6d superconformal field theories II

(lecture 4/4)

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References:

[Earlier works on 6d SCFTs from F-theory]

Witten, 9603150

Morrison, Vafa, 9602114, 9603161

[Classification of 6d SCFTs from F-theory]

Heckman, Morrison, Vafa, 1312.5746

Heckman, Morrison, Rudelius, Vafa, 1502.05405

[Conformal matters]

Del Zotto, Heckman, Tomasiello, Vafa, 1407.6359

Tachikawa, 1508.06679

[Gauge theories on self-dual strings]

Haghighat, Iqbal, Kozcaz, Lockhart, Vafa, 1305.6322

Joonho Kim, SK, Kimyeong Lee, Jaemo Park, Vafa, 1411.2324

Haghighat, Klemm, Lockhart, Vafa, 1412.3152

Gadde, Haghighat, Joonho Kim, SK, Lockhart, Vafa, 1504.04614

Joonho Kim, SK, Kimyeong Lee, 1510.03128

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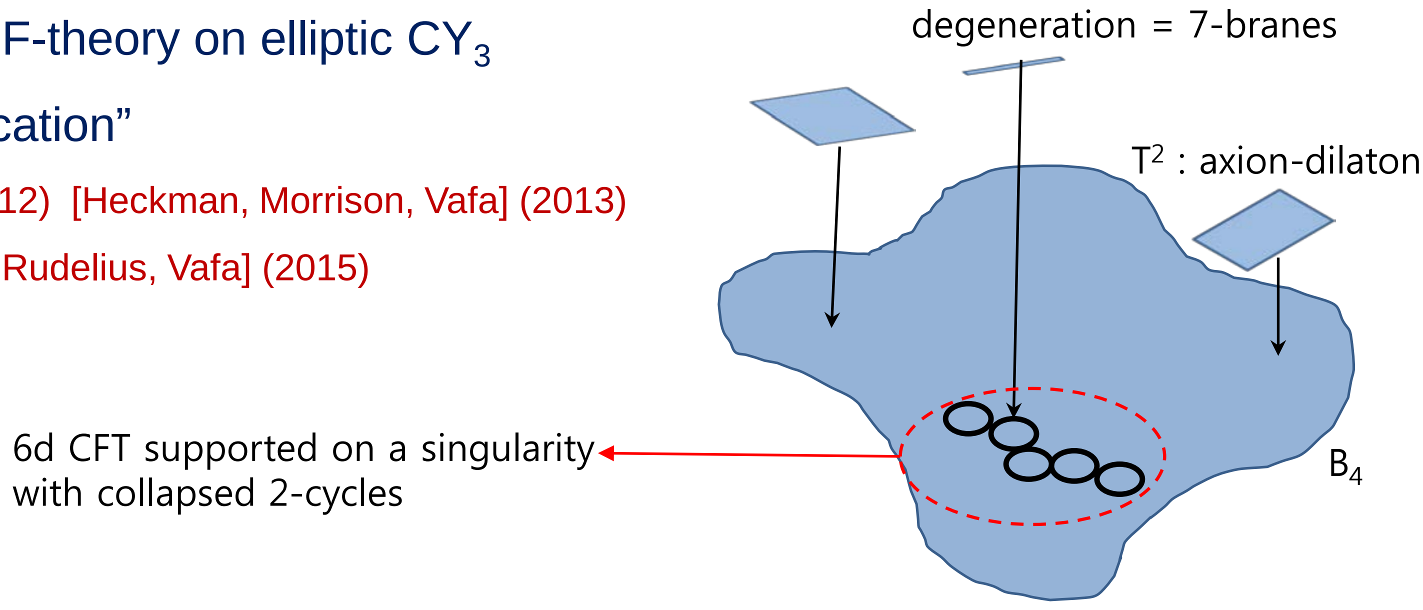
6d SCFTs from F-theory

- 6d SCFTs from F-theory on elliptic CY_3
- "Atomic classification"

[Morrison, Taylor] (2012) [Heckman, Morrison, Vafa] (2013)

[Heckman, Morrison, Rudelius, Vafa] (2015)

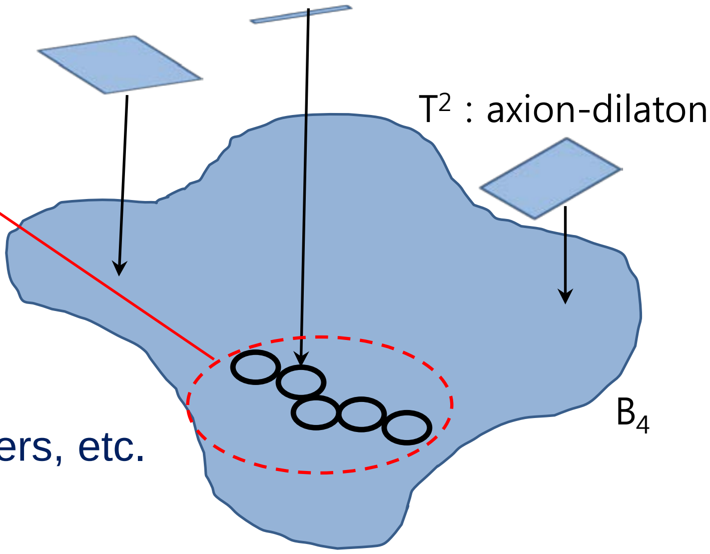


- 2d N=(0,4) QFTs on self-dual strings in tensor branch

- study subsectors of 6d SCFT from exact Lagrangian
- shed more concrete light on the geometric classification
- related to other problems (Yang-Mills instantons, compactifications of 4d isolated SCFTs)

Some features

- The base:
  - singularity resolved to intersecting P^1's (tensor branch)



- The fiber: degeneration yields 7-branes
  - wrapping compact 2-cycles: gauge symmetry
  - wrapping non-compact 2-cycles: global symmetry, matters, etc.

- 6d CFTs appear in a sequence of Higgsing:
  - no relevant deformations allowed (e.g. no mass terms for "quarks")

- The classification can be viewed in two ways:
  - top-down: classify base (non-Higgsrable CFTs), and then fiber (unHiggsing sequence)
  - bottom-up: 6d EFT in tensor branch, anomaly-free SYM coupled to hypers

- We shall mostly rely on bottom-up approach.

The “atoms”

- 6d minimal SCFTs [Witten] [Morrison,Vafa] (1996)

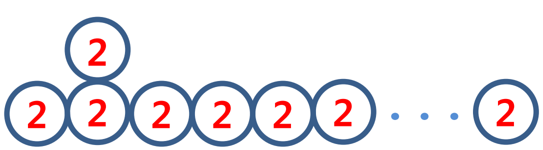
n	1	2	3	4	5	6	7	8	12
gauge symmetry	-	-	$SU(3)$	$SO(8)$	F_4	E_6	E_7	E_7	E_8
global symmetry	E_8	-	-	-	-	-	-	-	-
matters	-	-	-	-	-	-	$\frac{1}{2}\mathbf{56}$	-	-

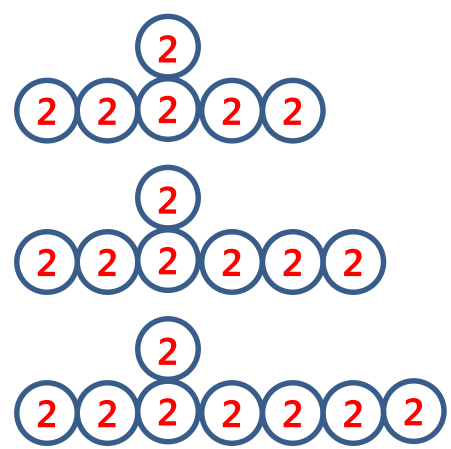
minimal SCFTs

- 1 tensor multiplet & non-Higgsable gauge symmetry
- F-theory: “atomic” building blocks, via “joining” and/or unHiggsing the atoms

- “atomic” SCFTs: minimal SCFTs w/ n ≥ 3, and the followings

base	$3,2$	$3,2,2$	$2,3,2$
gauge symmetry	$G_2\times SU(2)$	$G_2\times Sp(1)\times\{0\}$	$SU(2)\times SO(7)\times SU(2)$
matters	$\frac{1}{2}(\mathbf{7}+\mathbf{1},\mathbf{2})$	$\frac{1}{2}(\mathbf{7}+\mathbf{1},\mathbf{2})$	$\frac{1}{2}(\mathbf{2},\mathbf{8},\mathbf{1})+\frac{1}{2}(\mathbf{1},\mathbf{8},\mathbf{2})$



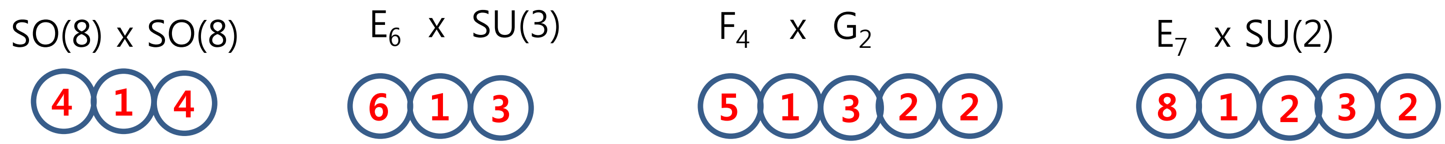


ADE (2,0) SCFTs

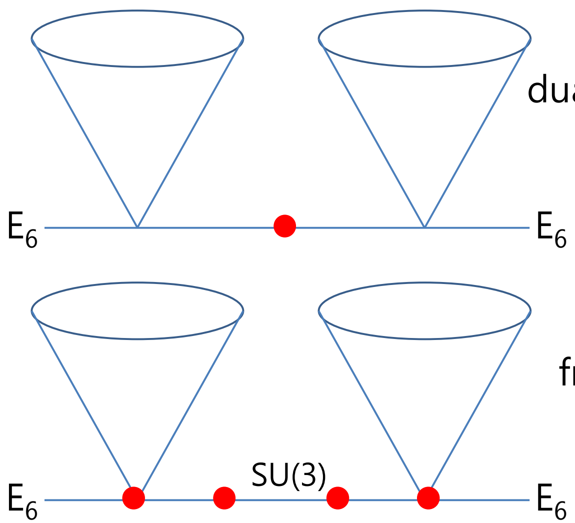
Combining the atoms

- basic rule: glue 2 atoms using E-string theory, gauging subgroup of E_8

- Examples:

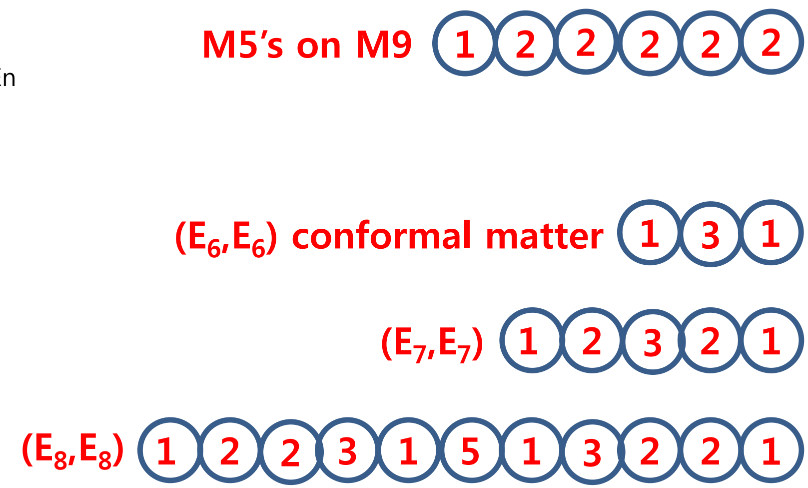


- Some (old & new) examples:



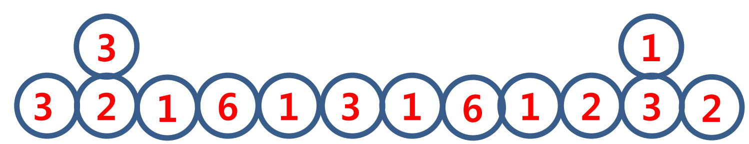
dual to M5's probing R x C^2/Γ_{En}

fractional M5's



- General results: "almost" a linear quiver

[Heckman, Morrison, Rudelius, Vafa]



[Note: linearity of NS5-D6 chains for 6d CFT vs. (p,q)-webs for 5d CFT]

Minimal SCFTs from bottom-up

- minimal SCFTs:

n	1	2	3	4	5	6	7	8	12
gauge symmetry	-	-	$SU(3)$	$SO(8)$	F_4	E_6	E_7	E_7	E_8
global symmetry	E_8	-	-	-	-	-	-	-	-
matters	-	-	-	-	-	-	$\frac{1}{2}\mathbf{56}$	-	-

- n=1 and 2: E-string theory and A_1-type (2,0) theory ($B_4 = C^2/Z_2$)
- other n's: gauge symmetry

$$H \equiv dB + \sqrt{c}\,\mathrm{tr}\left(AdA - \frac{2i}{3}A^3\right)$$

$$S^{\rm bos}_{\rm v+t} = \int \left[\frac{1}{2}d\Phi\wedge\star d\Phi + \frac{1}{2}H\wedge\star H\right] + \sqrt{c}\int\left[-\Phi\mathrm{tr}(F\wedge\star F) + B\wedge\mathrm{tr}(F\wedge F)\right]$$

- Classical gauge anomaly: $\delta\left[\sqrt{c}\int B\wedge\mathrm{tr}(F\wedge F)\right] = -c\int \mathrm{tr}(\epsilon F)\wedge\mathrm{tr}(F\wedge F)$

contributing a term $\sim c\,\mathrm{tr}(F^2)^2$ $\qquad \delta A_\mu = D_\mu\epsilon\ ,\quad \delta B_{\mu\nu} = -\sqrt{c}\,\mathrm{tr}(\epsilon F_{\mu\nu})$

- 1-loop ~ $\mathrm{tr}_{\rm adj}(F^4)$ and $\mathrm{tr}_{\mathbf{R}}(F^4)$: should factorize
- all exceptional & SU(2), SU(3), SO(8)
- Global anomaly constraints: →

[Bershadsky, Vafa]

$$\begin{array}{lcll}
E_7 & : & n_{\frac{1}{2}\mathbf{56}} = 8-n & (n=1,2,\cdots,8)\\
E_6 & : & n_{\mathbf{27}} = 6-n & (n=1,2,\cdots,6)\\
F_4 & : & n_{\mathbf{26}} = 5-n & (n=1,2,\cdots,5)\\
SO(8) & : & n_{\mathbf{8}_v} = n_{\mathbf{8}_s} = n_{\mathbf{8}_c} = 4-n & (n=1,2,3,4)\\
G_2 & : & n_{\mathbf{7}} = 10-3n & (n=1,2,3)\\
SU(3) & : & n_{\mathbf{3}} = 18-6n & (n=1,2,3)\\
SU(2) & : & n_{\mathbf{2}} = 16-6n & (n=1,2)\ ,
\end{array}$$

UnHiggsing

- Can make G bigger & add more hypers: constrained by anomaly cancelation.

\- allowed unHiggsing patterns of some minimal SCFTs

n=1: $\leftarrow (SU(2), n_{\mathbf{2}} = 10) \leftarrow \begin{cases} (Sp(N), n_{\mathbf{2N}} = 8+2N) \\ (SU(3), n_{\mathbf{3}} = 12) \leftarrow \begin{cases} (SU(N), n_{\mathbf{N}} = 8+N, n_{\mathbf{anti}} = 1) \\ (G_2, n_{\mathbf{7}} = 7) \leftarrow (SO(7), n_{\mathbf{7}} = 2, n_{\mathbf{8}} = 6) \end{cases} \end{cases}$

$\leftarrow (SO(8), n_{\mathbf{8}_v} = n_{\mathbf{8}_s} = n_{\mathbf{8}_c} = 3) \leftarrow \begin{cases} (SO(N), n_{\mathbf{N}} = N-5, n_{\mathbf{S}} = \cdots)_{N=9,\cdots,12} \\ (F_4, n_{\mathbf{26}} = 4) \leftarrow (E_6, n_{\mathbf{27}} = 5) \leftarrow (E_7, n_{\frac{1}{2}\mathbf{56}} = 7) \leftarrow (E_8, n_{\text{inst}} = 11) \end{cases}$

n=2: $\leftarrow (SU(2), n_{\mathbf{2}} = 4) \leftarrow (SU(3), n_{\mathbf{3}} = 6) \leftarrow \begin{cases} (SU(N), n_{\mathbf{N}} = 2N) \\ (G_2, n_{\mathbf{7}} = 4) \leftarrow (SO(7), n_{\mathbf{7}} = 1, n_{\mathbf{8}} = 4) \end{cases}$

$\leftarrow (SO(8), n_{\mathbf{8}_v} = n_{\mathbf{8}_s} = n_{\mathbf{8}_c} = 2) \leftarrow \begin{cases} (SO(N), n_{\mathbf{N}} = N-6, n_{\mathbf{S}} = \cdots)_{N=9,\cdots,12} \\ (F_4, n_{\mathbf{26}} = 3) \leftarrow (E_6, n_{\mathbf{27}} = 4) \leftarrow (E_7, n_{\frac{1}{2}\mathbf{56}} = 6) \leftarrow (E_8, n_{\text{inst}} = 10) \end{cases}$

n=3: $(SU(3)) \leftarrow (G_2, n_{\mathbf{7}} = 1) \leftarrow (SO(7), n_{\mathbf{7}} = 0, n_{\mathbf{8}} = 2) \leftarrow (SO(8), n_{\mathbf{8}_v} = n_{\mathbf{8}_s} = n_{\mathbf{8}_c} = 1)$

$\leftarrow \begin{cases} (SO(N), n_{\mathbf{N}} = N-7, n_{\mathbf{S}} = \cdots)_{N=9,\cdots,12} \\ (F_4, n_{\mathbf{26}} = 2) \leftarrow (E_6, n_{\mathbf{27}} = 3) \leftarrow (E_7, n_{\frac{1}{2}\mathbf{56}} = 5) \leftarrow (E_8, n_{\text{inst}} = 9) \end{cases}$

n=4: $(SO(8)) \leftarrow \begin{cases} (SO(N), n_{\mathbf{N}} = N-8) \\ (F_4, n_{\mathbf{26}} = 1) \leftarrow (E_6, n_{\mathbf{27}} = 2) \leftarrow (E_7, n_{\frac{1}{2}\mathbf{56}} = 4) \leftarrow (E_8, n_{\text{inst}} = 8) \end{cases}$

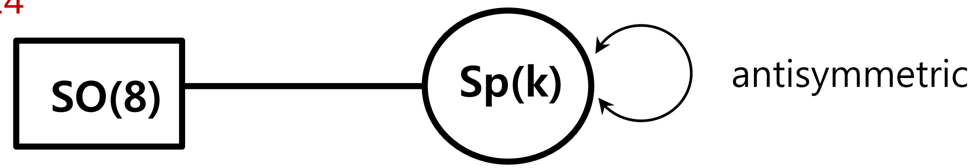
[red box]: classical Higgsing chains

Strings of minimal SCFTs

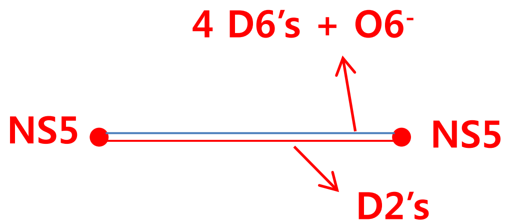
- We know two 2d QFTs well: strings at n=1,2 (from D-branes, open strings)
- Other minimal SCFTs: self-dual strings = instanton strings

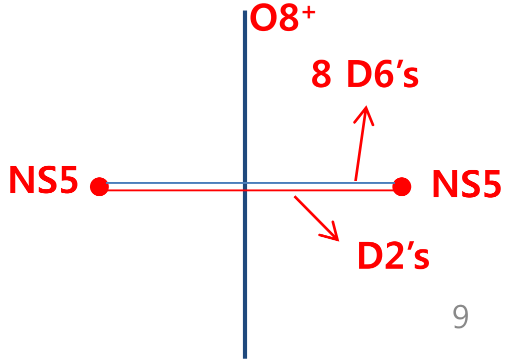
$$F_{\mu\nu} = \star_4 F_{\mu\nu} \qquad k \equiv \frac{1}{8\pi^2} \int \mathrm{tr}\,(F \wedge F) \in \mathbb{Z} \qquad S \leftarrow \int B \wedge \mathrm{tr}(F \wedge F)$$

- Most gauge groups are exceptional.
- Consider the apparently simpler cases: n=3,4 with SU(3), SO(8)
- n=4: [Haghighat, Klemm, Lockhart, Vafa] 2014
- "Bottom-up": SO(8) ADHM:



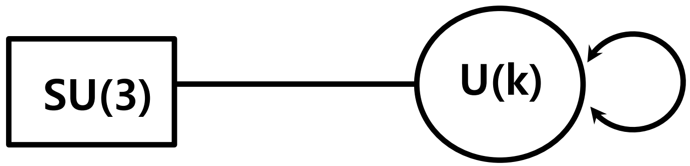
- Sp(k) anomaly-free. So a good uplift of the UV incomplete NLSM.
- F-theory construction has orientifold limit
- Or, (dual) realizations from massive IIA



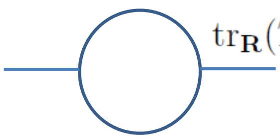


Strings of minimal SCFTs: n=3

- Naively, can try a guess w/ SU(3) ADHM ("bottom-up" approach)
- SU(3) ADHM:



- U(k) anomaly:



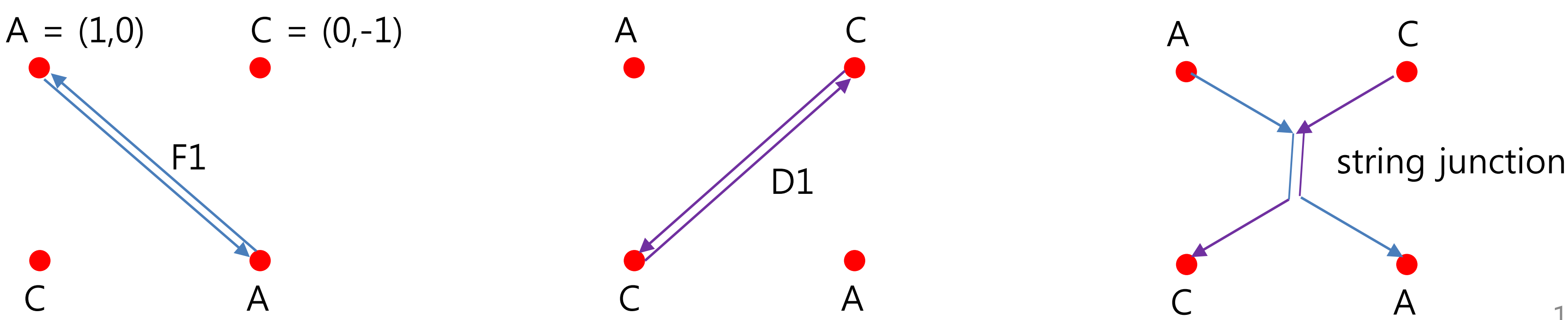
$$\mathrm{tr}_{\mathbf{R}}(T^aT^b) = D_{\mathbf{R}}\delta^{ab}$$

$$D_{\mathbf{k}} = 1 \qquad D_{\mathbf{adj}} = 2k,$$

fields	$U(k)$	$SU(3)$	$SU(2)_F$	$SU(2)_1$	$SU(2)_2$
$\lambda_{\dot\alpha A-}$	**adj**	**1**	**1**	**2**	**2**
$q_{\dot\alpha}(\rightarrow \psi_{A+})$	**k**	$\bar{\mathbf{3}}$	**1**	**2**	**1**
$a_{\alpha\dot\beta}(\rightarrow \chi_{\alpha A+})$	**adj**	**1**	**2**	**2**	**1**

$$\sim \; 2\cdot 3\cdot 1 + 2\cdot 2k - 2\cdot 2k = 6 \neq 0$$

- Anyway, it is natural for it to fail. (ADHM is for open strings.)
- SU(3) is realized "nonperturbatively" or "exceptionally" [Grassi, Halverson, Shaneson]



Exceptional instanton strings

- So including the SU(3) case, the followings are realized “non-perturbatively.”

n	1	2	3	4	5	6	7	8	12
gauge symmetry	-	-	$SU(3)$	$SO(8)$	F_4	E_6	E_7	E_7	E_8
global symmetry	E_8	-	-	-	-	-	-	-	-
matters	-	-	-	-	-	-	$\frac{1}{2}\mathbf{56}$	-	-

- The SU(3) SCFT is also important for understanding other “atoms”

base	$3,2$	$3,2,2$	$2,3,2$
gauge symmetry	$G_2 \times SU(2)$	$G_2 \times Sp(1) \times \{0\}$	$SU(2) \times SO(7) \times SU(2)$
matters	$\frac{1}{2}(\mathbf{7}+\mathbf{1},\mathbf{2})$	$\frac{1}{2}(\mathbf{7}+\mathbf{1},\mathbf{2})$	$\frac{1}{2}(\mathbf{2},\mathbf{8},\mathbf{1})+\frac{1}{2}(\mathbf{1},\mathbf{8},\mathbf{2})$

- SU(3) is closely related to G2 instantons, and also instantons in “SO(7) + spinors”

- Strategy w/ SU(3) self-dual strings:

- Keep going on with the bottom-up approach
- Cure the pathology of naïve SU(3) quiver, and check other physics.

The cure for SU(3)

- Proposal: I couldn't make an N=(0,4) gauge theory uplift. I can do N=(0,2).

- Add the following N=(0,2) matters:

fields	$U(k)$	$SU(3)$	$SU(2)_F$	$SU(2)_1$	$SU(2)_2$
$\lambda_{\dot{\alpha}A-}$	**adj**	**1**	**1**	**2**	**2**
$q_{\dot{\alpha}}(\to \psi_{A+})$	**k**	$\bar{\mathbf{3}}$	**1**	**2**	**1**
$a_{\alpha\dot{\beta}}(\to \chi_{\alpha A+})$	**adj**	**1**	**2**	**2**	**1**

(ϕ, χ) : chiral multiplet in $(\bar{\mathbf{k}}, \bar{\mathbf{3}})$

$(b_{1,2}, \xi_{1,2})$: two chiral multiplet in $(\overline{\mathbf{anti}}, \mathbf{1})$

$\hat{V} = (\hat{A}_-, \hat{\lambda}, \bar{\mu}, \hat{D})$: complex vector multiplet in $(\mathbf{sym}, \mathbf{1})$

$(\check{\lambda}, G_{\check{\lambda}})$: complex Fermi multiplet in $(\mathbf{sym}, \mathbf{1})$

$v = (a_-, \zeta, \bar{\mu}_\zeta, D_\zeta)$: complex vector multiplet in $(\bar{\mathbf{k}}, \mathbf{1})$

Shouldn't affect non-linear sigma model.
New light d.o.f. at small instanton singularity.

New ingredients of N=(0,2) theories to turn on non-holomorphic interactions

- complex vector multiplet: $\hat{V} = \hat{A}_0 - \hat{A}_1 - 2i\theta^+\bar{\mu}_- - 2i\bar{\theta}^+\hat{\lambda}_- + 2\theta^+\bar{\theta}^+\hat{D}$

$$S_{\hat{V}} = -\frac{1}{2}\int d^2y d^2\theta\, \hat{\bar{\Upsilon}}\hat{\Upsilon} = \int d^2x \left[\frac{1}{2}\left|D_+\hat{A}_- - i\hat{D}\right|^2 + i\hat{\bar{\lambda}}(D_0 + D_1)\hat{\lambda}\right]$$

$$\mathcal{L}_{\text{int}} = \# \int d^2\theta F(\Phi, \bar{\Phi})\hat{V} + c.c.$$

- anomaly: SU(k)

from ADHM ~ $2\cdot 3\cdot 1 + 2\cdot 2k - 2\cdot 2k = 6 \neq 0$

from others ~ $+3\cdot 1 + 2(k-2) - (k+2) - (k+2) - 1 = -6$

$D_{\text{sym}} = k+2$

$D_{\text{anti}} = k-2$

- Suitable superpotentials or D-term-like potentials for Fermi and complex vectors.

The moduli space, NLSM & UV completion

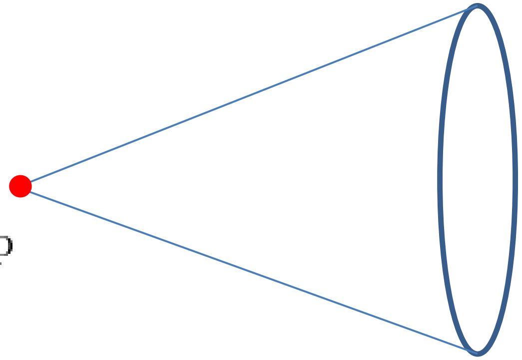
- Solving the zero potential condition, we find

$$V(\phi_{\text{ADHM}}, \phi_{\text{others}}) = V_1(\phi_{ADHM}) + V_2(\phi_{\text{others}}, \phi_{\text{ADHM}})$$

- Extra fields = 0
- The ADHM fields satisfying $D^I \equiv q_{\dot\alpha}(\tau^I)^{\dot\alpha}{}_{\dot\beta}\bar q^{\dot\beta} + (\tau^I)^{\dot\alpha}{}_{\dot\beta}[a_{\alpha\dot\alpha}, a^{\alpha\dot\beta}] = 0$
- The moduli space becomes hyper-Kahler: supports (0,4) enhancement of NLSM in IR

- In the Higgs branch, the non-linear sigma model description shouldn't change.
- All the other fields: extra degrees localized at the small instanton singularity. UV completion.

ϕ_{extra} are massless only at the tip



$$S_{2d} = \int d^2x \left[- g_{MN}(X)\partial_\mu X^M \partial^\mu X^N + \cdots \right]$$

Observables

- elliptic genus:

$$Z_k(\tau, \epsilon_{1,2}, m_a) = \mathrm{Tr}\left[(-1)^F e^{2\pi i\tau H_+} e^{2\pi i\bar{\tau} H_-} e^{2\pi i\epsilon_1(J_1+J_R)} e^{2\pi i\epsilon_2(J_2+J_R)} \cdot \prod_{a\in\text{flavor}} e^{2\pi i m_a F_a}\right]$$

$$H_\pm \equiv \frac{H\pm P}{2} \qquad H_- \sim \{Q, \overline{Q}\}$$

- Easily computable if we have a UV gauge theory. [Benini, Eager, Hori, Tachikawa]

- For simplicity, let us consider single string: (similar works done for k=2,3)

$$Z_1^{SU(3)}(v, \epsilon_{1,2}) = -\frac{\eta^2}{\theta_1(\epsilon_{1,2})} \sum_{i=1}^{3} \frac{\eta^4 \theta_1(4\epsilon_+ - 2v_i)\theta_1(v_i)}{\prod_{j(\neq i)} \theta_1(v_{ij})\theta_1(2\epsilon_+ - v_{ij})\theta_1(2\epsilon_+ + v_j)}$$

- This is very rich data. One can make highly nontrivial tests of our theory with it.

Relation to topological strings on CY3

- Elliptic genus is defined after compactifying spatial circle.

- T-dualize F-theory on $R^{4,1}$ x S^1 x CY_3 ~ type IIB on $R^{4,1}$ x S^1 x B_4
- M-theory on $R^{4,1}$ x [same CY_3]

- D3 charge (IIB) ~ D2 charge (IIA) ~ M2 charge (M)
- P (IIB) ~ F1 winding (IIA) ~ M2 wrapped on T^2 fiber

- BPS states counted by elliptic genus ~ BPS states of wrapped M2-branes on CY_3
- This is basically counted by topological string amplitudes

- We have abundant "experimental data" on these strings obtained from topological strings.

Tests

- Partial data known from topological strings at k=1,2,3 [Haghighat, Klemm, Lockart, Vafa]

$$\log Z(\tau,\epsilon_+,\epsilon_+,\mu) = \sum_{g\geq 0, n\geq 0} (\epsilon_1\epsilon_2)^{g-1}(\epsilon_1+\epsilon_2)^n F_{g,n}(\tau,\mu)$$

$$\begin{aligned} F_{0,0} &= -\left[\frac{\theta_1(2v_1)\theta_1(v_1)}{\theta_1(v_{12})^2\theta_1(v_{13})^2\theta_1(v_2)\theta_1(v_3)} + (1,2,3\to 2,3,1) + (1,2,3\to 3,1,2)\right] \\ &= e^{-\pi i\tau+2\pi i v_{12}+2\pi i v_{23}} \sum_{d_0,d_1,d_2=0}^{\infty} N_{d_0,d_1,d_2}\left(\frac{e^{2\pi i\tau}}{e^{2\pi i v_{12}}e^{2\pi i v_{23}}}\right)^{d_0} e^{2\pi d_1 v_{12}} e^{2\pi d_2 v_{23}} \end{aligned}$$

$d_1 \setminus d_2$	0	1	2	3	4	5
0	1	3	5	7	9	11
1	3	4	8	12	16	20
2	5	8	9	15	21	27
3	7	12	15	16	24	32
4	9	16	21	24	25	35
5	11	20	27	32	35	36

Table 1: q^0

$d_1 \setminus d_2$	0	1	2	3	4	5
0	3	4	8	12	16	20
1	4	16	36	60	84	108
2	8	36	56	96	144	192
3	12	60	96	120	180	252
4	16	84	144	180	208	288
5	20	108	192	252	288	320

Table 2: q^1

$d_1 \setminus d_2$	0	1	2	3	4	5
0	5	8	9	15	21	27
1	8	36	56	96	144	192
2	9	56	149	288	465	651
3	15	96	288	456	735	1080
4	21	144	465	735	954	1371
5	27	192	651	1080	1371	**1632**

Table 3: q^2

$d_1 \setminus d_2$	0	1	2	3	4	5
0	7	12	15	16	24	32
1	12	60	96	120l	180	252
2	15	96	288	456	735	1080
3	16	120	456	1012	1788	**2796**
4	24	180	735	1788	**2823**	**4356**
5	32	252	1080	**2796**	**4356**	**5760**

Table 4: q^3

complete agreement

Tests *(continued)*

- This also works perfectly well with higher string numbers.

- Another test: is the 1d reduction consistent with conventional SU(3) ADHM?
- 1d limit $N_{0,d1,d2}$: agrees w/ Nekrasov partition function from standard ADHM quiver.

$$
\begin{aligned}
F_{0,0} \overset{q\ll 1}{\sim} & -\frac{\sin(2\pi v_1)\sin(\pi v_1)}{4\sin^2(\pi v_{12})\sin^2(\pi v_{13})\sin(\pi v_2)\sin(\pi v_3)} + (2,3,1) + (3,1,2) \\
= & \frac{1}{4\sin^2(\pi v_{12})\sin^2(\pi v_{13})} + (2,3,1) + (3,1,2) = Z^{SU(3),k=1}_{\text{Nekrasov}}(\mathbb{R}^4 \times S^1)
\end{aligned}
$$

- Alternative SU(3) ADHM in 1d/5d: different UV completion visible only in 2d/6d.

- Claim: flows to the same superconformal QM in 1d.
- The new version allows interesting generalizations (later)

6d unHiggsing in 2d

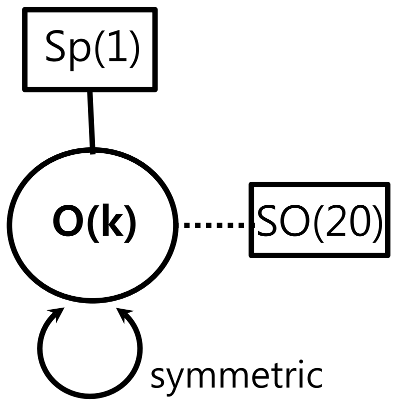
- There are many sequences of Higgsing/unHiggsing chains.
- Have studied the unHiggsings of n=1,2,3:

- n=2: $\leftarrow (SU(2), n_{\mathbf{2}} = 4) \leftarrow (SU(3), n_{\mathbf{3}} = 6) \leftarrow \begin{cases} (SU(N), n_{\mathbf{N}} = 2N) \\ (G_2, n_{\mathbf{7}} = 4) \leftarrow (SO(7), n_{\mathbf{7}} = 1, n_{\mathbf{8}} = 4) \end{cases}$ ⟶ 2d uplift of standard ADHM works

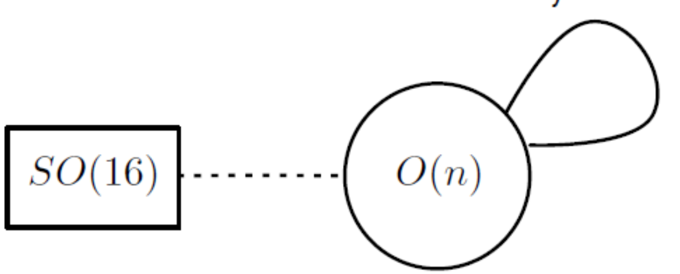
- n=1: $\leftarrow (SU(2), n_{\mathbf{2}} = 10) \leftarrow \begin{cases} (Sp(N), n_{\mathbf{2N}} = 8 + 2N) \\ (SU(3), n_{\mathbf{3}} = 12) \leftarrow \begin{cases} (SU(N), n_{\mathbf{N}} = 8 + N, n_{\mathbf{anti}} = 1) \\ (G_2, n_{\mathbf{7}} = 7) \leftarrow (SO(7), n_{\mathbf{7}} = 2, n_{\mathbf{8}} = 6) \end{cases} \end{cases}$

- It is easy for "standard ADHM" to go bad in 2d: 6d SU(2) at N_f = 10

SU(2) w/ Nf = 10



E-strings



UnHiggsing of SU(3) in 2d

- Cannot unHiggs to SU(N)'s: SU(3) at $N_f = 0$ is really exceptional

- Some progress with G2 instantons. SO(7) w/ matters in spinor rep.

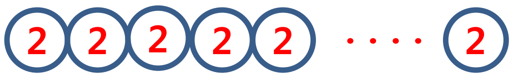
- In the new SU(3) instanton gauge theory, easy to do exceptional unHiggsing procedures

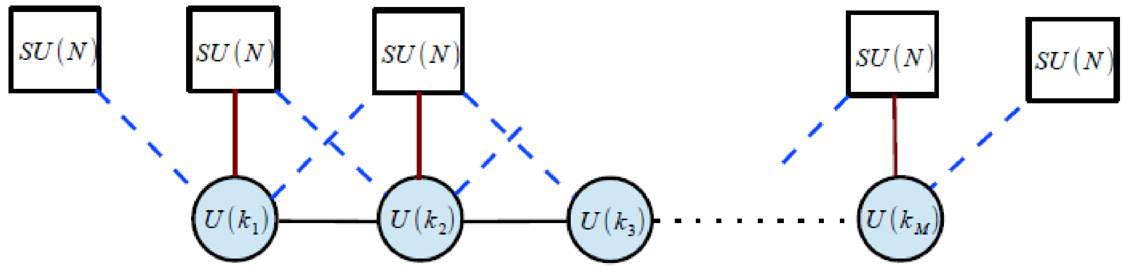
- G2 & SO(7) w/ spinor matters: under construction [Hee-Cheol Kim, SK, Jaemo Park] in progress

- Correct gauge theory descriptions of the elliptic genera and 1d-reduced Witten indices

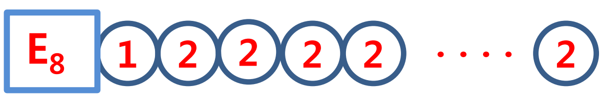
Chains of strings

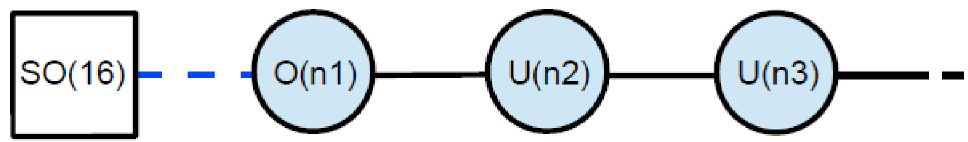
- One can "glue" the minimal CFTs or strings: [Gadde, Haghighat, J.Kim, SK, Lockhart, Vafa]
- These make 6d CFTs & strings with higher dim'l tensor branches
- A_M (2,0) CFT strings probing A_{N-1} orbifold [Haghighat, Iqbal, Kozcaz, Lockhart, Vafa] (2013)





- (1,0) CFT for M9-M5-M5- …. (higher rank E-strings): [GHKKLV] [J.Kim, SK, K.Lee]





- (E6, E6) conformal matter [Del Zotto, Heckman, Tomasiello, Vafa] 2014:

to appear [H.-C. Kim, SK, J. Park]

Concluding remarks

- 6d CFTs are hard. Even the soliton QFTs are often hard for most (1,0) theories.

- We are getting some clues on gauge theories on solitons:
- not only open strings, but also various (p,q) strings
- exceptional instantons' ADHM-like description
- Further extensions? To all exceptional instantons?

- Related to describing some physics of 4d exceptional CFTs: D3 probing exceptional 7-branes

- 6d (2,0) on Riemann surface yields class S. 4d exceptional SCFTs on S2 yields our 2d gauge theories.

- Of course, can try to use these 2d (or 1d) observables in CFT partition functions