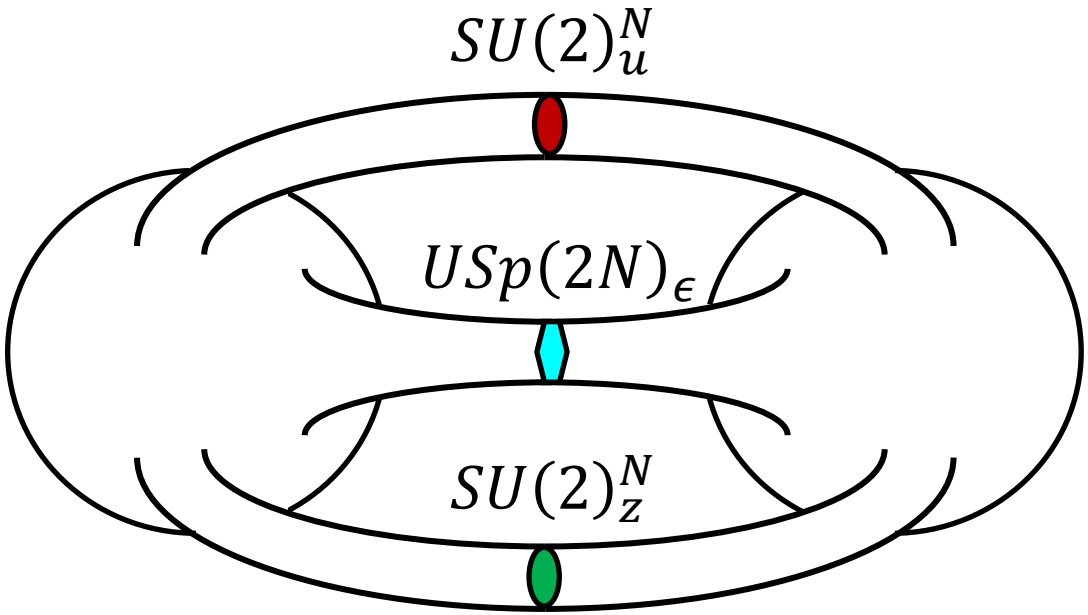


Minimal S_D Lagrangians

- The superconformal index of a genus g surface

$$I = 1 + pq\left(\boldsymbol{Adj}_{SO(4N+12)}(g-1) + 3(g-1)\right) + \cdots$$

- $SO(4N+12)$ is the global symmetry of the 6d SCFT
  - In 4d it appears as a subgroup of same rank



Summary

- We found 4d Lagrangians for three punctured spheres (trinions) in class S_D with two $SU(2)^N$ maximal and one $SU(2)$ puncture

- We found 4d Lagrangians for all the theories for the entire minimal class S_D
  - **An infinite amount of 6d SCFTs for which we know all the compactifications to 4d (<10 until now)**
  - All other punctures can be found by RG flows breaking the maximal punctures symmetries
  - All genus g surfaces can be built by gluing maximal punctures