Gauded 2-form symmetries in 6D SCFTs coupled to Gravity

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with A. Braun and M. Larfors

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Higher form symmetry basics

Conventional 0-form symmetries in d dimensions have 1-form current j

- **Conserved charge** $Q(M^{d-1}) = \int_{M^{d-1}} *j$
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Generalize to p-form symmetries with $p+1$ form current j

[Gaiotto,Seiberg,Kapustin,Willet'14]

- **Conserved charge:** integrate current over M^{d-1-p} spacetime slice
- **Couples** to p-dimensional (topological) operators $V(C_p)$
  - 1-form symmetries couple to (Wilson-) line operators
  - 2-form symmetries couple to (Wilson-) 2-surface operators

Theory specified only by classifying all topological operators/symmetries

6D SCFTs and 2-form symmetry

$\mathcal{N} = (1,0)/(2,0)$ SCFTs are **necessarily strongly coupled**, admit **light non-critical strings** in the spectrum [Seiberg/Seiberg,Witten'96]

- These strings admit a global **self-dual discrete 2-form** symmetry [Bhardwaj, Schafer-Nameki'20]
- If **string charge lattice** Λ_S does **not coincide** with its dual Λ_S^* their **discriminant group** measures a discrete global 2-form symmetries

$$G_S = \Lambda_S^* / \Lambda_S$$

G_S also known as the **Defect group** , also specifies **discrete 2-form flux backgrounds** [Del Zotto, Heckman, Park, Rudelius'15; GarcÃŋa-Etxebarria, Heidenreich, Regalado'19]

6D SCFTs coupled to gravity

SCFT sectors **naturally appear** in 6D SUGRA theories as well

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- **D3** branes wrap curves $\mathcal{C}$ in B yield massive 6D Strings
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- Quantum Gravity Lore: Global Symmetries **broken** or **gauged**

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What about 2-form symmetries then ?

Global 2-form symmetries in 6D Gravity

For 6D Gravity theory, the string charge lattice Λ_B must be **unimodular and self-dual** [Seiberg, Taylor'11]

- **It follows directly**: $G_S = \Lambda_B^*/\Lambda_B = 1$
- **Example:** for $\mathcal{N} = (1,0)$, B must be $B = \mathbb{P}^2$ or $\mathbb{F}_n$ and **generic blow-ups thereof** [Grassi'97]
- **Check:** G_S is **trivial** for above cases
- Generic blow-ups are (-1) curves that **do not contribute** to G_S

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How to gauge a 2-form symmetry then?

2-form Symmetries with gravity

Want a discrete 2-form group G, under which all strings transform trivially, since G_S is trivial, such a group must then be gauged

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SCFTs i.e. their lattice Λ_S must be **non-primitively** embedded into Λ_B:

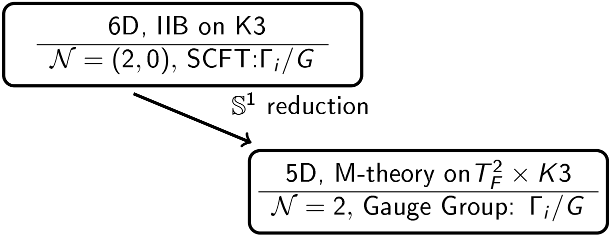
$$\boxed{G=\text{tors}(\Lambda_B/\Lambda_S)}$$

(2, 0) theories and dualities

$$\frac{\text{6D, IIB on K3}}{\mathcal{N} = (2,0),\ \text{SCFT:}\Gamma_i/G}$$

IIB on $K3$ with $\Lambda_S = \sum_i \Gamma_i \in ADE$ and 2-form gauging G

$(2,0)$ theories and dualities



IIB on $K3$ with $\Lambda_S = \sum_i \Gamma_i \in ADE$ and 2-form gauging G

- $\mathbb{S}^1$ **reduction:** 6D strings become W-bosons of 5D **gauge group** Γ_i/G
  $2 \to 1$-form symmetry: 5D gauge group is **non-simply connected**
- **Dual to**: M-theory on $T^2_F \times K3$

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6D, IIB on K3

$\mathcal{N} = (2, 0)$, SCFT:Γ_i / G

$\mathbb{S}^1$ reduction

5D, M-theory on $T^2_F \times K3$

$\mathcal{N} = 2$, Gauge Group: Γ_i / G

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- **Assume** $K3$ is elliptic: $G =$tors$(H^{1,1}(K3, \mathbb{Z}) / \Lambda_S) =$MW(K3)$_{tor}$

  [Aspinwall,Morrison'97]

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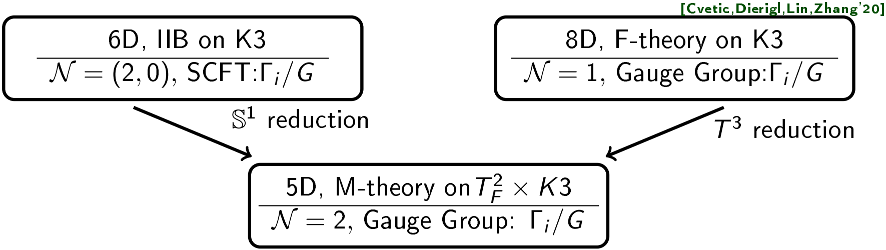

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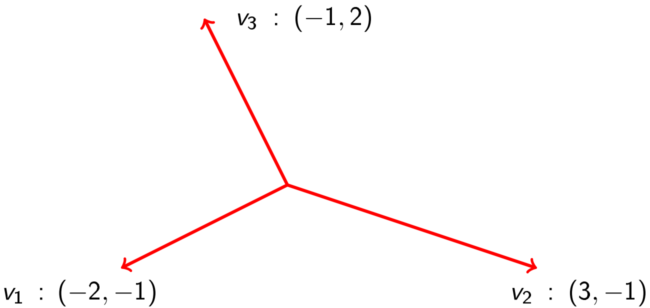
  [Aspinwall,Morrison'97]
- There exists a **second F-theory lift** to 8D

Simple (1,0) Examples



F-theory compactification on base $B = \mathbb{P}^2/\mathbb{Z}_m$ for m=5

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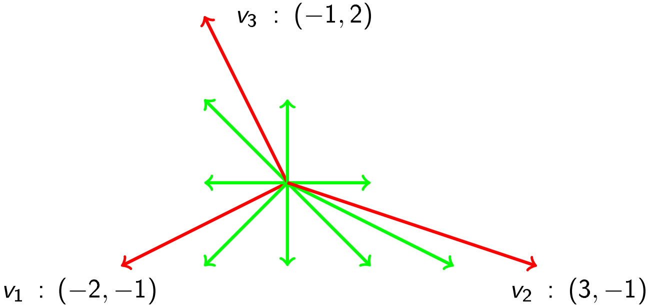

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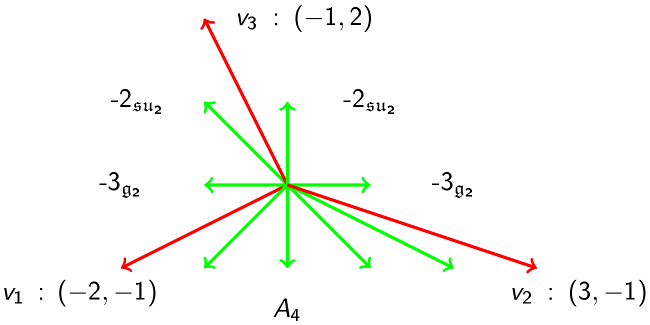

F-theory compactification on base $B = \mathbb{P}^2/\mathbb{Z}_m$ for m=5

- A minimal **resolution** to B_{res} via exceptional divisors D_{res}
- Geometry hosts an A_4 (2,0) theory and two (-3,-2) clusters
- G= $H^{1,1}(B_{\text{res}}, \mathbb{Z})/ < D_{res} > \sim \mathbb{Z}_5$ 2-form gauging

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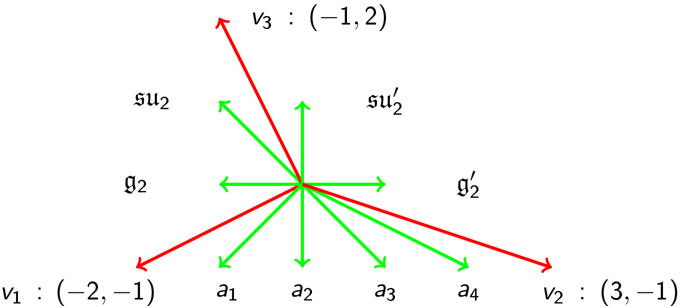

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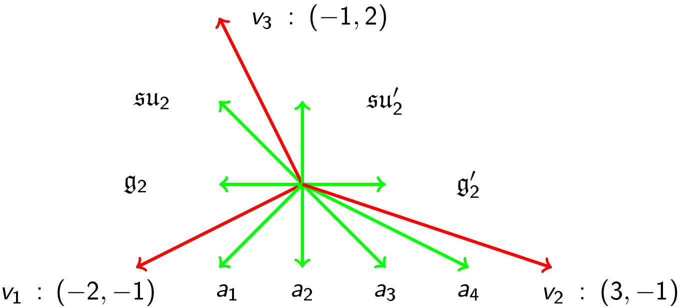

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- Using toric relation on divisors to obtain Σ_5 :

$$5[x_1] = 5[x_2] + (3[a_1] + [a_2] - [a_3] - 3[a_4]) - (2[g_2] + [su_2]) + (2[g_2'] + [su_2'])$$

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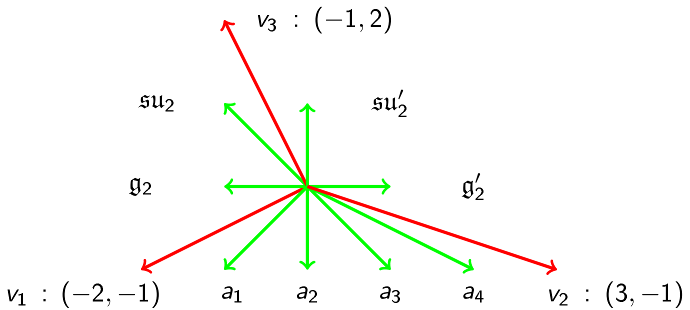

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BPS string charges restricted by Σ_5

Summary and Outlook

When **coupling** 6D $\mathcal{N} = (1,0)/(2,0)$ SCFTs to gravity

- their **global** 2-form symmetries are always **broken**
- **diagonal gauged 2-form group** G if: SCFT string charge lattices Λ_S **not primitive** embedded in the base lattice Λ_B
- $\boxed{G = (\Lambda_B \cap \Lambda_S^*)/\Lambda_S = tor(\Lambda_B/\Lambda_S) \neq 1}$
- G enforces **restricted** BPS string **charges**
- **Very universal proposal**, applicable for **little string theories**
- **check**: (2,0) theories on $\mathbb{S}^1$ reduce to non-simply connected gauge groups
- **More duality checks** in **heterotic** theories and (1,0) theories

What now?

Visible in Gopakumar-Vafa invariants, Gauged 2-form anomaly cancellation, Classification of toric bases, ...

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Gamsahabnida !

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