
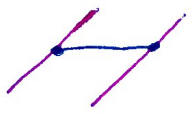
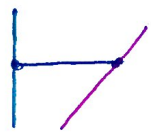




Theory with 1 infinite D3 is 4d  $\mathcal{N}=4$  with matter content

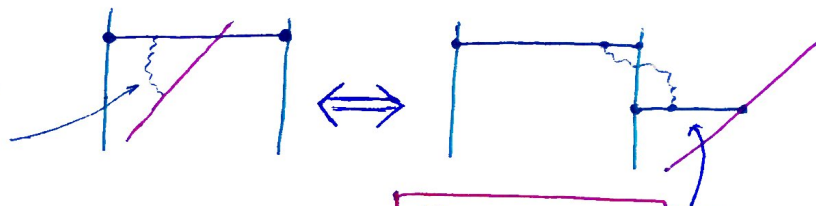
- 3d  $\mathcal{N}=4$  vector
- 3d  $\mathcal{N}=4$  hyper.

Ending on branes gives boundary conditions that project out part of this matter content.

|   |   |
|---|---|
|  | 3d $\mathcal{N}=4$ vector. Electric gauge group with coupling $\frac{1}{g^2} =  t_1 - t_2 $         |
|  | 3d $\mathcal{N}=4$ hyper. After RS duality, magnetic gauge group with $\frac{1}{g^2} =  z_1 - z_2 $ |
|  | No massless modes. IR theory has unique vacuum with mass gap.                                       |

### Hanany - Witten move

hyper that becomes massless  $\vec{x} = \vec{m}$



$\mathcal{N}=4$  D3 with no moduli!

- s-rule Config where more than one D3 connects an NS5 to a D5 is called "s-config".

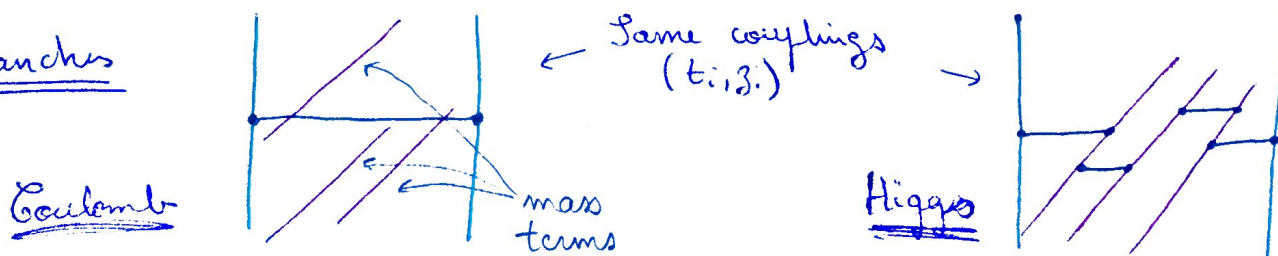
Conjecture: s-config are not supersymmetric.

- Linking number Consider a brane of type D5 or NS5. call  $l, n = \#$  branes of the other type on the left/right  
 $L, R = \#$  D3 ending on left/right.

Then

$$\text{linking} = \frac{1}{2}(n-l) + (L-R)$$

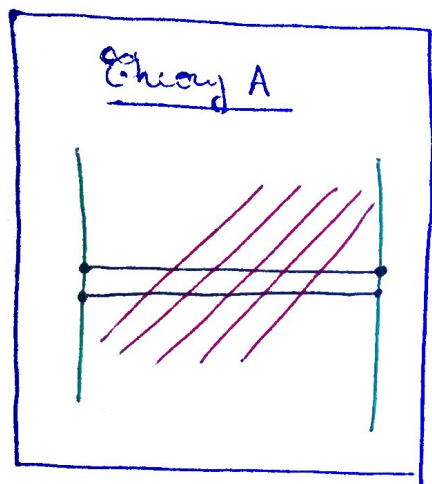
### Branches



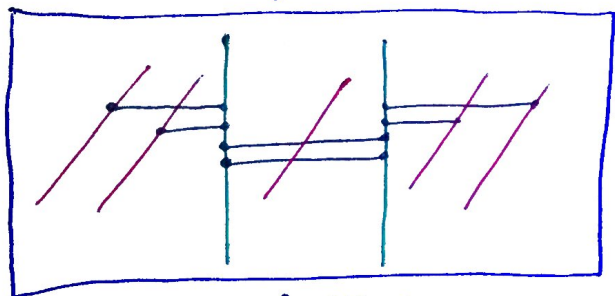


# Mirror symmetry

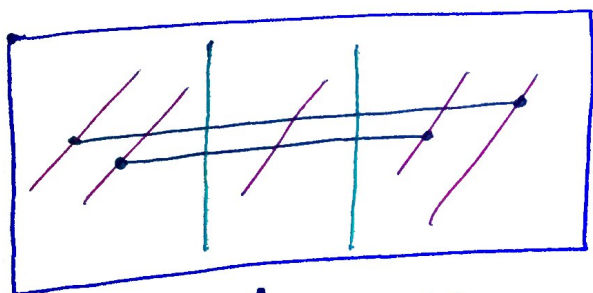
Look at  $U(k)$  theory with  $m$  flavours  
(on pictures  $k=2$  and  $m=5$ )



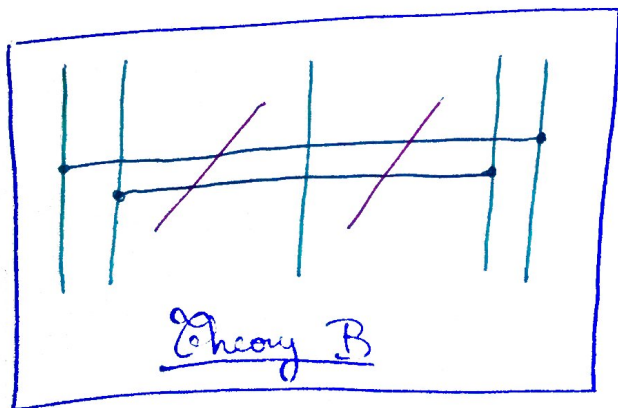
HW move



Attach all D3 only to D5



S-duality



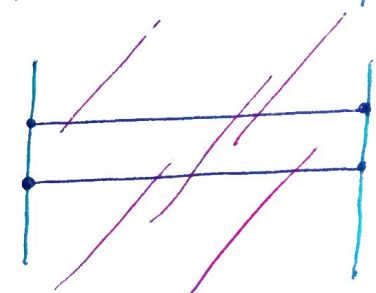
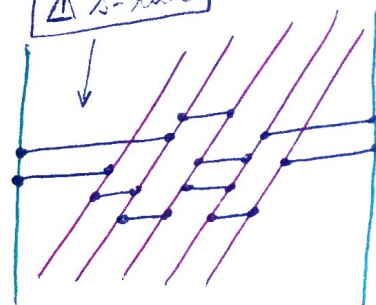
Quiver



Higgs branch  
 $\dim_{\mathbb{H}} = k(m-k)$

Coulomb branch  
 $\dim_{\mathbb{H}} = k$

$\Delta$  s-rule



Theory A :  $U(k)$  with  $m$  flavours

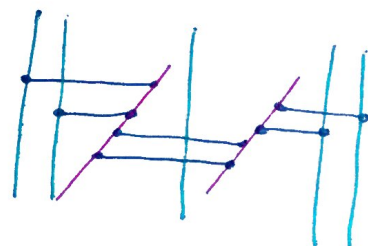
Theory B :  $U(k)^{m-2k+1} \times \left( \prod_{\ell=1}^{k-1} U(\ell) \right)^2$  with

matter  $\sum_{\ell=1}^{k-1} \left[ (\ell, \bar{\ell}+1) + (\ell+1, \bar{1}) \right] + (m-2k)(k, \bar{k}) + 2 \underline{k}$   
are mirror.

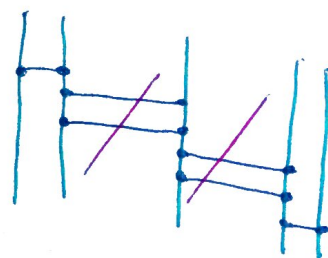
Quiver :



Higgs branch  
 $\dim_{\mathbb{H}} = k$



Coulomb branch  
 $\dim_{\mathbb{H}} = k(m-k)$



The dimensions of Higgs and Coulomb branches are exchanged.

NB . Complete Higgsing is only possible for  $m \geq 2k$ .

According to Hanany-Witten, this means that a mirror, understood as a model whose Coulomb branch is the Higgs branch of the original model, can only exist when  $m \geq 2k$ .

### Mirror for $SU(k)$ theory

$SU(k)$  is obtained from  $U(k)$  by ungauging the  $U(1)$

$$\rightarrow \text{then } \begin{cases} \dim \text{Coul} & (-1) \\ \dim \text{Higgs} & (+1) \end{cases}$$

In the mirror the process is reversed. Hence the conjecture:

The mirror of ungauging a  $U(1)$  is gauging a  $U(1)$

In the example above we can gauge the 2  $U(1)$  since one decouples. We obtain the mirror pair

