The Higgs Branch of Heterotic LSTs Hasse Diagrams and Generalized Symmetries.

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Based on work with Craig Lawrie

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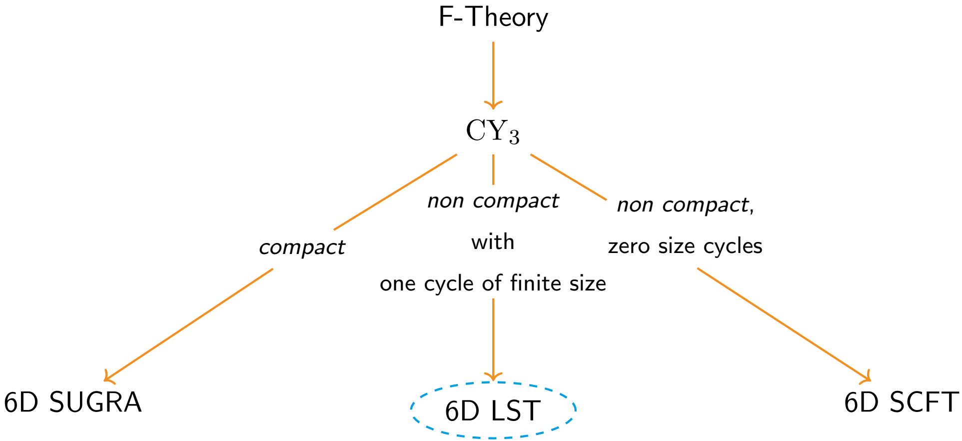
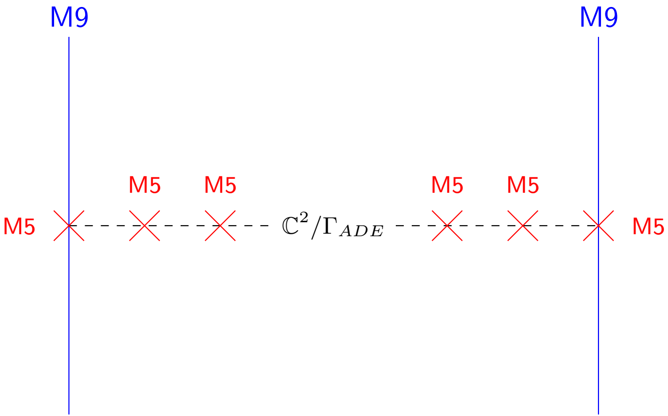
What is a Little String Theory (LST)?

What is an LST? - The F-Theory picture.



What is an LST? - The M-Theory picture.



	Spatial Orientation
M5	$x^0, x^1, x^2, x^3, x^4, x^5$
M9	$x^0, x^1, x^2, x^3, x^4, x^5, x^7, x^8, x^9, x^{10}$
$\mathbb{C}^2/\Gamma_{ADE}$	$x^0, x^1, x^2, x^3, x^4, x^5, x^6$

With $SU(2) \supset \Gamma_{ADE} = \{\mathbb{Z}_k, \mathrm{Dic}_k, \mathbb{BT}, \mathbb{BO}, \mathbb{BI}\}$

x^6 distance between M-branes

$\cong$

curve size in F-theory

What is an LST? - Generalities.

- Little String Theories are *non local* and *non gravitational*.
- Can be described via QFT for $E \ll L_{string}$.
- Exhibit T-Duality, upon compactification in presence of Wilson lines.

$$
\begin{tikzcd}
E_8 \times E_8 \arrow[rr, leftrightarrow, bend left, "\text{T-dual}"] \arrow[dr, "\text{on } S^1 \text{ with } \mathcal{W}_1 \text{ lines}"'] & & \mathrm{Spin}(32)/\mathbb{Z}_2 \arrow[dl, "\text{on } S^1 \text{ with } \mathcal{W}_2 \text{ lines}"] \\
& 5d \text{ theory} &
\end{tikzcd}
$$

- Presence of an higher group symmetry:

$$
\text{2-Grp}_{LST} = (SU(2)_R \times \mathscr{P} \times \mathcal{F})^{0\text{-forms}} \times_{\hat{\kappa}_R, \hat{\kappa}_{\mathscr{P}}, \hat{\kappa}_{\mathcal{F}}} U(1)^{1\text{-form}}_{LST} \,,
$$

$$
\begin{aligned}
B^{(1)} \to B^{(1)} + d\Lambda^{(1)} +& \\
&+ \underline{\hat{\kappa}_R} \lambda^{(0)}_R dA^{(1)}_R + \\
&+ \underline{\hat{\kappa}_{\mathscr{P}}} \theta^{(0)} d\omega^{(1)} + \\
&+ \underline{\hat{\kappa}_{\mathcal{F}}} \lambda^{(0)}_F dA^{(1)}_F \,.
\end{aligned}
$$

the 2-Group structure constants $\underline{\hat{\kappa}}$ need to match between T-duals. [M. Del Zotto, K. Ohmori]

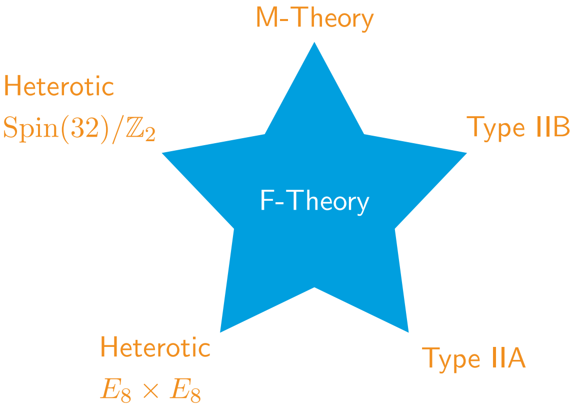
What is an LST? - The Question.

Although under compactification the Higgs branch of a $6d$ LST is modified by the presence of Wilson lines:

- Are we able to understand something about T-Dual pairs just by looking at the $6d$ theory?
- How does an Higgs Branch RG flow in $6d$ affect T-duality?

Outline of this talk.

1. What is an LST?
2. Magnetic Quiver and Higgs Branch
3. T-duality and Hasse Diagram
4. Outlook



Magnetic Quiver and Higgs Branch.

Magnetic Quiver and Higgs Branch - The Magnetic Quiver.

How do we resume all the instantonic contribution to the $6d$ Higgs Branch given by tensionless BPS strings?

Use a $3d$ $\mathcal{N} = 4$ quiver such that:

$$Higgs\ Branch\,(6d \text{ electric theory}) \cong Coulomb\ Branch\,(3d \text{ magnetic theory})$$

The above equality is meant as a *moduli space* equality, each three-dimensional quiver theory whose Coulomb Branch is the same as the Higgs Branch of a six-dimensional theory is called *magnetic quiver*. [S. Cabrera, A. Hanany, M. Sperling]

The Magnetic Quiver is not a priori the 3d mirror!!!

Magnetic Quiver and Higgs Branch - The $E_8 \times E_8$ Model.

Consider $\Gamma_{ADE} = \mathbb{Z}_2$, the resulting electric theory is:

$$\mathcal{K}_N(\mu_L, \mu_R, \mathfrak{su}_2) := \ \mathcal{T}(\mu_L) - \overset{\mathfrak{su}_2}{2} - \underbrace{\overset{\mathfrak{su}_2}{2} \cdots \overset{\mathfrak{su}_2}{2}}_{N-2} - \overset{\mathfrak{su}_2}{2} - \mathcal{T}(\mu_R) \ ,$$

$$\hat{\kappa}_R\left(\mathcal{K}_N(\mu_L, \mu_R, \mathfrak{su}_2)\right) = \hat{\kappa}_R\left(\mathcal{T}(\mu_L)\right) + \hat{\kappa}_R\left(\mathcal{T}(\mu_R)\right) + 2N \ .$$

Where we defined:

$\mu_{L/R} : \mathbb{Z}_2 \to E_8$ and

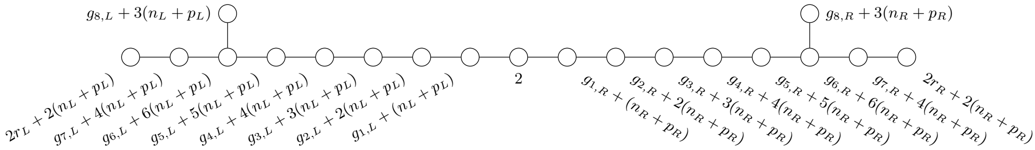
$$\mathcal{T}(1+1) = \ [E_8]\ 1\ 2\ \overset{\mathfrak{su}_2}{2}\ [G_2]\ ,\ \hat{k}_R = 4\,,$$

$$\mathcal{T}(2) = \ [E_7]\ 1\ \overset{\mathfrak{su}_2}{2}\ \ [SO(7)]\ ,\ \hat{k}_R = 3\,,$$

$$\mathcal{T}(2') = \ [SO(16)]\ \overset{\mathfrak{sp}_1}{1}\ \ [SO(4)]\ ,\ \hat{k}_R = 2\,.$$

Magnetic Quiver and Higgs Branch - The $E_8 \times E_8$ Model.

The magnetic quiver is the following:

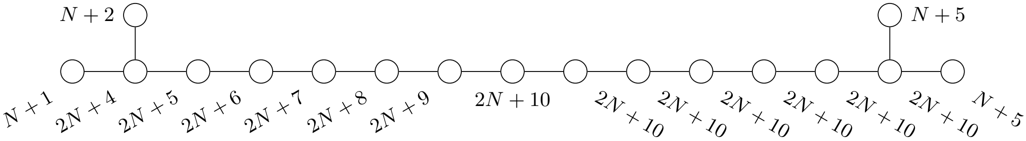


Where the various g_i-s and p are determined by the embedding μ, whereas $n_L + n_R = N$ is a measure of the conformal matter we put in the middle.

The proposed T-dual model is determined by $\lambda : \mathbb{Z}_2 \to SO(32)$, and its electric theory is:

$$\begin{aligned} \widetilde{\mathcal{K}}_N(2p, 16-2p) &= \ [SO(4p)] \ \overset{\mathfrak{sp}_N}{1} \ \ \overset{\mathfrak{sp}_{N+4-p}}{1} \ \ [SO(32-4p)] \ , \\ \hat{k}_R &= 2N + 6 - p \ . \end{aligned}$$

The associated magnetic quiver for $p = 0$ is:



[M. Del Zotto, M. Fazzi, S. Giri]

T-duality and Hasse Diagram.

- 8 Supercharges $\rightarrow$ The Higgs branch is a *Symplectic singularity*. [A. Beauville]
- Studying the foliation of the singularity $\cong$ Exploring which theory can be reached by Higgs Branch RG flow. [A. Bourget, S. Cabrera, J. F. Grimminger, A. Hanany, M. Sperling, A. Zajac, Z. Zhong]
- Use *Quiver Subtraction* to extract the slices $\cong$ Give vev to moment map operator of flavor symmetries. [S. Cabrera, A. Hanany]

In these terms our initial questions can be rephrased as follows:

- How do we see the effect of a slice (*i.e.* a non trivial vev) on the structure constant $\hat{\kappa}$?

T-duality and Hasse Diagram - Slices spectroscopy.

For the $E_8 \times E_8$ model we have:

$$\textit{Classical Higgsing}: \mathfrak{su}_2 \to \emptyset \ , \ \Delta\hat{\kappa}_R = 1 \ , \ \text{Slices: } d_8, A_1$$

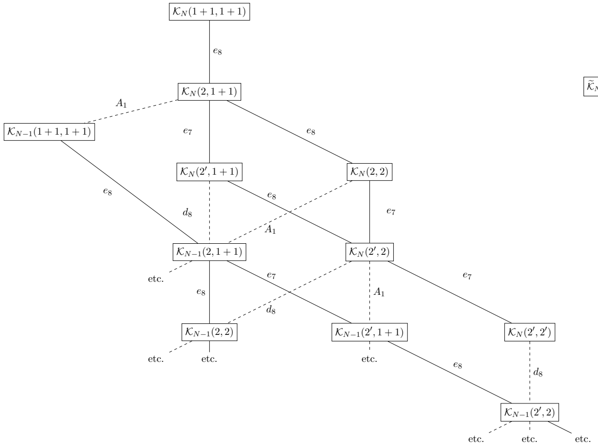
$$\textit{E-String Higgsing}: \Delta\hat{\kappa}_R = 1 \ , \ \text{Slices: } e_8, e_7$$

Whereas for the $\mathrm{Spin}(32)/\mathbb{Z}_2$:

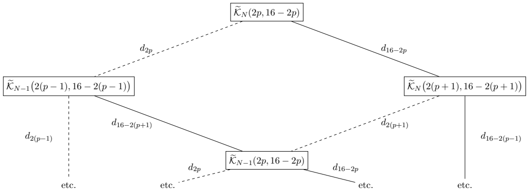
$$\textit{Classical Higgsing}: \mathfrak{sp}_k \to \mathfrak{sp}_{k-1} \ , \ \Delta\hat{\kappa}_R = 1 \ , \ \text{Slices: } d_*$$

T-duality and Hasse Diagram - Hasse Diagrams.

$E_8 \times E_8$ Model



$\mathrm{Spin}(32)/\mathbb{Z}_2$ Model



Obtain dual pairs whenever the structure constants (and Coulomb Branch dimension) are equal.

Thus classify families of pairs according to $\hat{\kappa}_R \bmod 2$:

- $\hat{\kappa}_R = 0 \bmod 2,$

$$\mathcal{K}_N(1+1,1+1) \sim \mathcal{K}_{N+1}(2,2) \sim \mathcal{K}_{N+1}(2',1+1) \sim \mathcal{K}_{N+1}(2',2') \sim \\ \sim \widetilde{\mathcal{K}}_N(0,16) \sim \widetilde{\mathcal{K}}_{N+1}(4,12) \sim \widetilde{\mathcal{K}}_{N+2}(8,8)\,,$$

- $\hat{\kappa}_R = 1 \bmod 2,$

$$\mathcal{K}_N(2,1+1) \sim \mathcal{K}_{N+1}(2',2) \sim \widetilde{\mathcal{K}}_N(2,14) \sim \widetilde{\mathcal{K}}_{N+2}(6,10)\,.$$

[M. Del Zotto, M. Liu, P.K. Oehlmann]

Outlook.

Outlook.

- We gave an understanding of the Higgs Branch of the low energy QFT associated with the LST.
- We proposed a general way to extract LSTs models and dual pairs starting from a parent theory.
- (*In the paper*) Gave a Magnetic Quiver interpretation of the notion of *Coulomb gauging* to construct *braney* LST models.

Thanks for your attention!