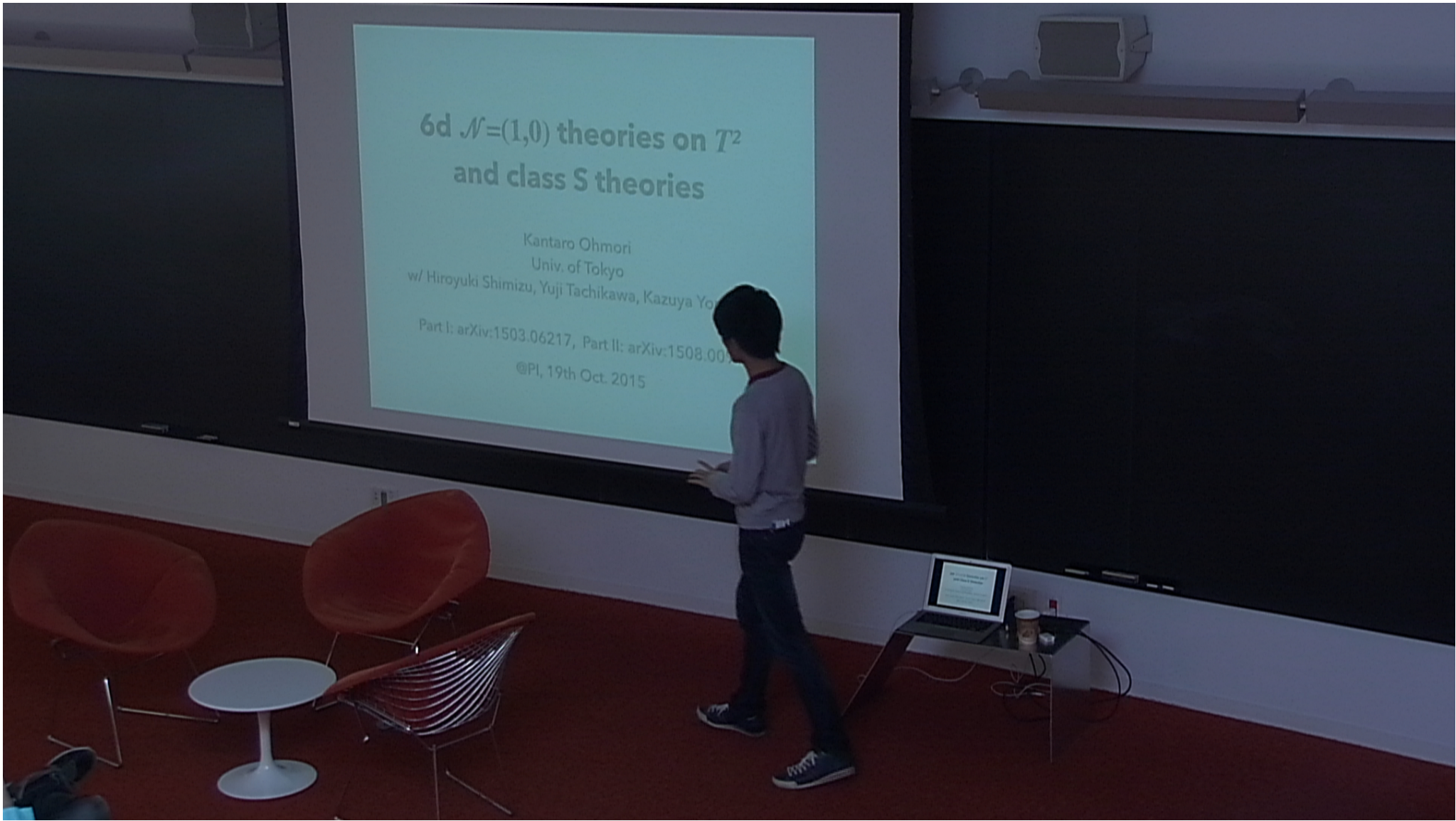


Title: 6d  $N=(1,0)$  theories on  $T^2$  and class S theories

Date: Oct 19, 2015 11:00 AM

URL: <http://pirsa.org/15100083>

Abstract: <p>In this talk I will discuss the most singular point and  $T^2$  compactifications of a 6d  $N=(1,0)$  supersymmetric conformal field theory (SCFT) which arises as the worldvolume theory on coincident  $N$  of M5 branes probing the singular locus of the ALE orbifold. When  $N=1$ , the compactified theory can be describe by a class S theory of three punctured sphere. Generalization to multiple M5s case results in a pair of 4d  $N=2$  SCFTs which are connected by a IR free gauge multiplet. Along the line, we see that the "dynamical version" of class S simple puncture plays a role. Closing one of two flavor groups, we can isolate one of them with manifest  $SL(2,Z)$  invariance of  $T^2$  and a non-abelian flavor group, including presumably new  $N=2$  SCFTs.</p>



**6d  $\mathcal{N}=(1,0)$  theories on  $T^2$   
and class S theories**

Kantaro Ohmori  
Univ. of Tokyo  
w/ Hiroyuki Shimizu, Yuji Tachikawa, Kazuya Yonekura

Part I: arXiv:1503.06217, Part II: arXiv:1508.00013  
@PI, 19th Oct. 2015



## Why 6d $\mathcal{N}=(1,0)$ SCFTs?

- $\mathcal{N}=(2,0)$  theories are known to be important



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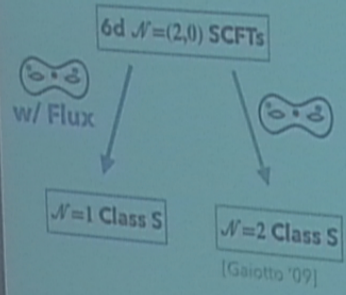


# 4d SCFTs from 6d theories



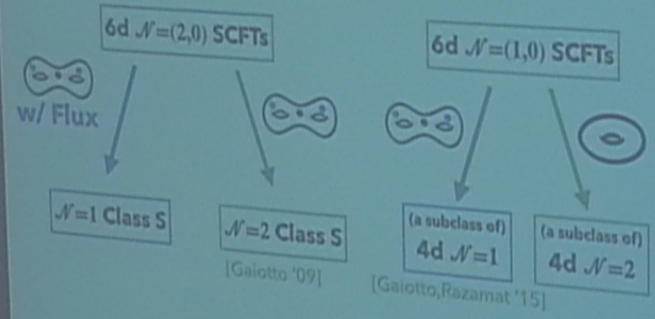


# 4d SCFTs from 6d theories



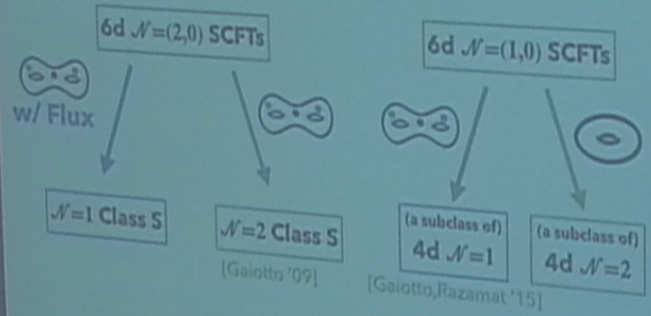


# 4d SCFTs from 6d theories



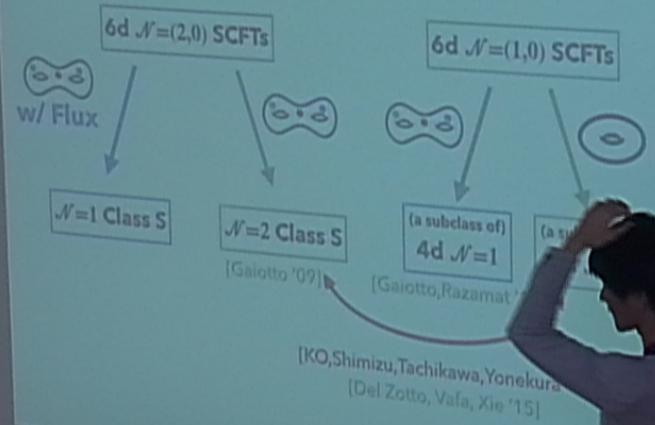


# 4d SCFTs from 6d theories





# 4d SCFTs from 6d theories






## Minimal conf. matter on $T^2$ [Part I]

Min. (g, g) conf. mat. = Single M5 probing  $\mathbb{C}^2/\Gamma_g$   
 $g = A, D, E$

Min. (g, g) conf. mat. on  $T^2$

=

Class S of type g with 

- : "full" puncture (g symmetry)
- : "simple" puncture ( $U(1)$  or no sym.)



## Minimal conf. matter on $T^2$ [Part I]

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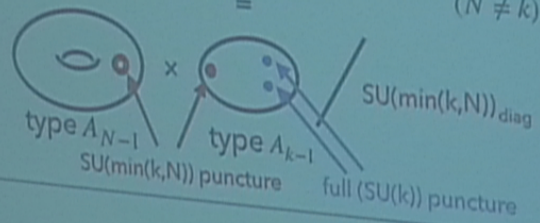


- : "full" puncture ( $\mathfrak{g}$  symmetry)
- : "simple" puncture ( $U(1)$  or  $n$ -sym)

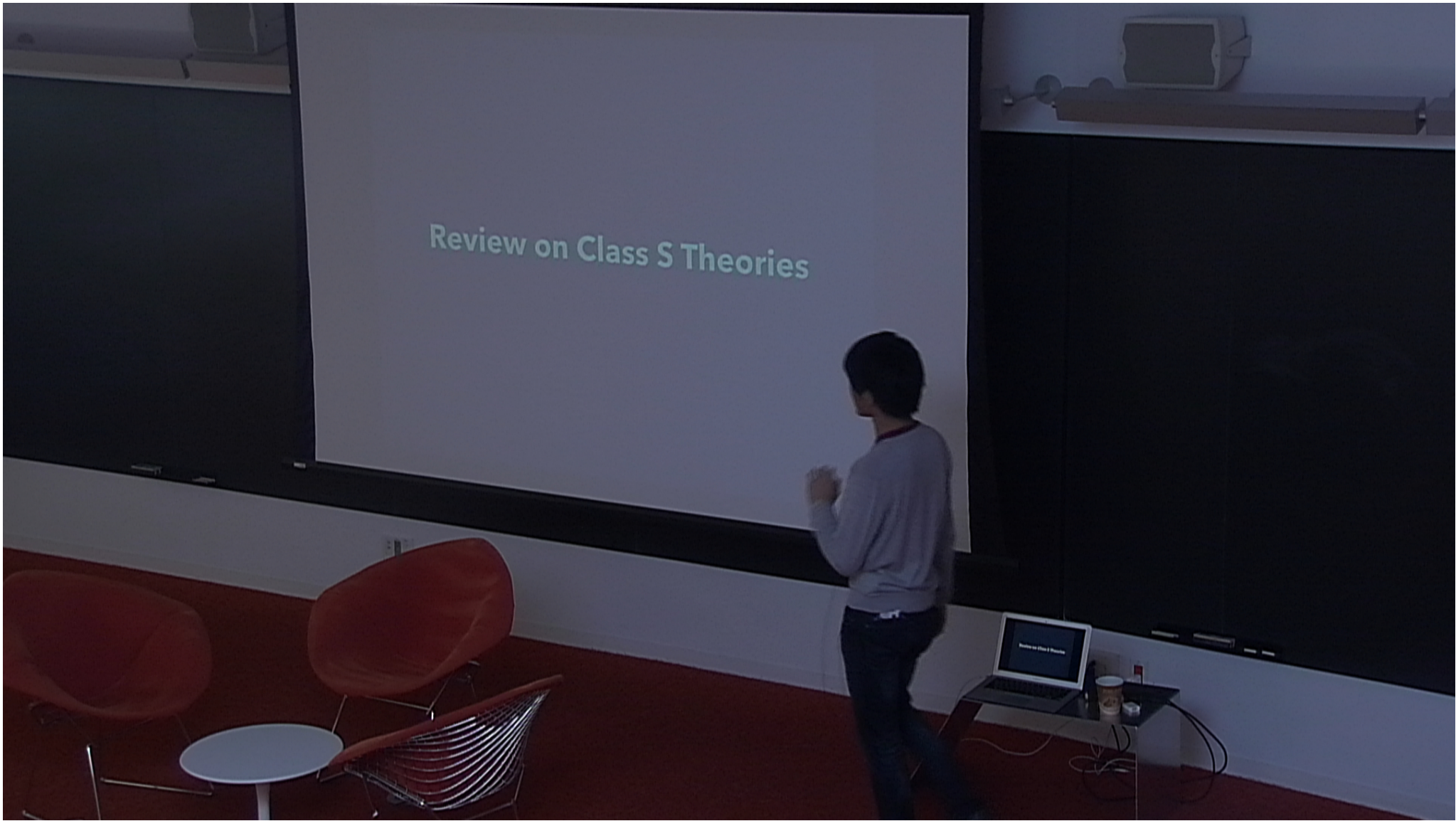


## An example of results

$T^2$  c.p.f.ed  $N$  Coincident M5s probing  $C^2/Z_k$   
( $N \neq k$ )




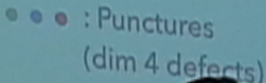






## Class S theories

6d  $\mathcal{N}=(2,0)$  theories of type  $\mathfrak{g} = A, D, E$   
(= A, D, E type sing. in IIB string)

on  

→ 4d  $\mathcal{N}=2$  Class S theory (of type  $\mathfrak{g}$ )




## Class S punctures





## Relevant examples

Type  $A_{k-1}$  class S w/   
= Bifundamental hyper



## Relevant examples


Type  $A_{k-1}$  class S w/




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## Relevant examples

Type  $A_{k-1}$  class S w/   
= Bifundamental hyper

Type  $D_4$  class S w/   
= Minahan-Nemeshansky  $E_8$   
Symmetry enhancement:  $SO$







## 6d $\mathcal{N}=(1,0)$ Supermultiplets

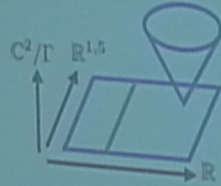
- 8 supercharges,  $SU(2)$  R-symmetry
- Tensor multiplet:  $(B_{\mu\nu}^+, \psi^+, a)$   
 $a \in \mathbb{R}$  : "tensor branch" vev (preserves R-sym)
- Vector multiplet:  $(A_\mu, \lambda^-)$   
No scalar
- Hyper multiplet:  $(\phi_i, \psi^+)$   $i = 1, 2, 3, 4$   
 $\phi \in \mathbb{R}^4$  : "Higgs branch" vev (breaks R-sym)



[Del Zotto, Heckman, Tomasiello, Vafa '14]

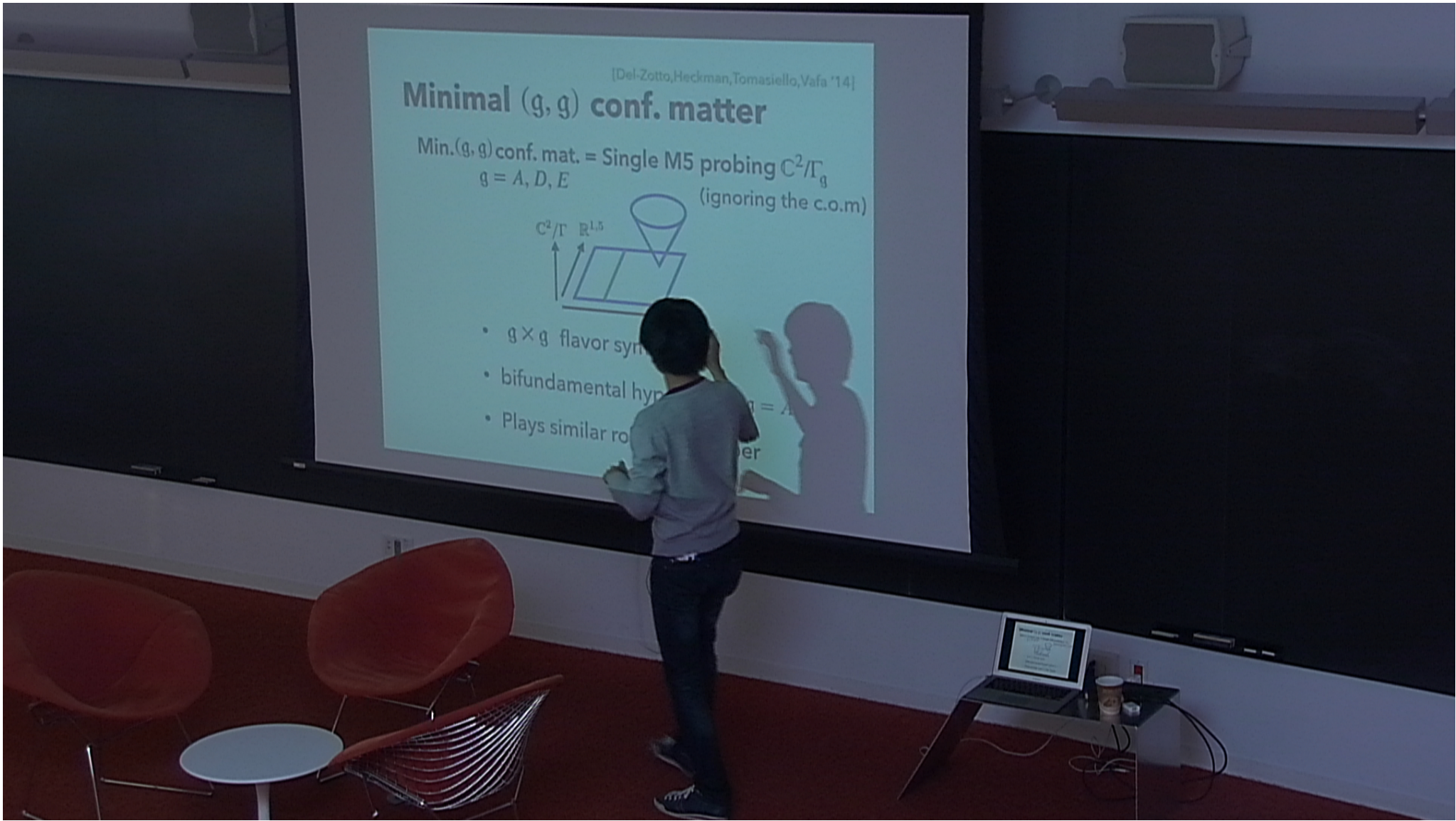
## Minimal $(g, g)$ conf. matter

Min.  $(g, g)$  conf. mat. = Single M5 probing  $C^2/\Gamma_g$   
 $g = A, D, E$  (ignoring the c.o.m)



- $g \times g$  flavor sym
- bifundamental hyper when  $g = A$
- Plays similar role to bif. hyper



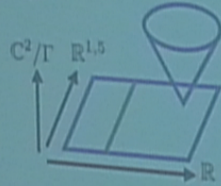




[Del Zotto, Heckman, Tomasiello, Vafa '14]

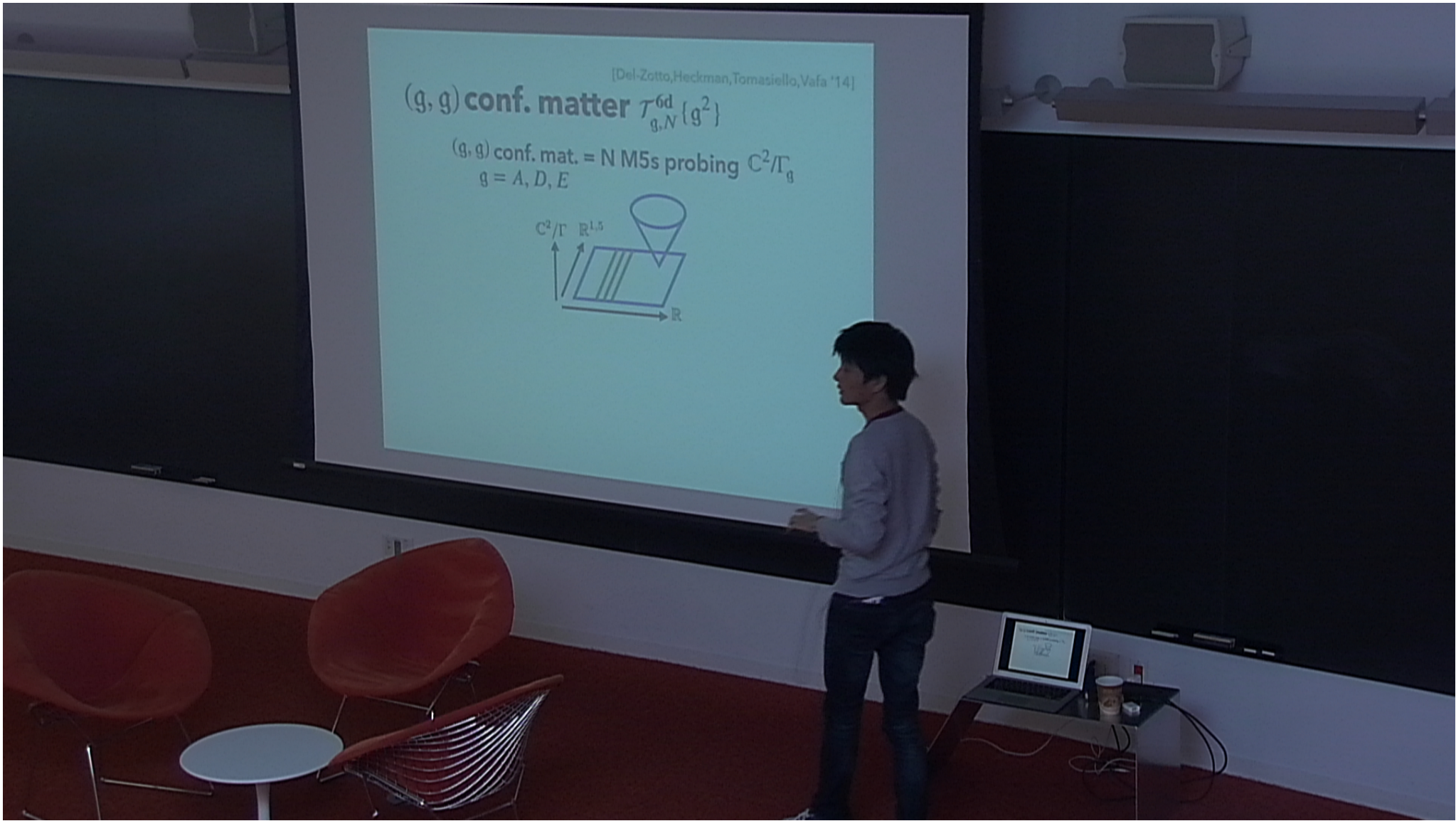
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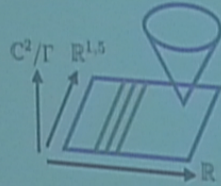




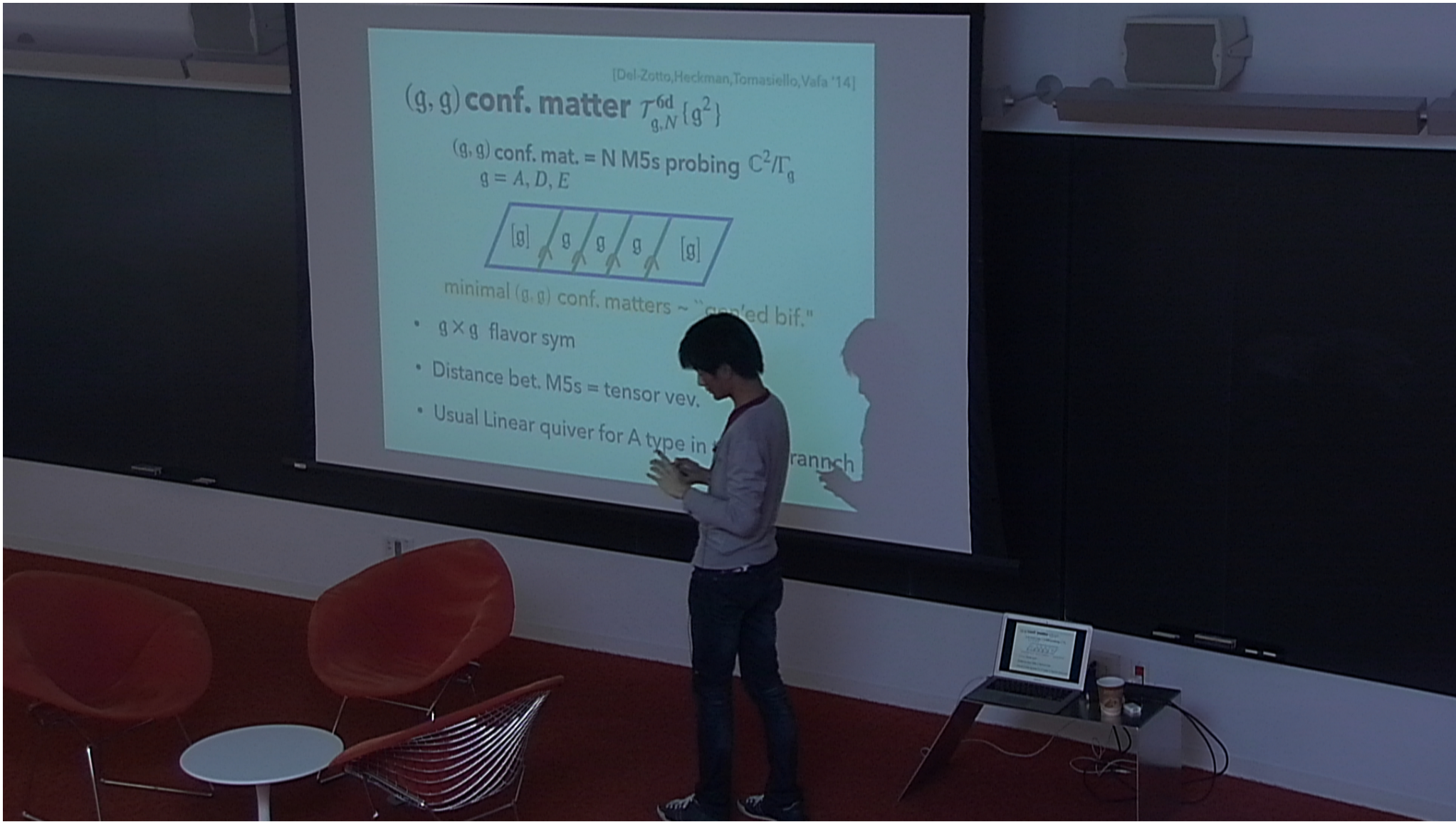
[Del-Zotto, Heckman, Tomasiello, Vafa '14]

**$(g, g)$  conf. matter**  $\mathcal{T}_{g, N}^{6d}(g^2)$

$(g, g)$  conf. mat. =  $N$  M5s probing  $C^2/\Gamma_g$   
 $g = A, D, E$



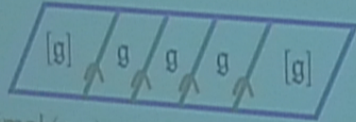




[Del Zotto, Heckman, Tomasiello, Vafa '14]

# $(g, g)$ conf. matter $\mathcal{T}_{g,N}^{6d} \{g^2\}$

$(g, g)$  conf. mat. = N M5s probing  $C^2/\Gamma_g$   
 $g = A, D, E$



minimal  $(g, g)$  conf. matters ~ "con'ed bif."

- $g \times g$  flavor sym
- Distance bet. M5s = tensor vev.
- Usual Linear quiver for A type in ... branch





# Minimal Conformal Matter on $T^2$

(Part I)





## Known examples and Class S

- Single M5 on  $\Gamma = A_k$  singularity  
⇒ bifundamental both in 6d and 4d.  
= type  $A_k$  class S w/ 
- Single M5 on  $\Gamma = D_4$  singularity  
⇒ Rank 1 E-sting theory in 6d  
⇒ Minahan-Nemeshansky  $E_8$  theory in 4d  
= type  $D_4$  class S w/ 



## Known examples and Class S

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= type  $D_4$  class S w/ 
- $X = \text{simple ?}$



## Checks

- Dim.s of Higgs/Coulomb branches matches
- Weakly gauged Higgs branch =  $C^2/\Gamma_\theta$
- Conformal anomalies and flavor levels
- Checked 4d "Base-Fiber duality" for

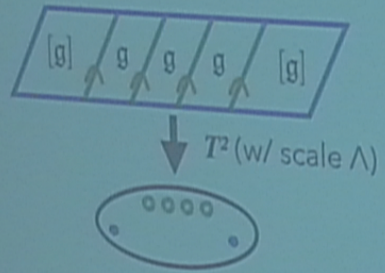


## Checks

- Dim.s of Higgs/Coulomb branches matches
- Weakly gauged Higgs branch =  $\mathbb{C}^2/\Gamma_0$
- Conformal anomalies and flavor levels
- Checked 4d "Base-Fiber duality" for  $g=D_4$
- Proven using mirror sym. by [Del Zotto, Vafa, Xie '15]



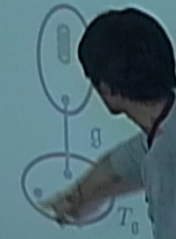
## Tensor branch theory



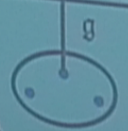


# What happens at the origin?

(N : sufficiently large)



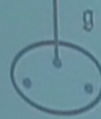
limit Something



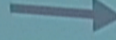


## Required properties

Something



Higgs



$N=4$  SYM of  $SU(N)$

"Something"  $\supset SU(N)_\tau$



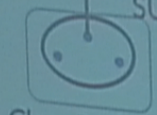
# Proposal for A type ( $k < N$ )

Class S of type  $A_{N-1}$



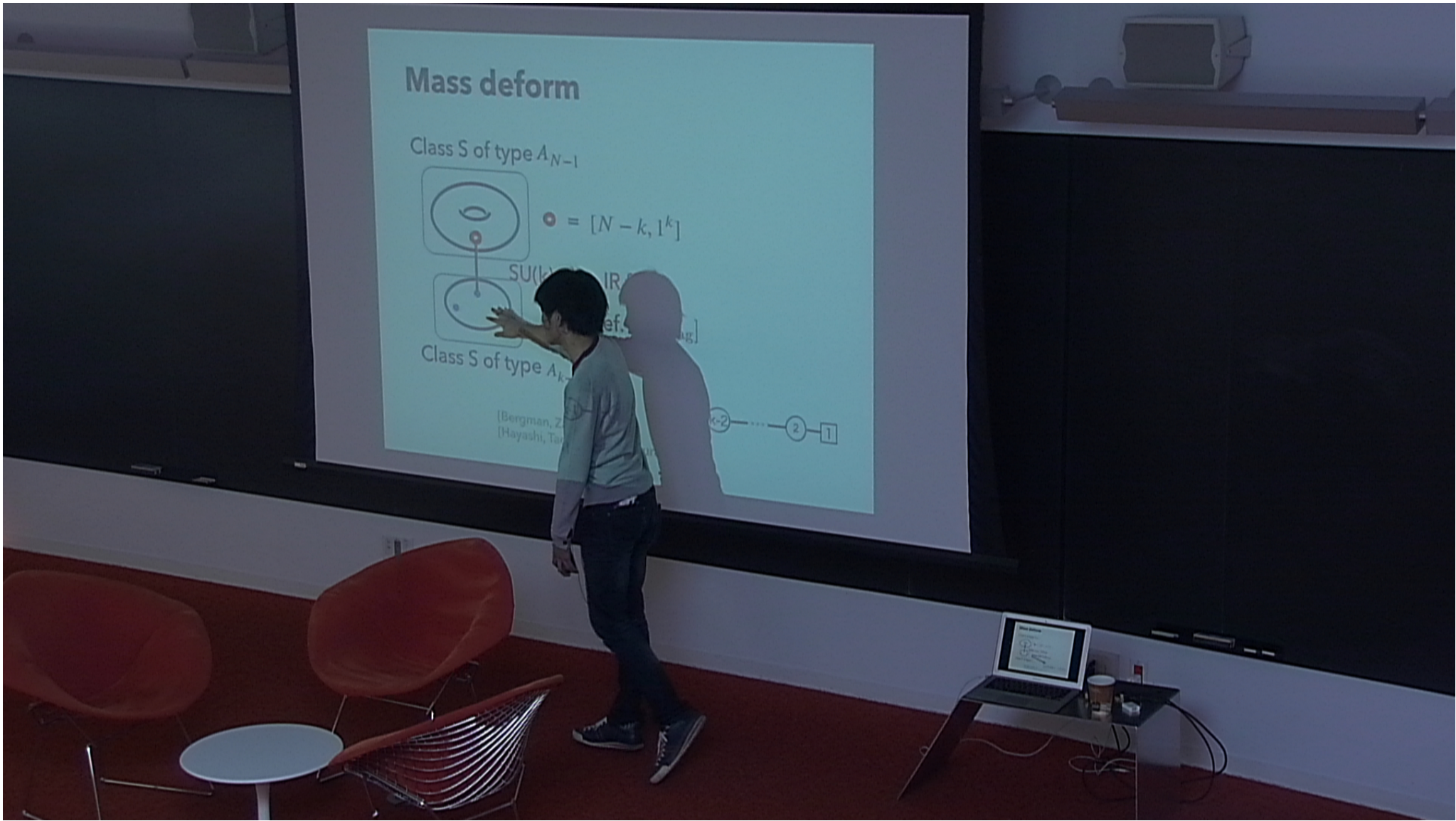
$$\bullet = [N - k, 1^k]$$

SU(k) vec.



Class S of type  $A_{k-1}$

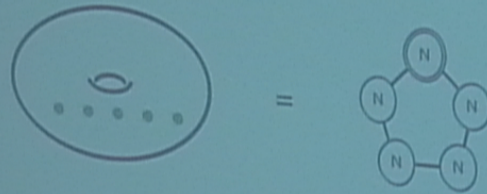






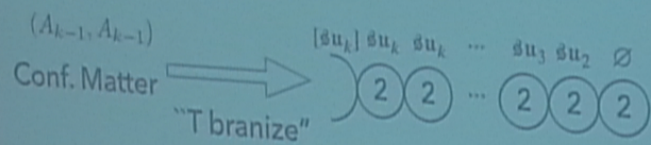
# Mass deform

Class S of type  $A_{N-1}$



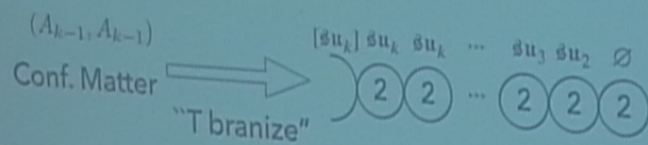


## Cases without IR free vector

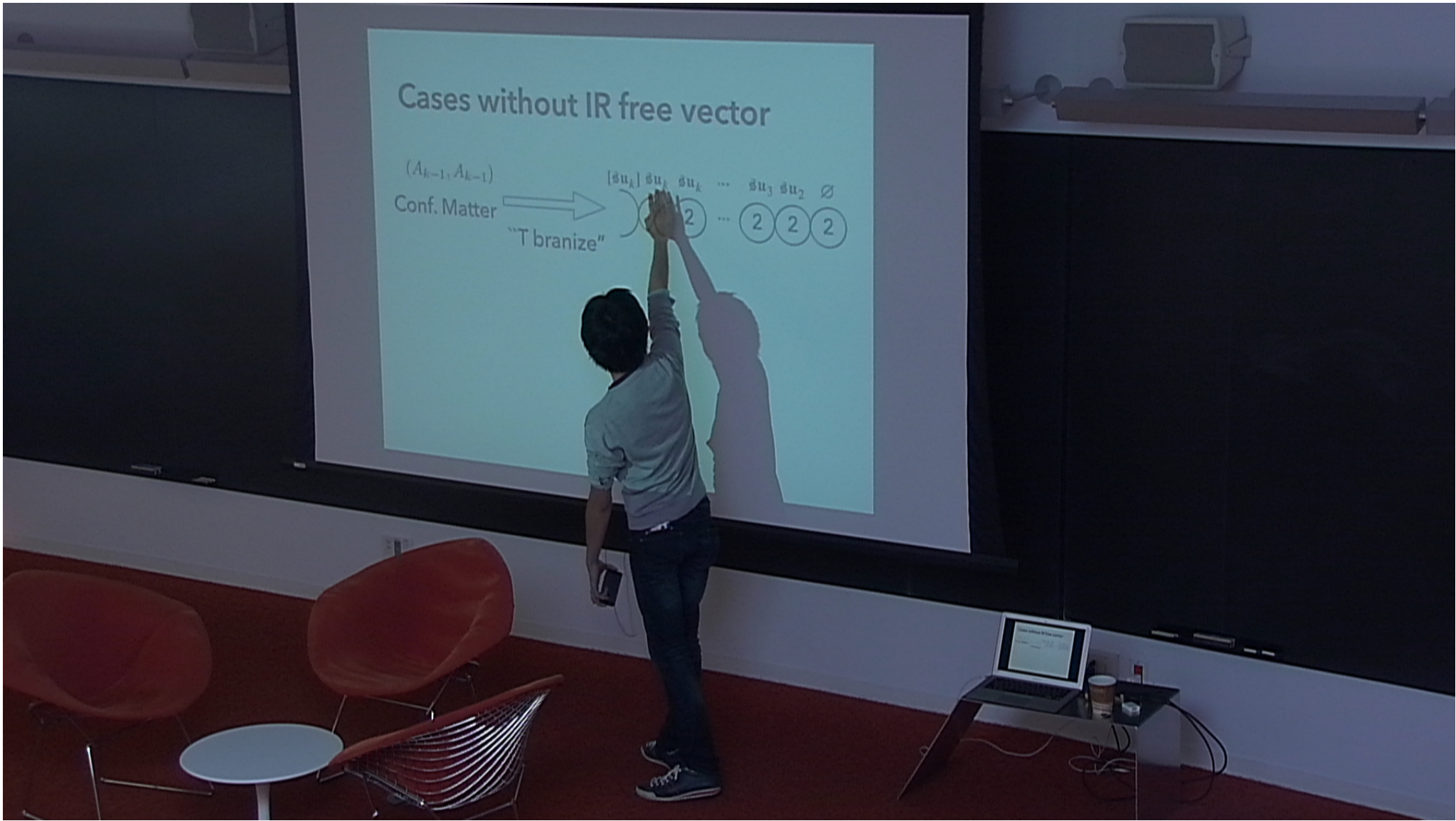




## Cases without IR free vector









## Summary

"Minimal  $(G,G)$  conformal matter" on  $T^2$

$\xrightarrow{IR}$

Class  $S$  of type  $G$  with





# Summary

"Minimal  $(G,G)$  conformal matter" on  $T^2$

$\xrightarrow{IR}$

Class S of type G with



conformal matter on  $T^2$  = Some

Another Class S (A,D type)

New (?) (E type)

Includes  $SU(N)_\tau : SL(2,Z)$  manifest





## Summary

"Minimal  $(G,G)$  conformal matter" on  $T^2$

$\xrightarrow{\text{IR}}$

Class S of type G with



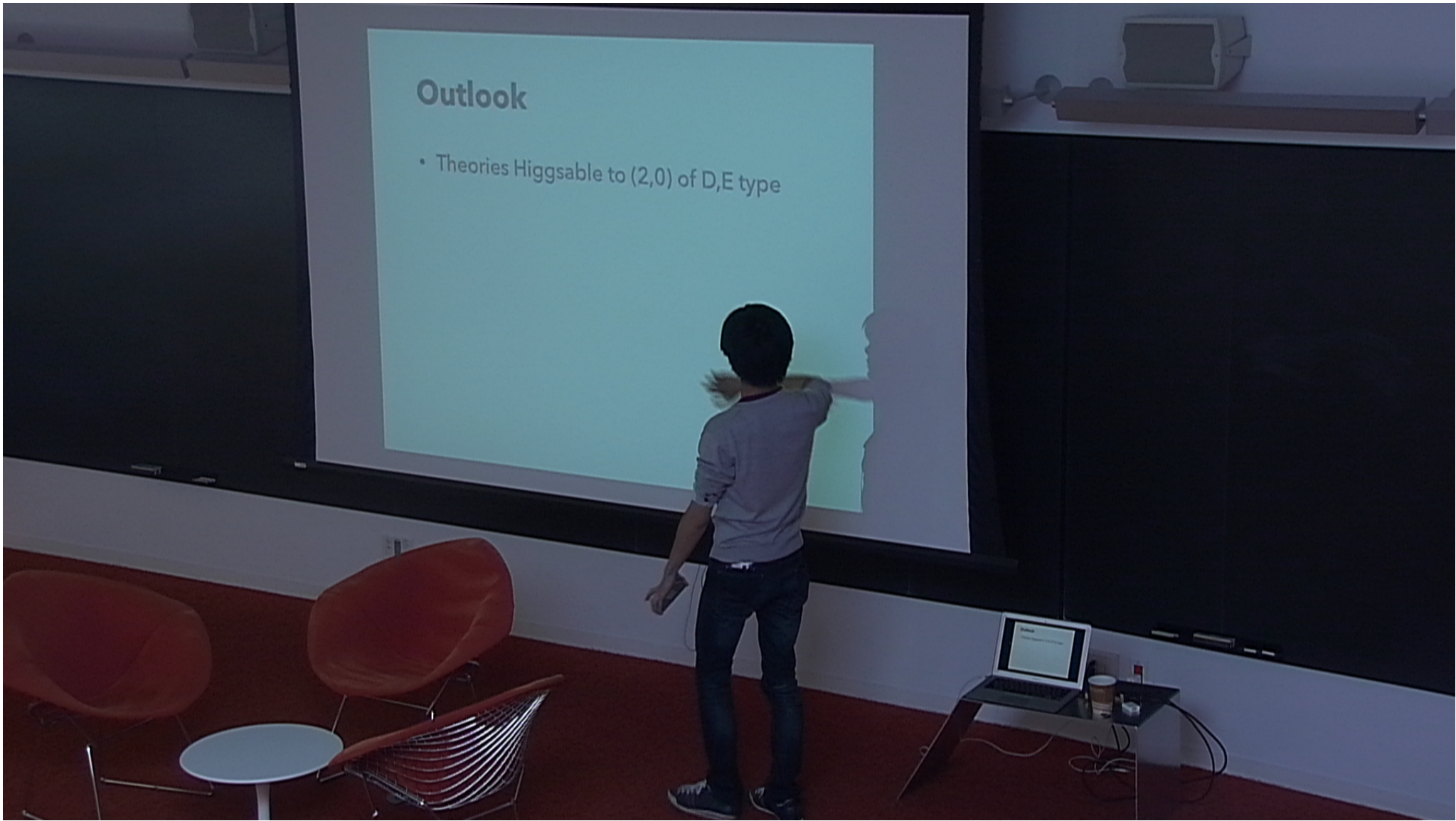
conformal matter = S-duality

Another Class S (A type) IR free

New (?) (E type)

Includes  $SU(N)_r$  : SL



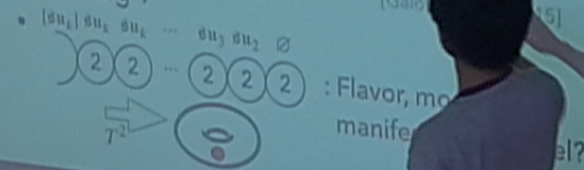




## Outlook

- Theories Higgsable to (2,0) of D,E type
- Compactification on Riemann surfaces
  - $\Rightarrow$  4d N=1 theories
- What 6d theories are suitable?

- (A,A) conf. matters breaking flavor
- E-string ?

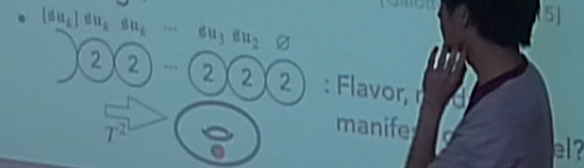




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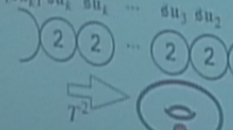
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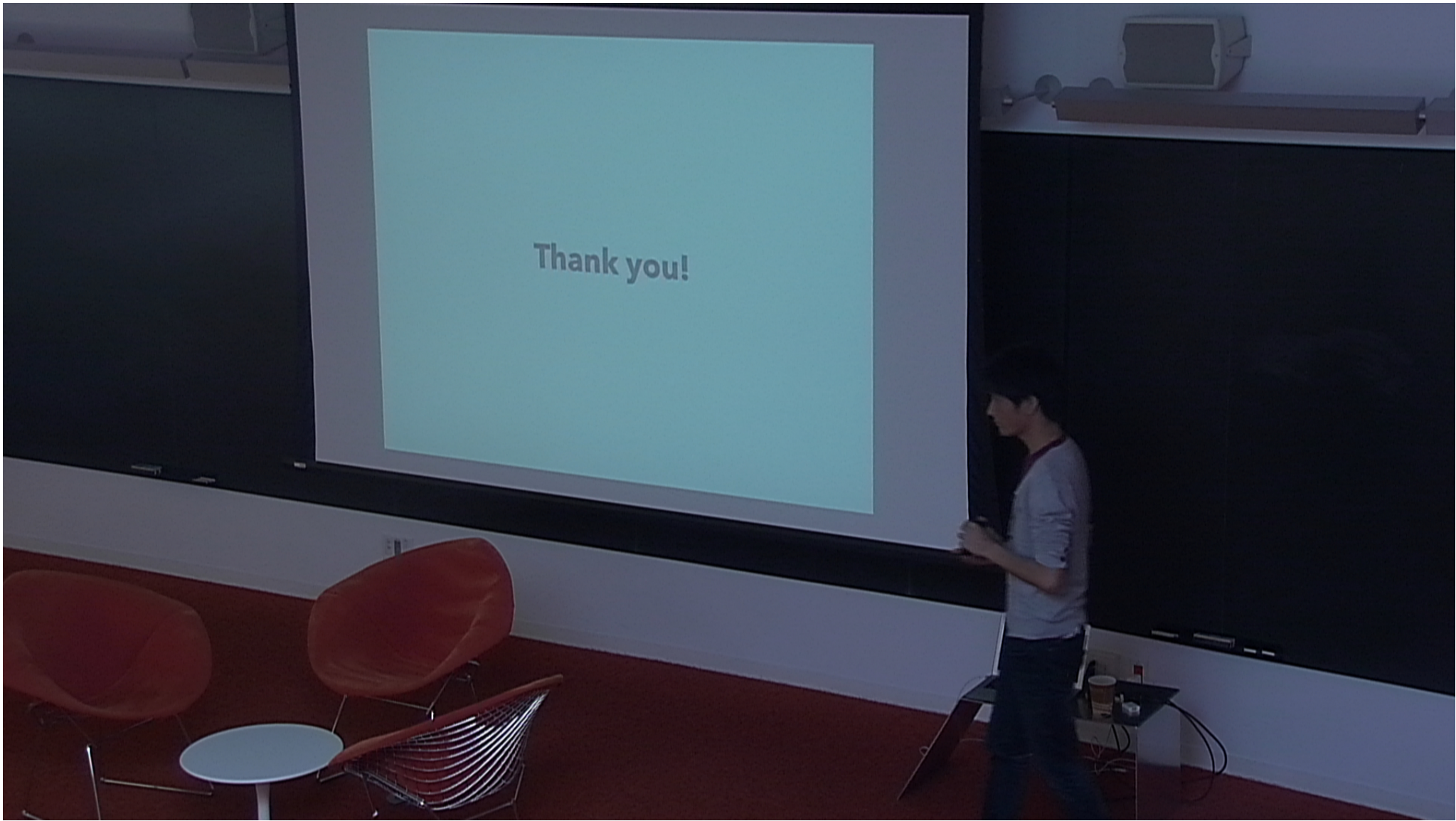
- (A,A) conf. matters breaking flavor

- E-string ?

- $|su_1| su_k su_l \dots su_3 su_2 \emptyset$   
 : Flavor, modular  
manifest conf. mode

[Gaiotto, Razamat]









### Cases without IR free vector

