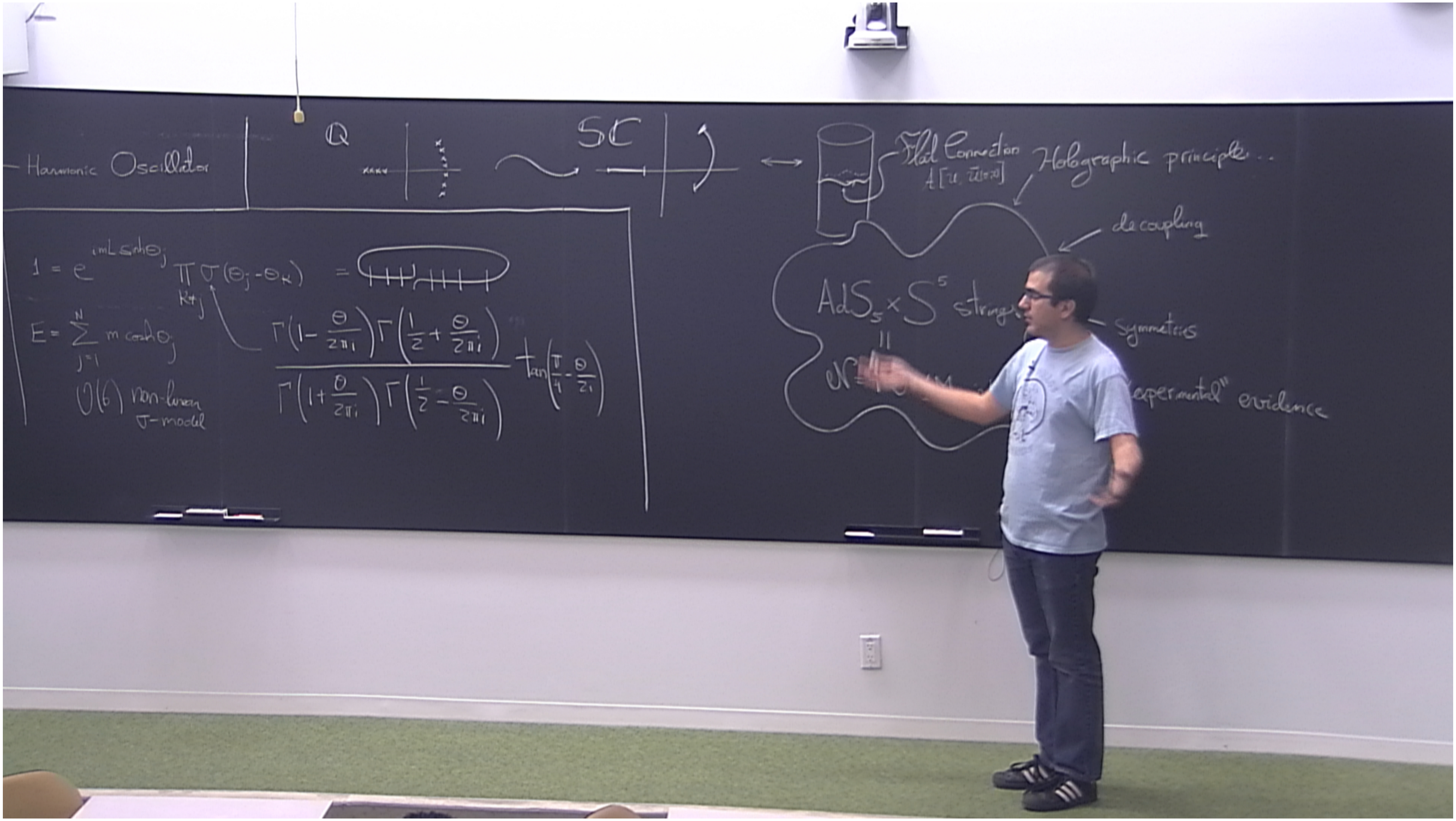
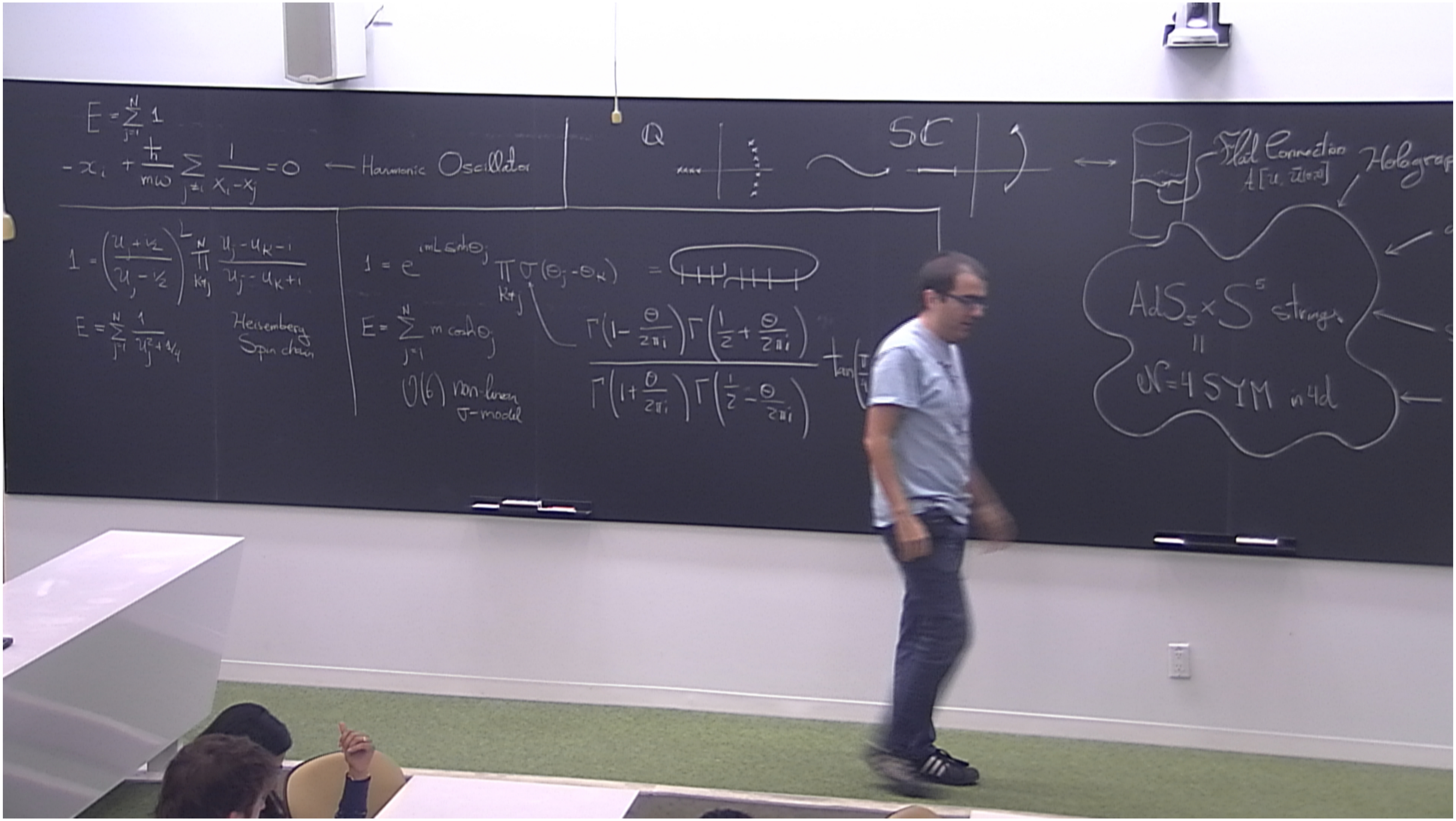
Title: Explorations in String Theory -15

Date: Apr 24, 2015 11:30 AM

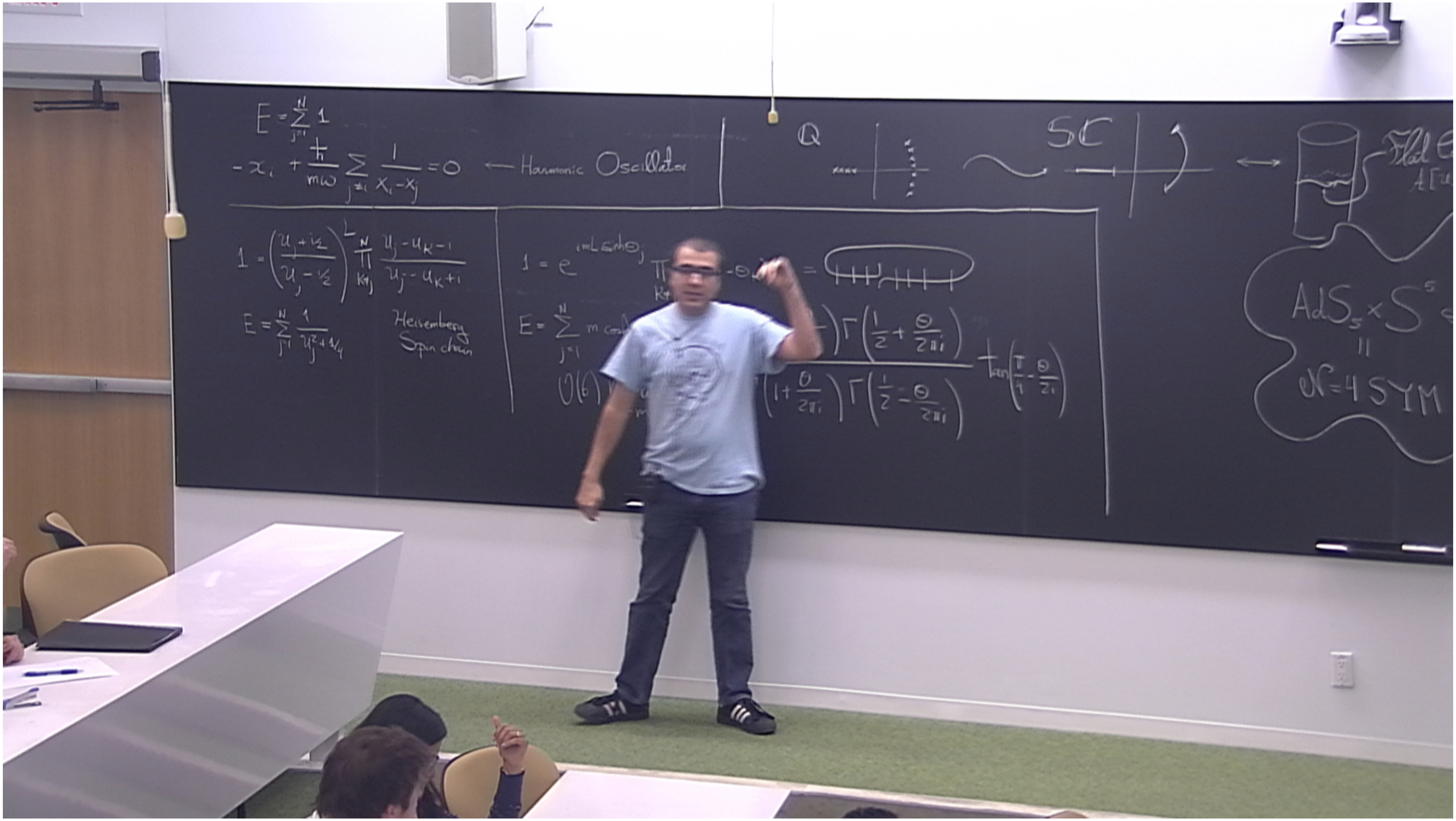
URL: http://pirsa.org/15040154

Abstract:


Harmonic Oscillator
Q
SC
Flat Connection
Holographic principle..
decoupling
AdS5 × S5 strings
symmetries
"experimental" evidence
non-linear
σ-model



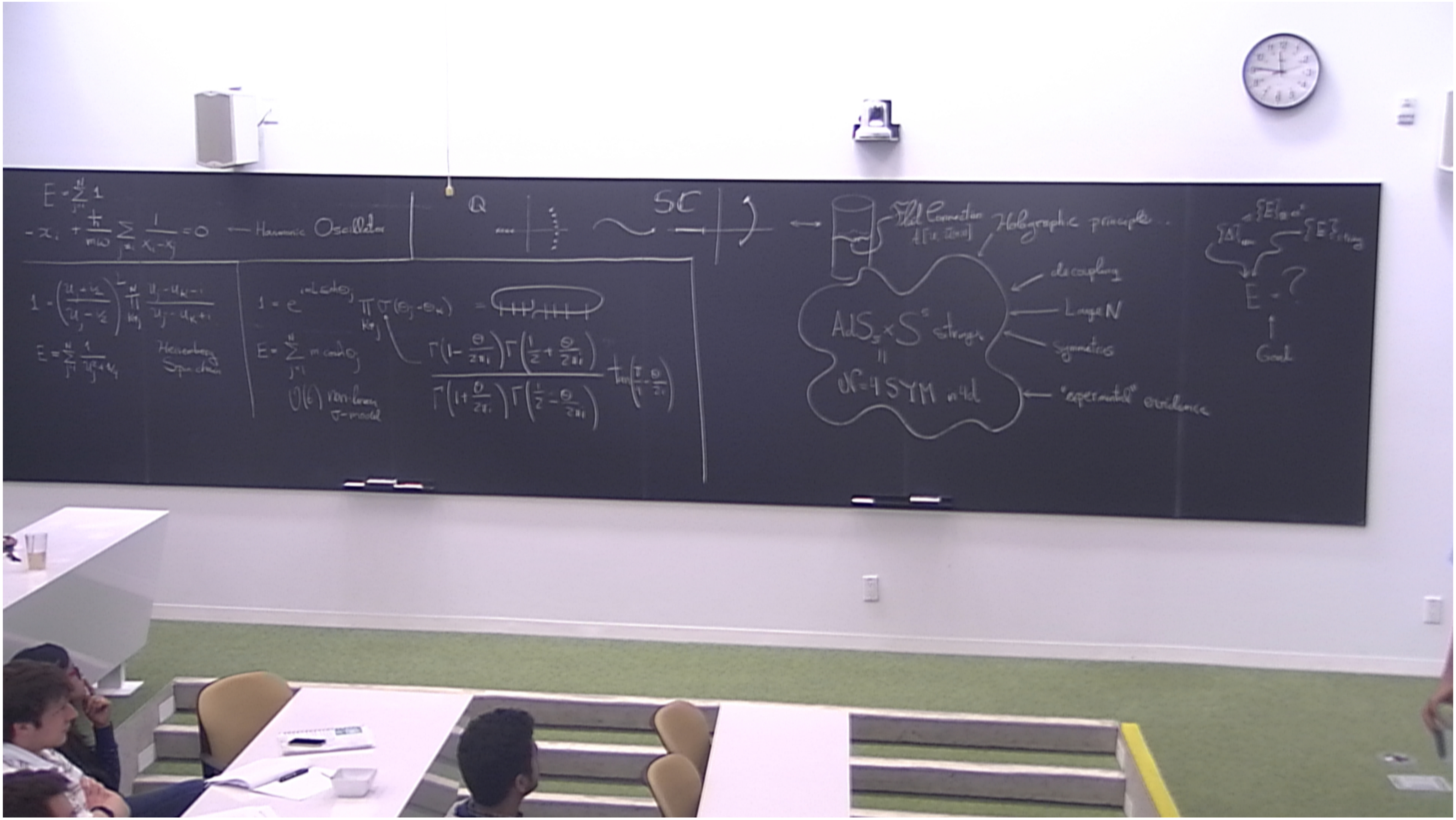
Harmonic Oscillator
Heisenberg Spin chain
O(6) non-linear σ-model
Q
SC
Flat Connection
Holograp
AdS5 × S5 strings
N=4 SYM in 4d

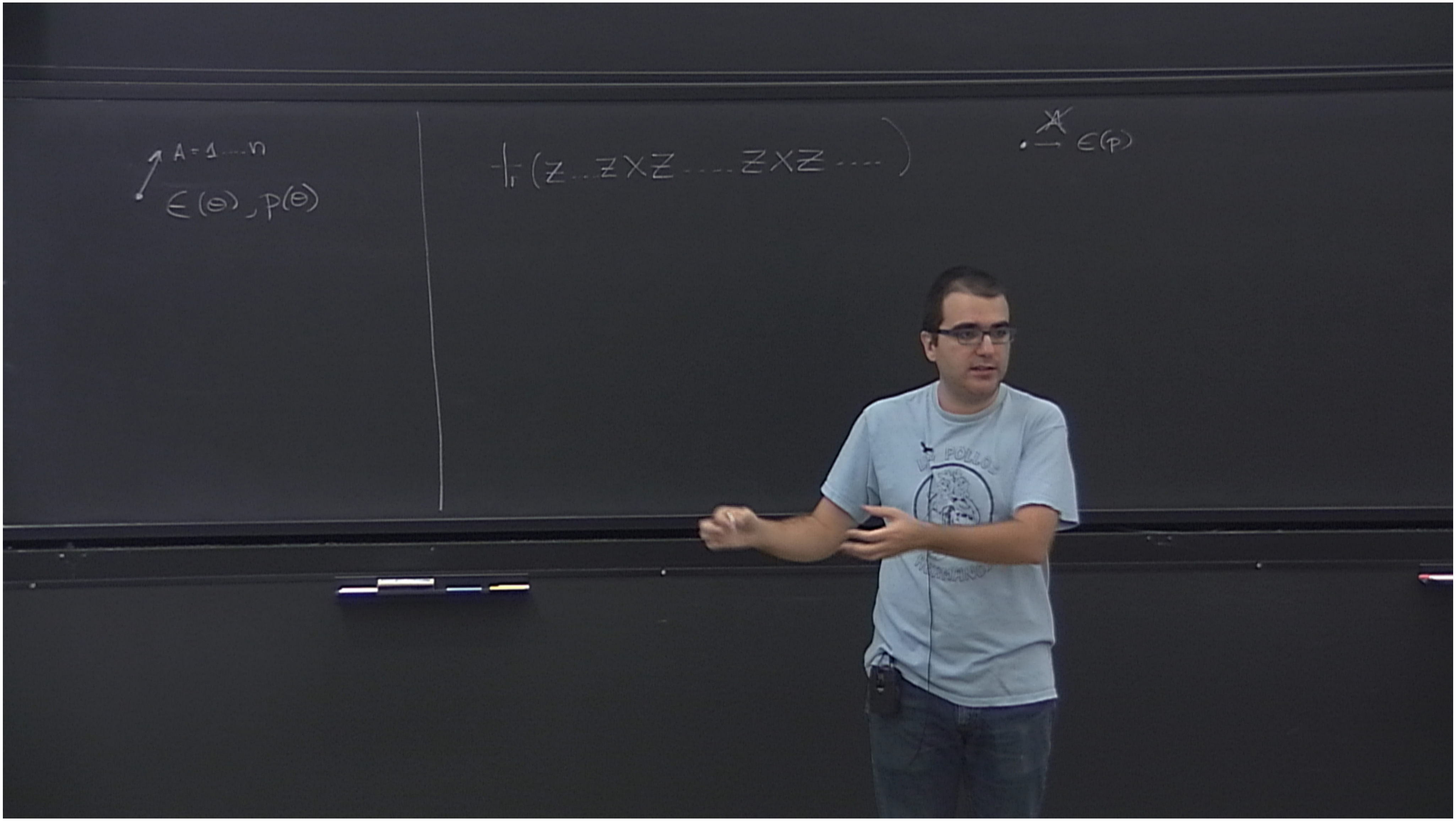

Harmonic Oscillator
Q
SC
Heisemberg Spin chain
AdS5 x S5
N=4 SYM

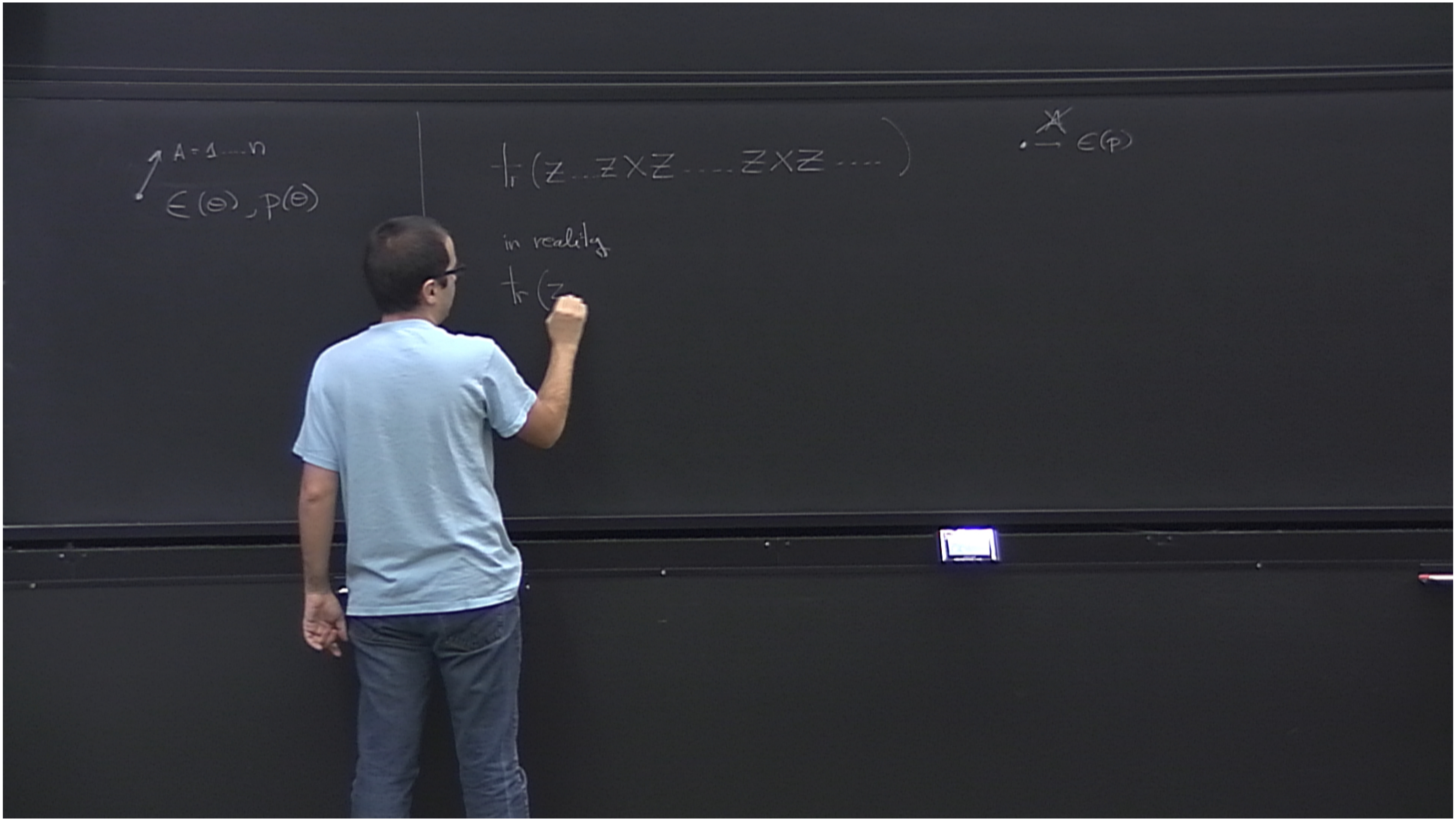

Harmonic Oscillator
Heisenberg Spin chain
O(6) non-linear σ-model
SC
Flat Connection
Holographic principle..
decoupling
AdS5 × S5 strings
N=4 SYM in 4d
symmetries
"experimental" evidence

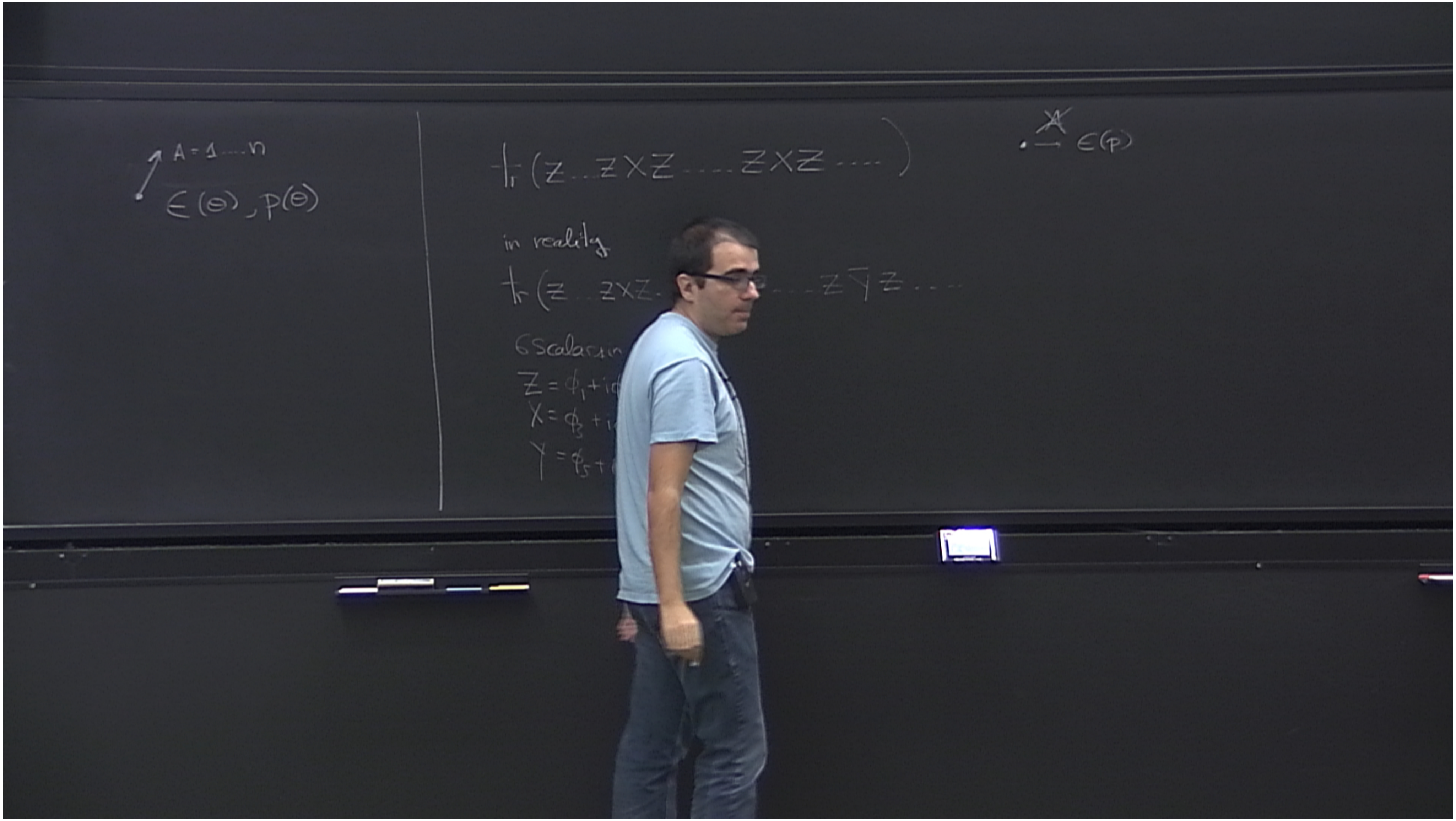

Harmonic Oscillator
Q
SC
Heisenberg Spin chain
O(6) non-linear σ-model
Holographic principle..
decoupling
symmetries
"experimental" evidence
AdS5×S5 strings
N=4 SYM in 4d

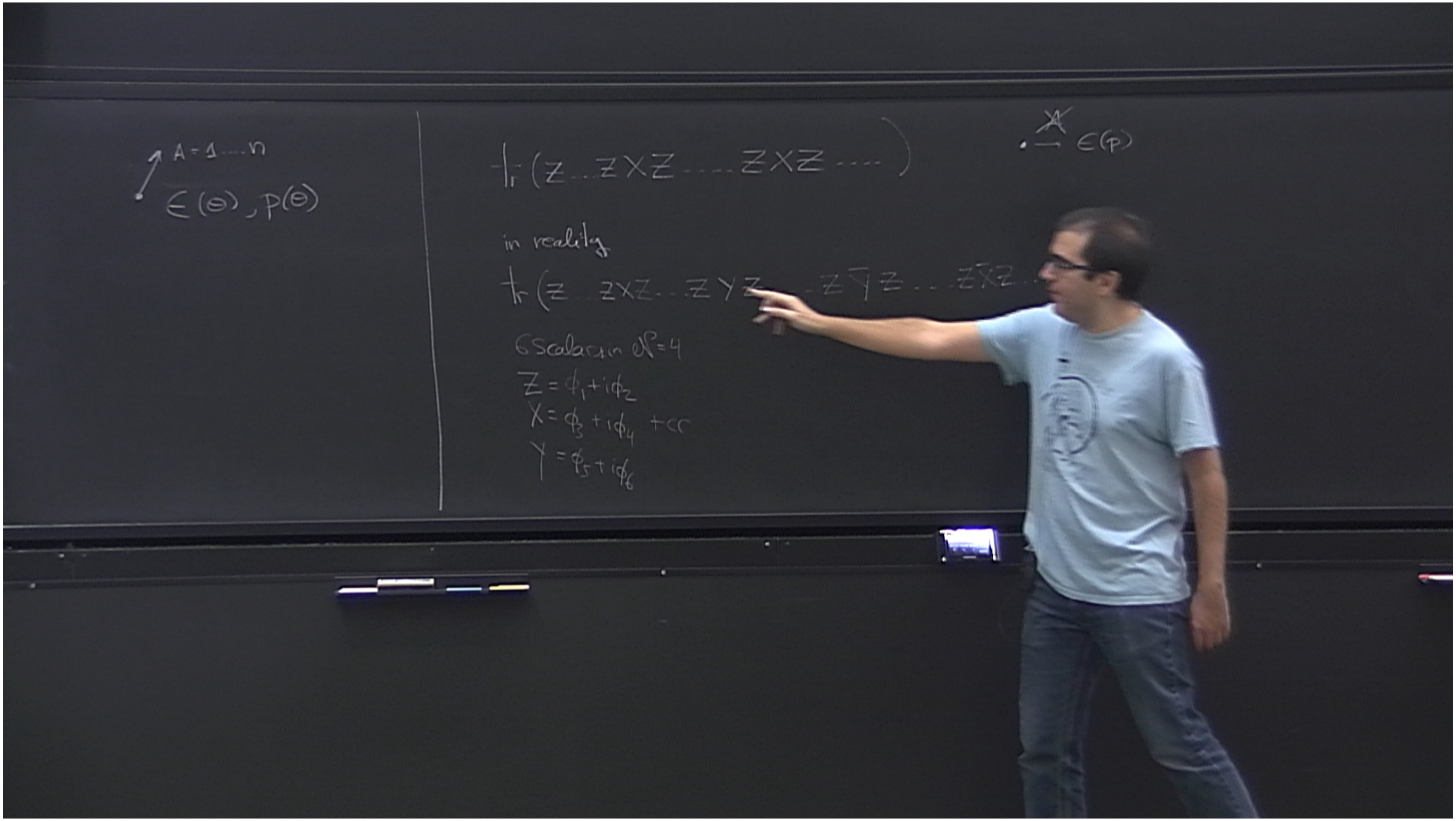

Harmonic Oscillator
Heisenberg Spin chain
O(6) non-linear σ-model
Q
SC
Holographic principle
decoupling
AdS5 × S5 strings
N=4 SYM in 4d
symmetries
"experimental" evidence

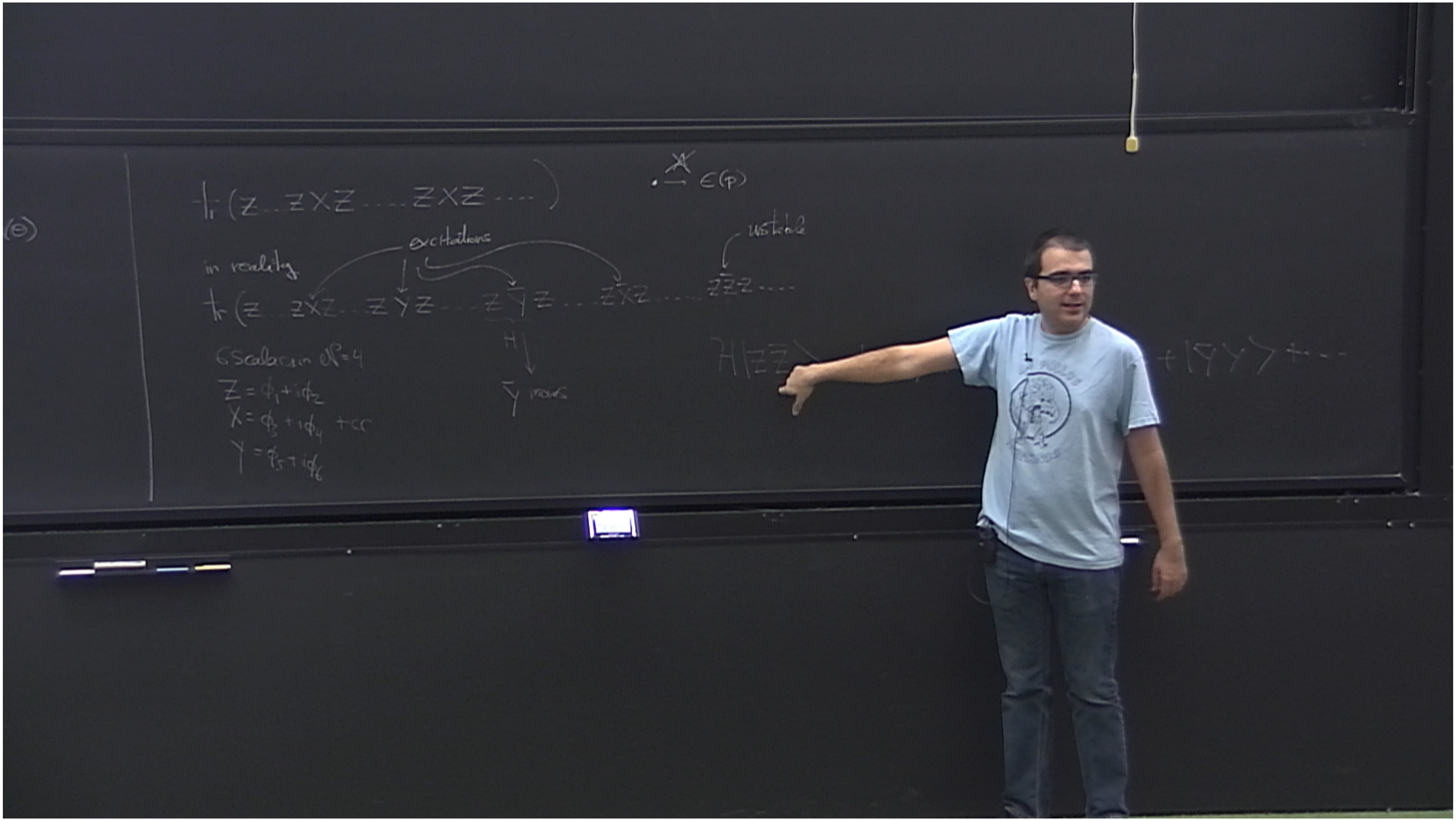

Harmonic Oscillator
Heisenberg Spin chain
Flat Connection
Holographic principle
decoupling
Large N
Symmetries
"experimental" evidence
strings
SYM in 4d
Goal

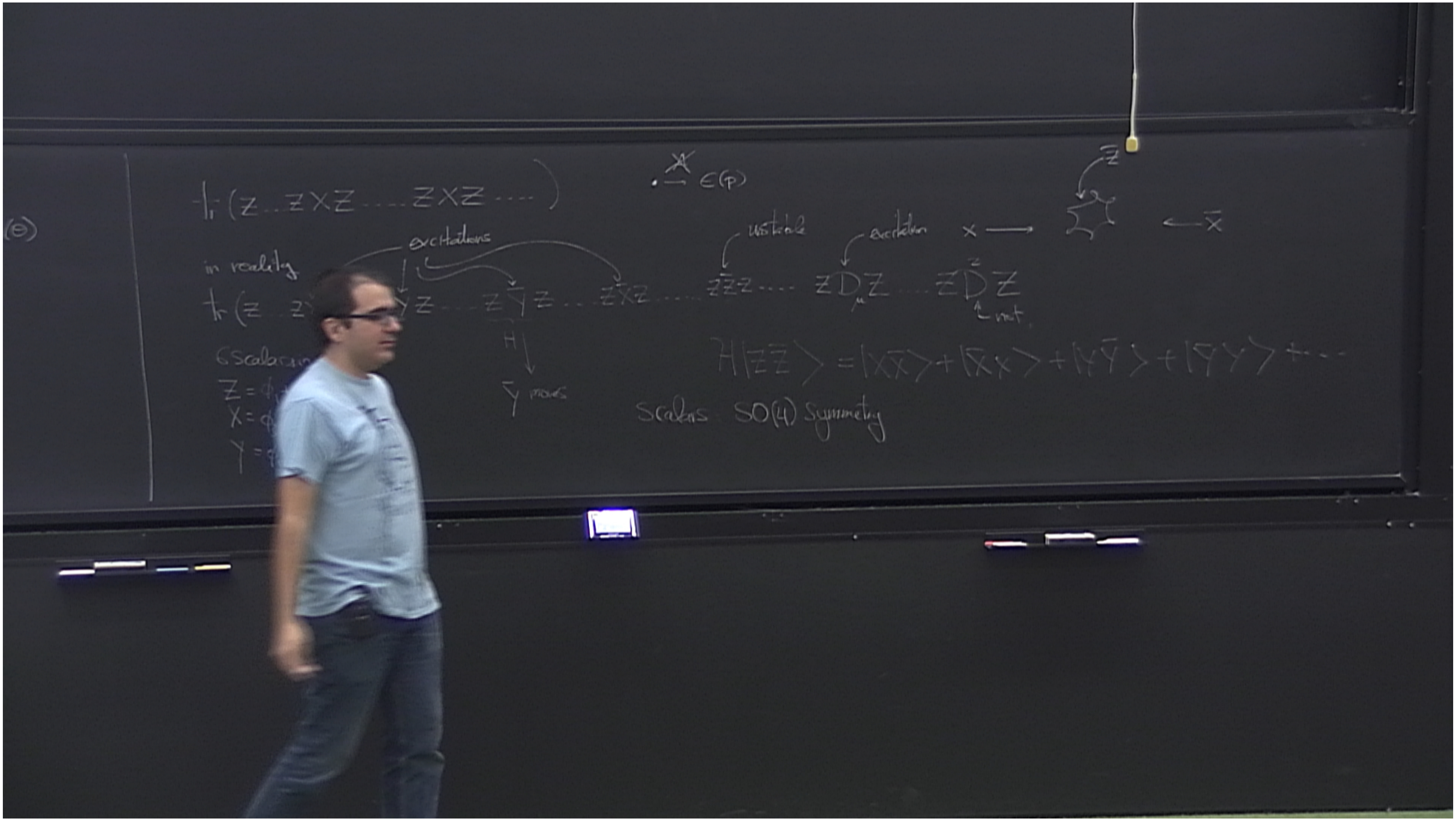

A = 1 .... n
∈(θ), p(θ)
tr (Z...ZXZ.....ZXZ.....)
∈(p)

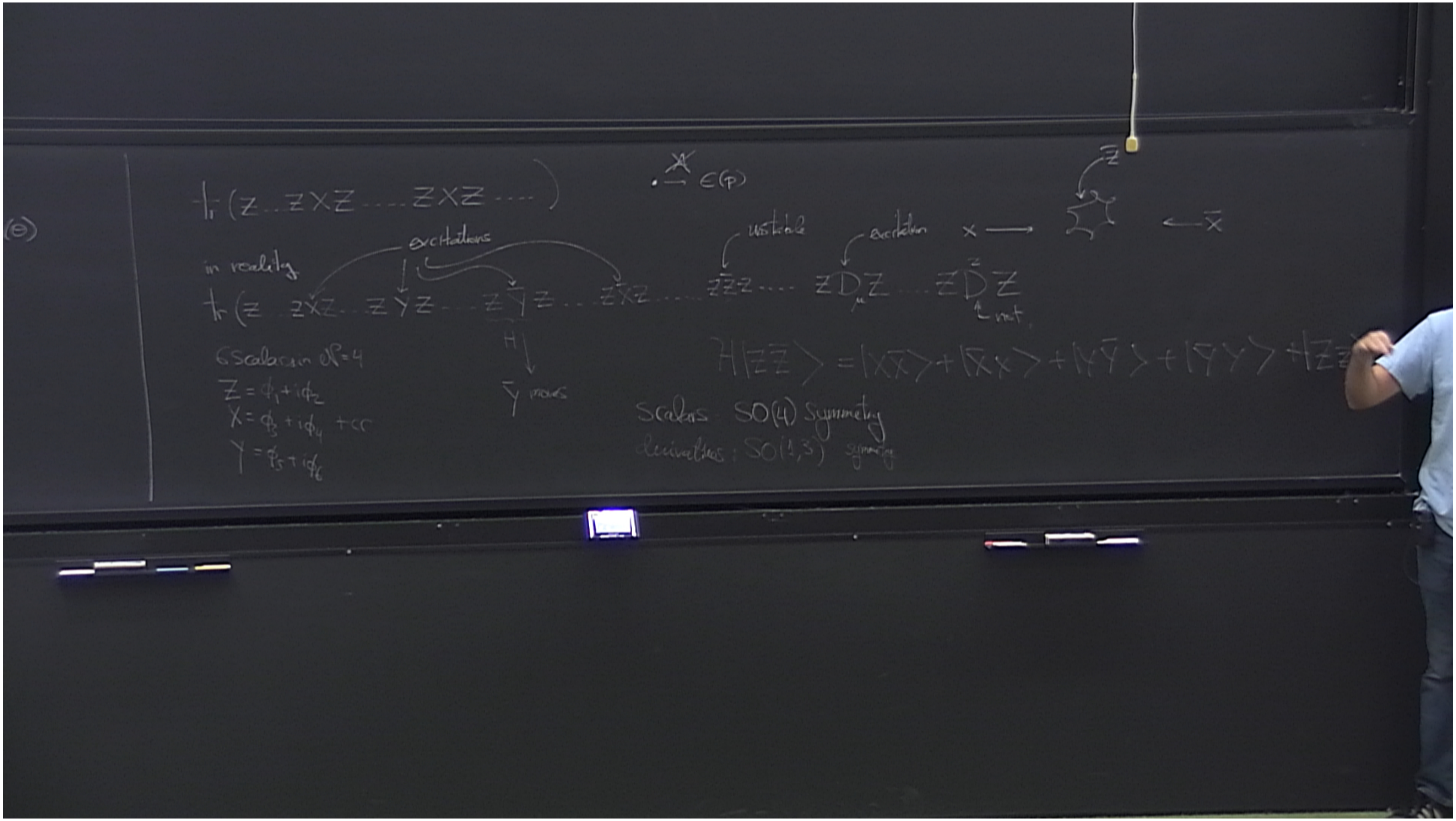

A = 1 .... n
∈(θ), p(θ)
tr(Z...ZXZ.....ZXZ....)
∈(p)
in reality
tr(Z

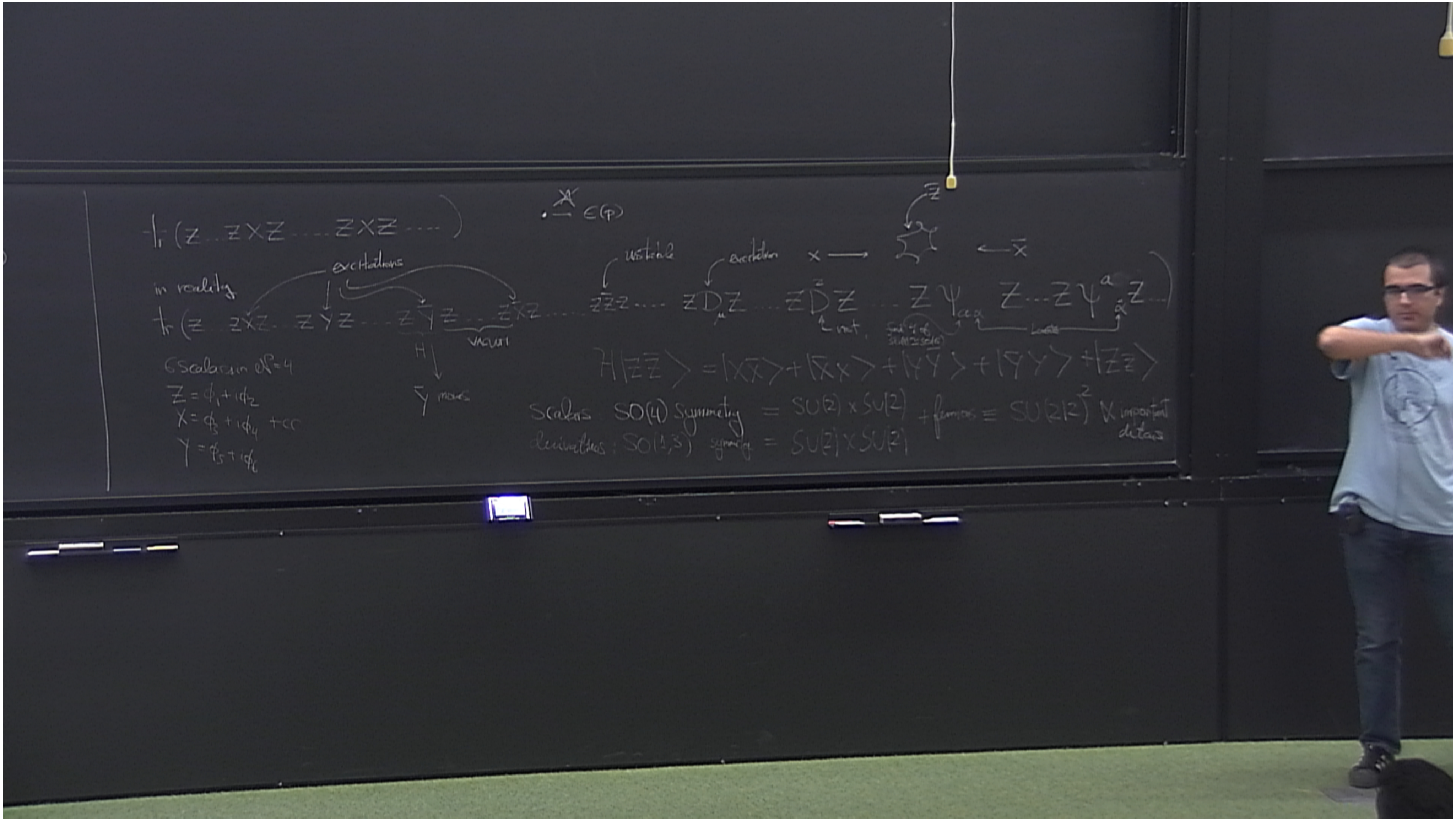

A = 1 .... n
E(θ), P(θ)
tr(Z...ZXZ.....ZXZ....)
E(p)
in reality
tr(Z...ZXZ
....ZȲZ....
6 scalars in
Z = φ1 + i
X = φ3 + i
Y = φ5 +

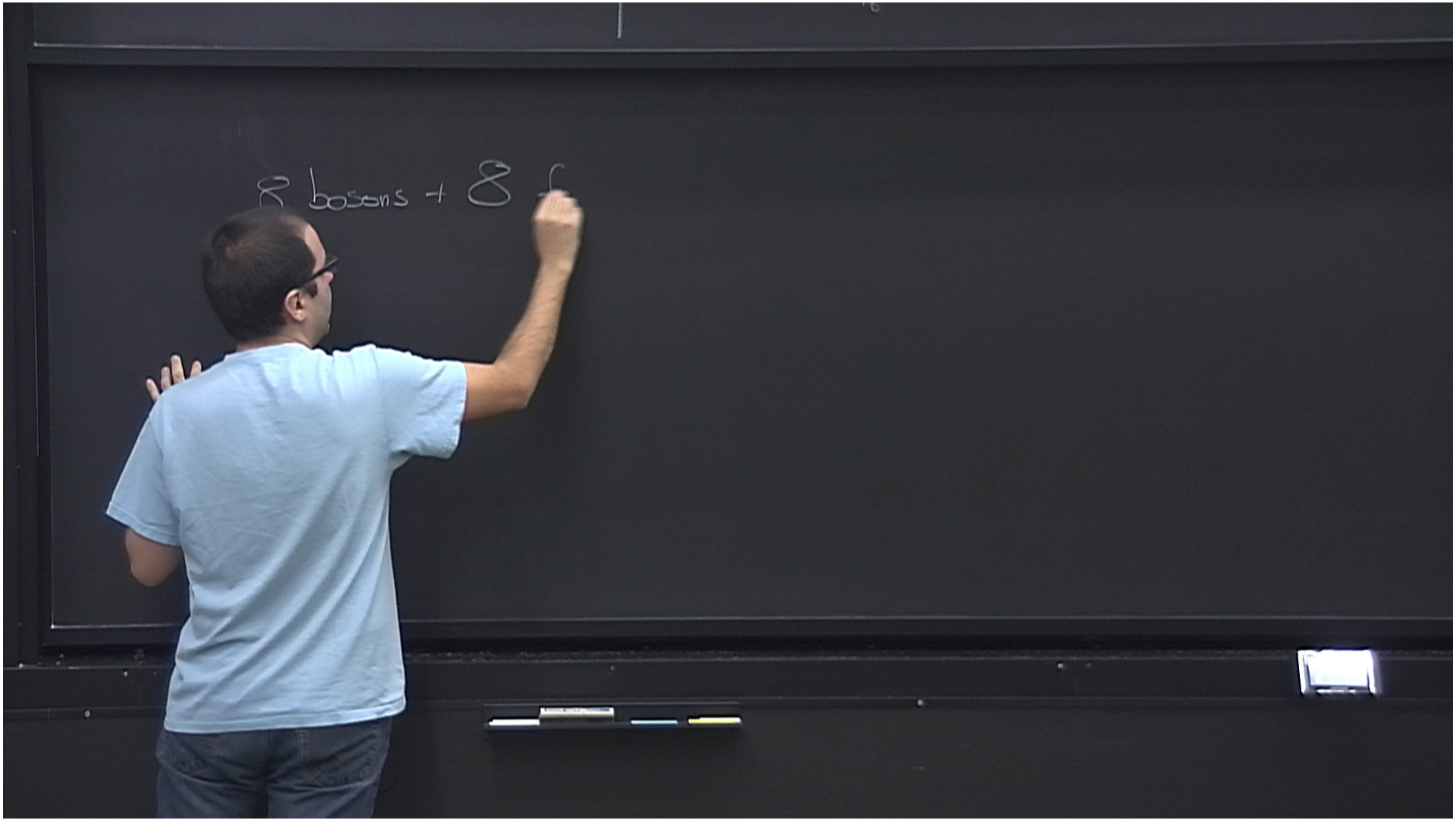

A = 1 .... n
∈(θ), p(θ)
tr(Z...ZXZ.....ZXZ....)
∈(p)
in reality
tr(Z...ZXZ...ZYZ...ZȲZ...ZX̄Z...
6 Scalars in N=4
Z = φ1 + iφ2
X = φ3 + iφ4 + cc
Y = φ5 + iφ6

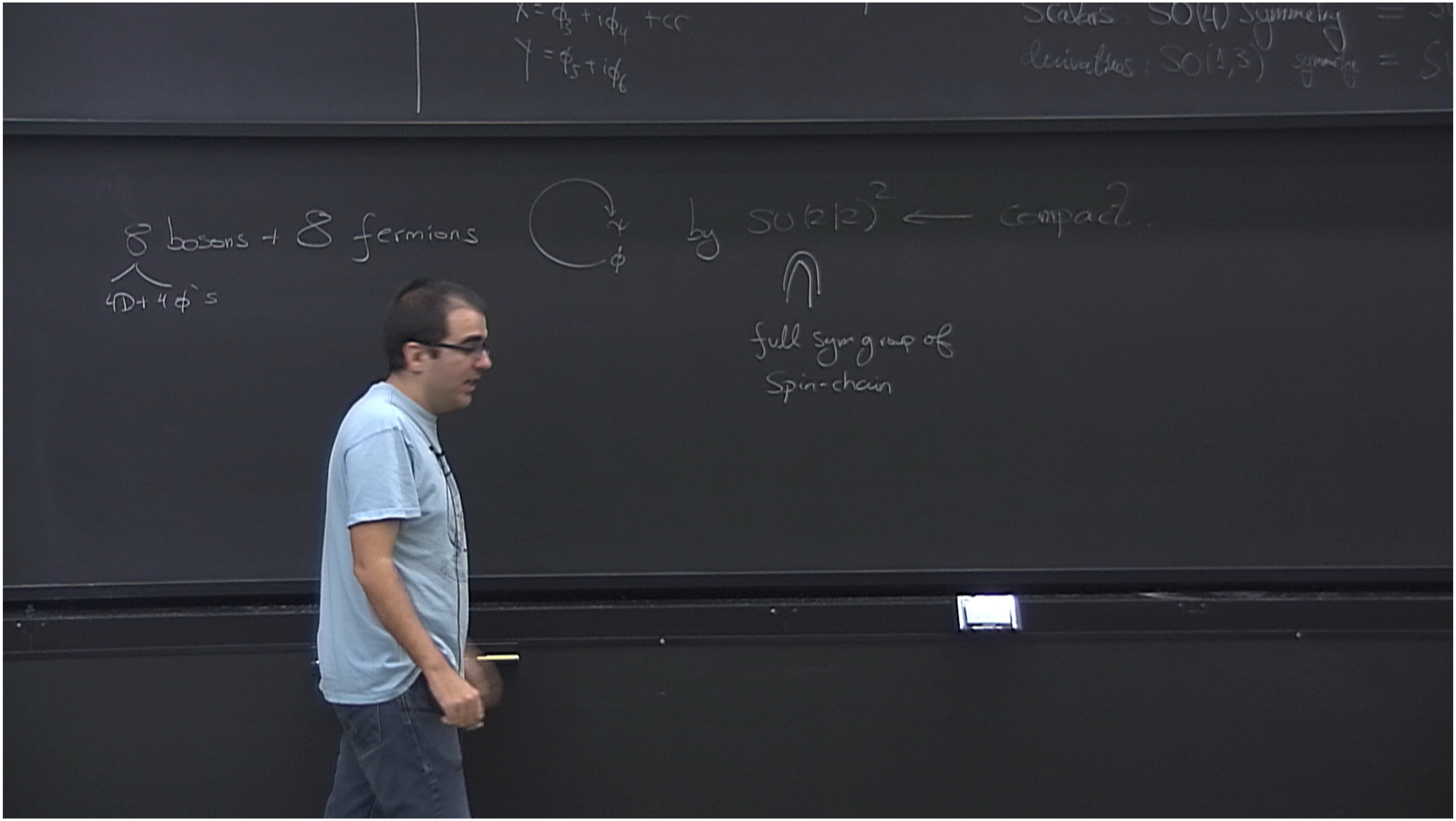

tr (Z ... ZXZ ..... ZXZ ....)
excitations
unstable
in reality
tr (Z ... ZXZ ... ZYZ ... ZȲZ ... Z̄XZ ..... Z̄ZZ ....
H
Ȳ moves
6 scalars in N=4
Z = φ1 + iφ2
X = φ3 + iφ4 + cc
Y = φ5 + iφ6
+ |ȲY⟩ + ...

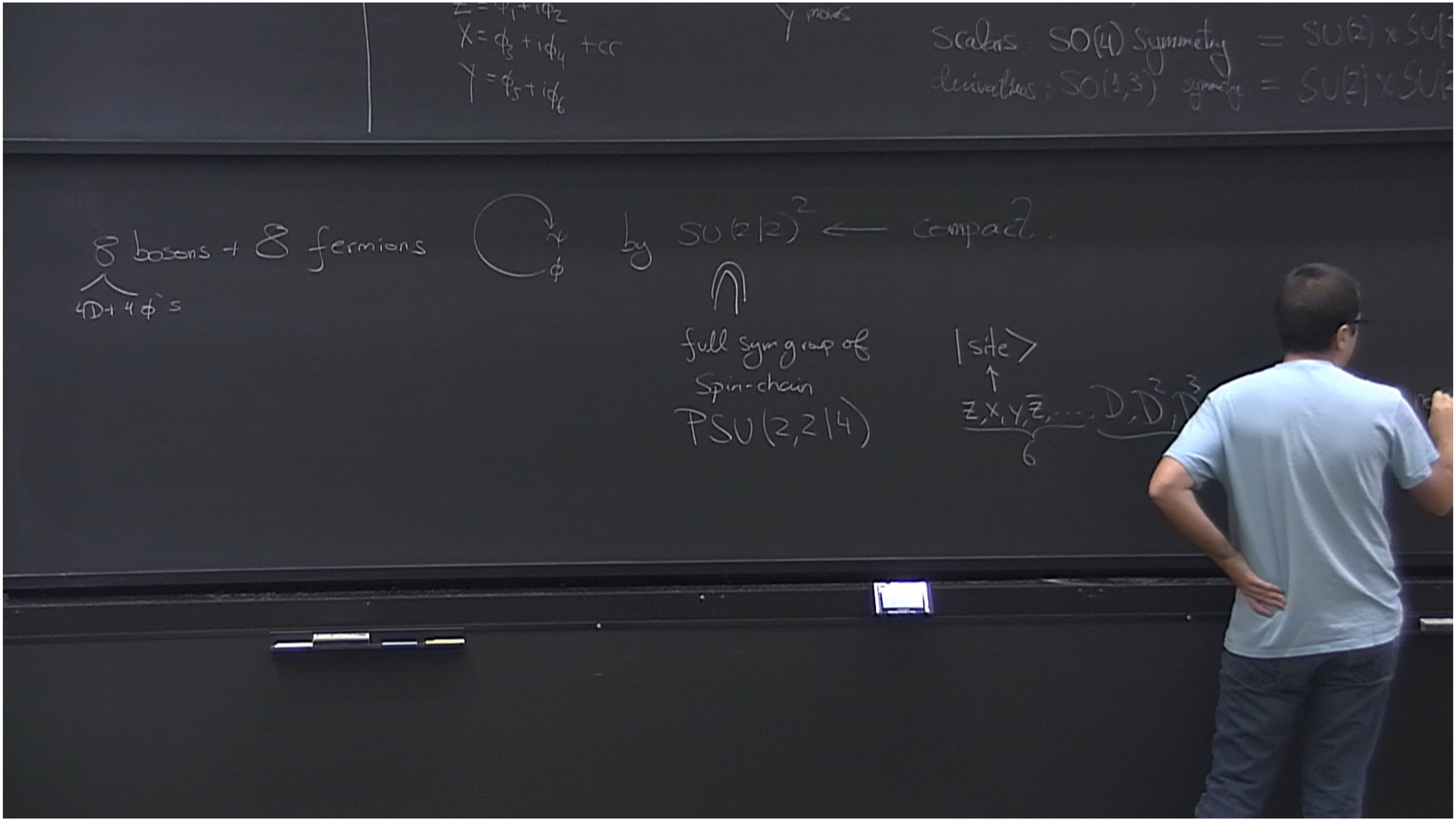

excitations
in reality
unstable
excitation
Scalars SO(4) Symmetry

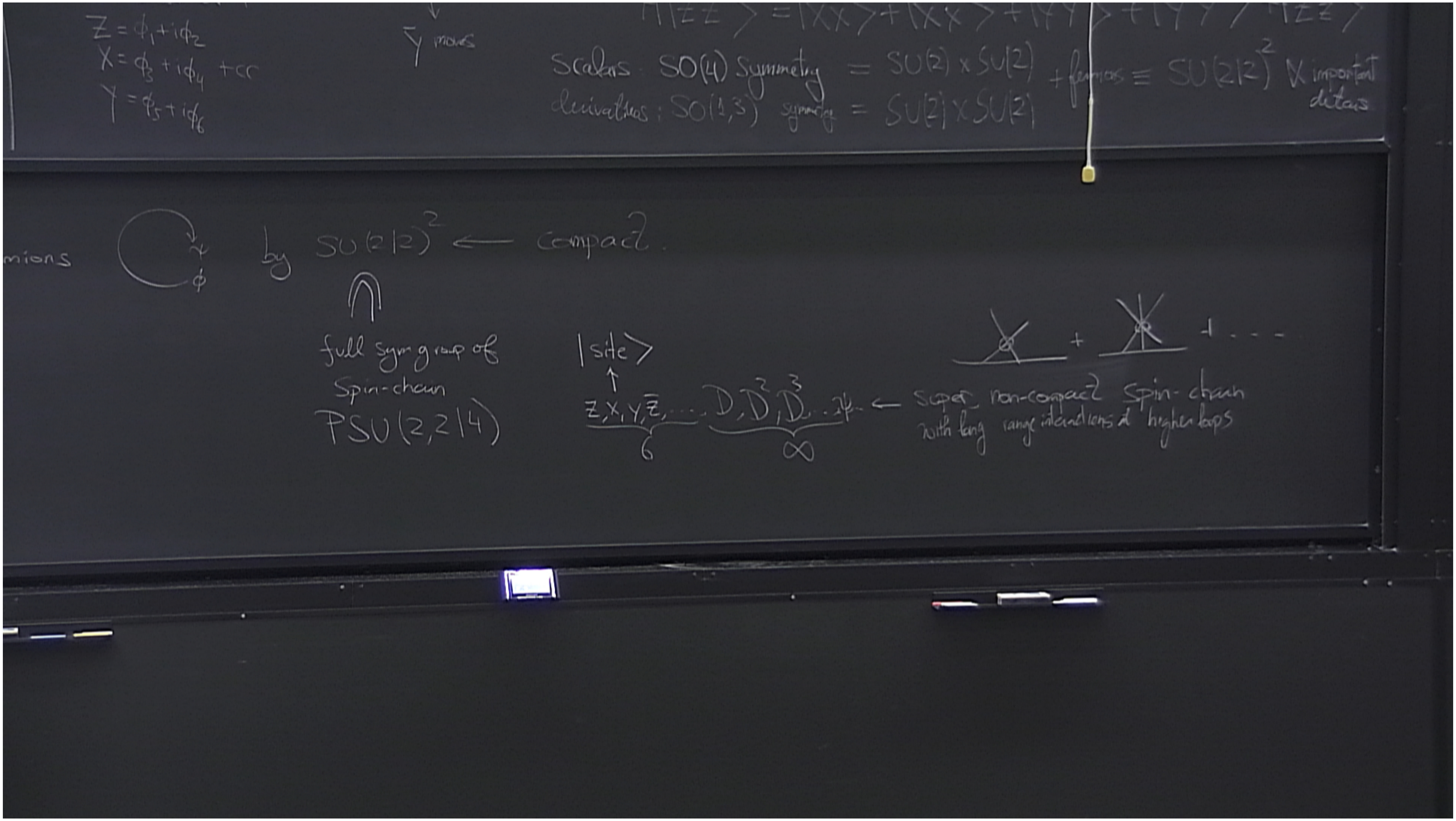

Tr (Z ... ZXZ ..... ZXZ .....)
excitations
in reality
Tr (Z ... ZXZ ... ZYZ ... ZȲZ .... ZX̄Z ..... ZZ̄Z .... ZD_μZ .... ZD̄Z
unstable
excitation
H
Ȳ moves
6 scalars in N=4
Z = φ1 + iφ2
X = φ3 + iφ4 + cc
Y = φ5 + iφ6
H|ZZ̄> = |XX̄> + |X̄X> + |YȲ> + |ȲY> + |ZZ̄
Scalars SO(4) symmetry
derivatives: SO(1,3) symmetry

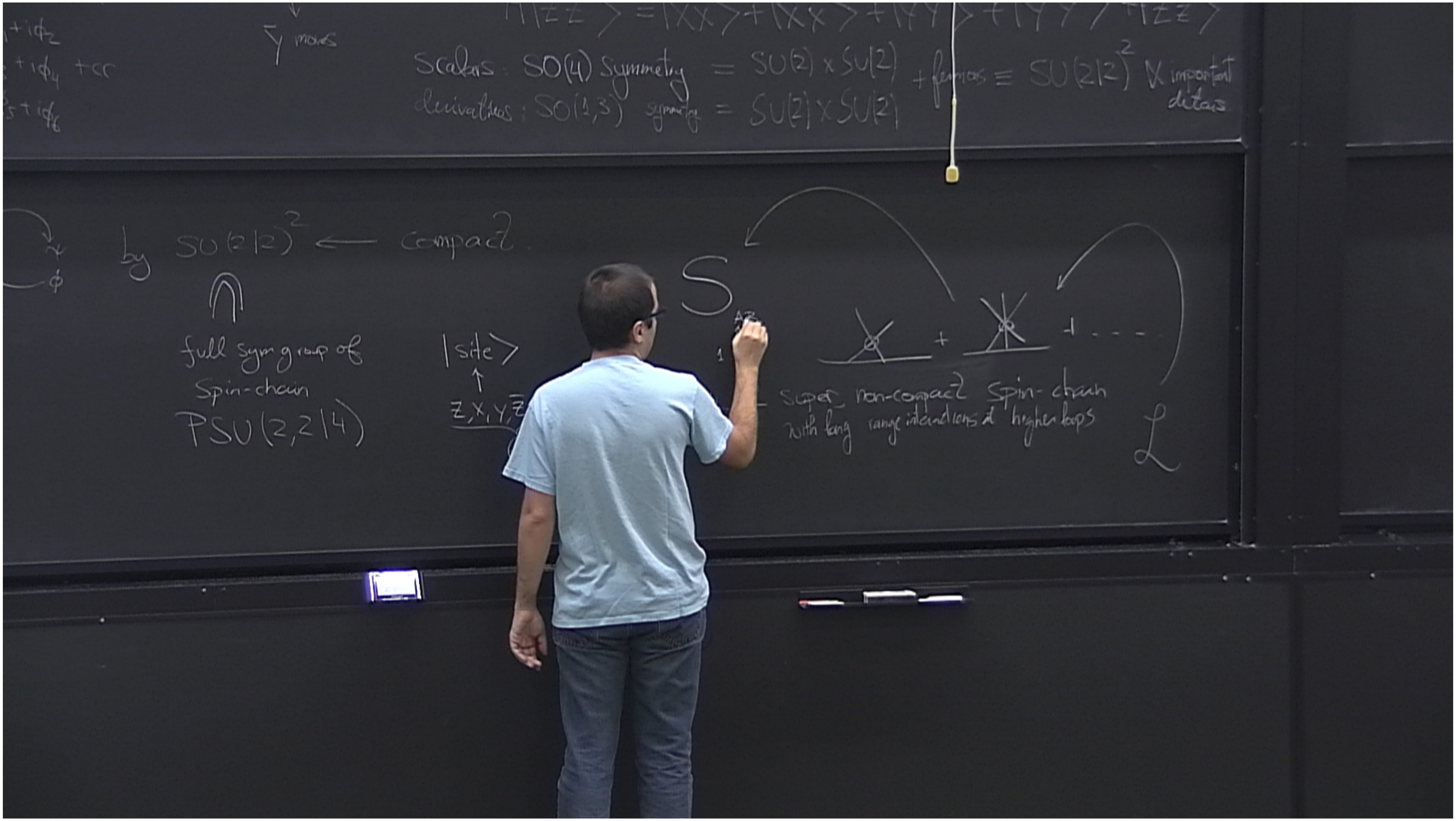

excitations
in reality
vacuum
6 scalars in N=4
excitation
Scalars SO(4) Symmetry = SU(2) x SU(2)
derivatives: SO(1,3) symmetry = SU(2) x SU(2)
important details

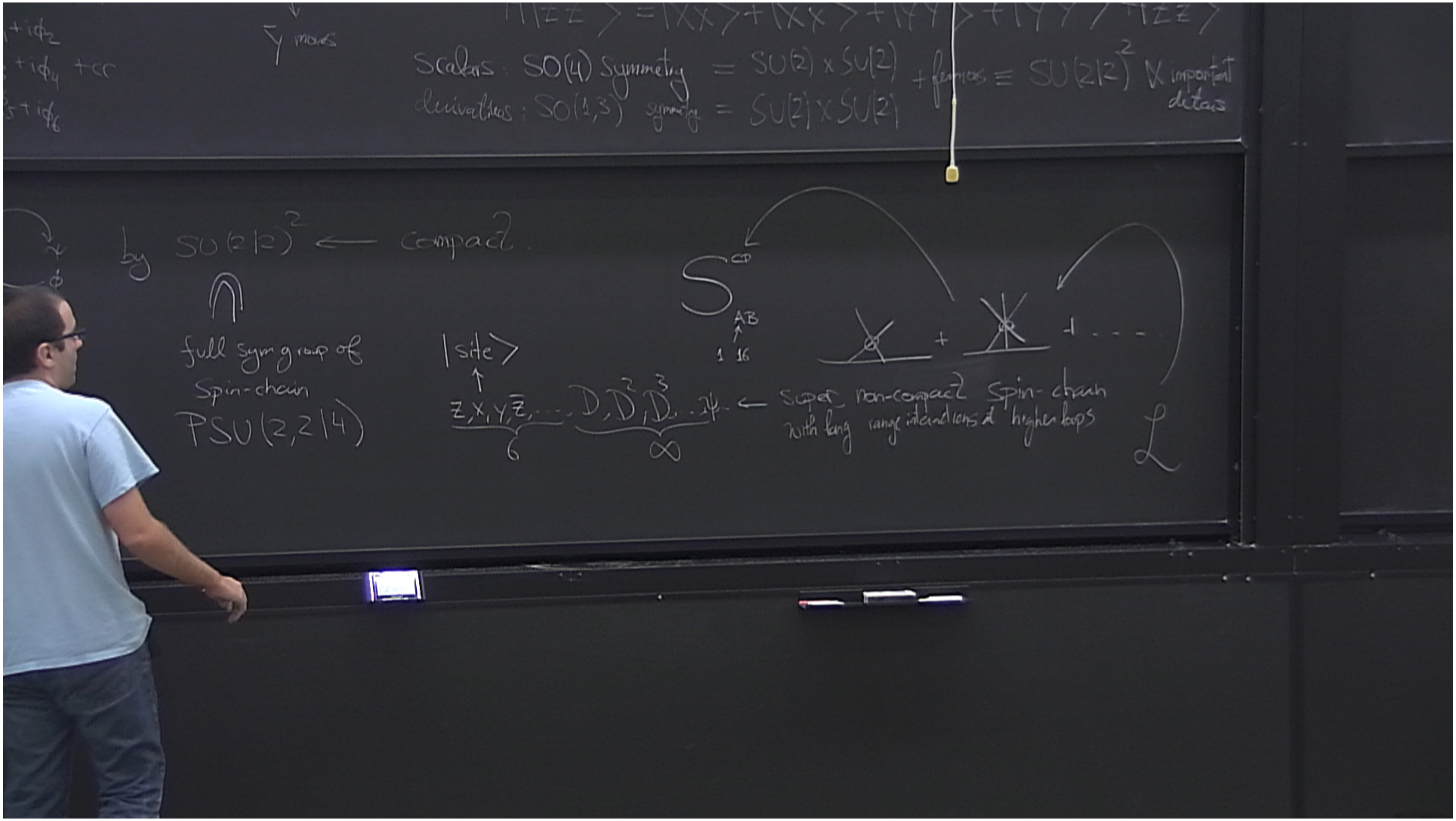

8 bosons + 8 f

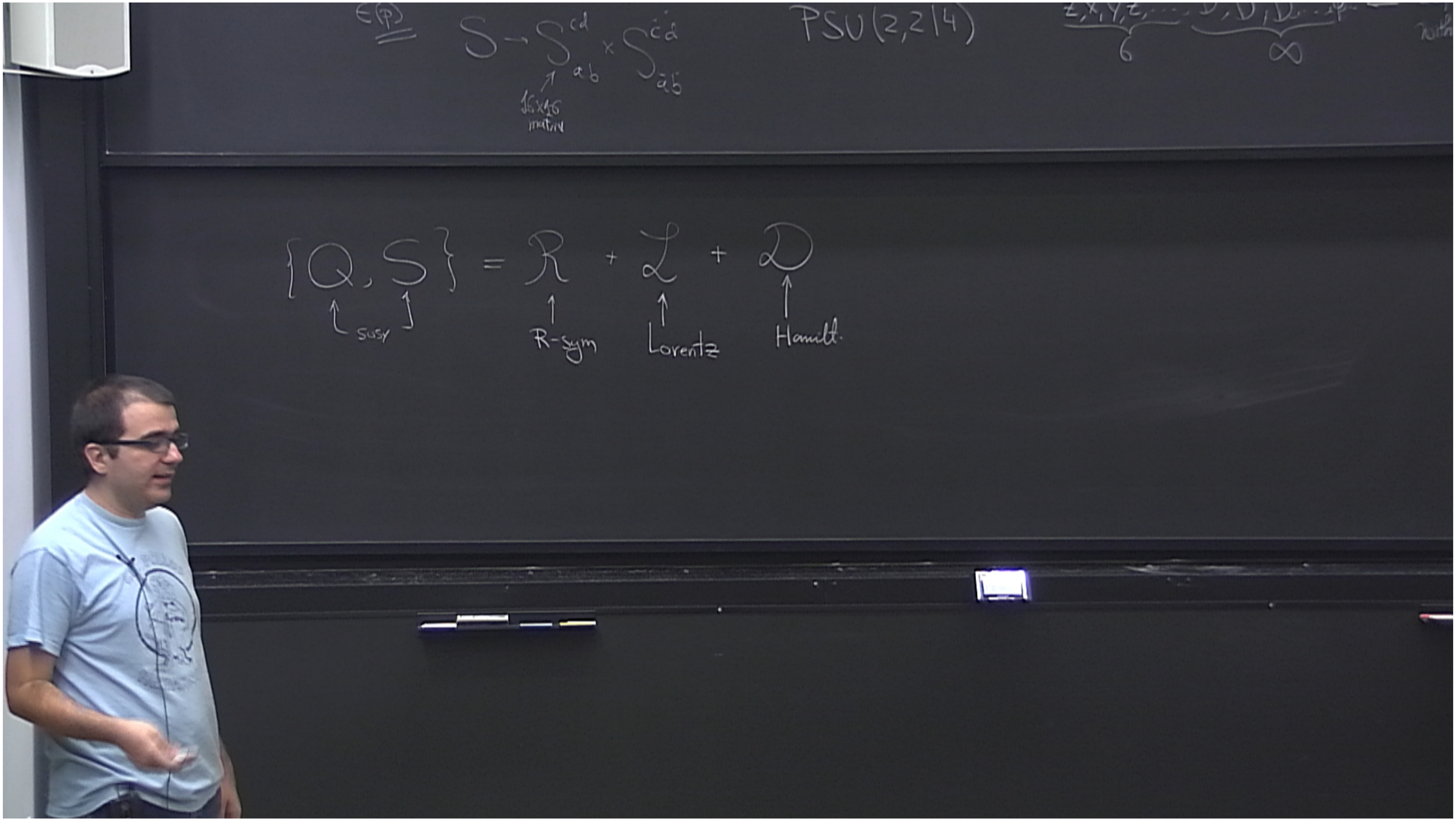

X = φ3 + iφ4 + cc
Y = φ5 + iφ6
Scalars : SO(4) Symmetry =
derivatives : SO(1,3) symmetry =
8 bosons + 8 fermions
by SO(2|2)^2 ← compact
4D + 4 φ`s
full sym group of
Spin-chain


X = φ3 + iφ4 + cc
Y = φ5 + iφ6
Scalars : SO(4) symmetry = SU(2) x SU
derivatives : SO(1,3) symmetry = SU(2) x SU
8 bosons + 8 fermions
4D + 4 φ's
by SU(2|2)²
compact.
full sym group of
Spin-chain
PSU(2,2|4)
|site>
Z, X, Y, Z̄, ...
6


Z = φ1 + iφ2
X = φ3 + iφ4 + cc
Y = φ5 + iφ6
Ȳ moves
Scalars: SO(4) Symmetry = SU(2) x SU(2)
derivatives: SO(1,3) symmetry = SU(2) x SU(2)
+ fermions ≡ SU(2|2)^2 X important
ditails
mions
by SU(2|2)^2 ← compact.
full sym group of
Spin-chain
PSU(2,2|4)
|site>
Z, X, Y, Z̄, ...
6
D, D^2, D^3 ... ψ
∞
← super non-compact spin-chain
with long range interactions at higher loops


Scalars: SO(4) Symmetry = SU(2) x SU(2)
+ fermions ≡ SU(2|2)^2 X important details
derivatives: SO(1,3) symmetry = SU(2) x SU(2)
by SU(2|2)^2 ← compact
full sym group of Spin-chain
PSU(2,2|4)
|site>
Z, X, Y, Z̄
super non-compact Spin-chain
with long range interactions at higher loops


Scalars : SO(4) Symmetry = SU(2) x SU(2)
derivatives : SO(1,3) symmetry = SU(2) x SU(2)
+ fermions ≡ SU(2|2)^2 X important details
by SU(2|2)^2 ← compact
full sym group of
Spin-chain
PSU(2,2|4)
|site>
Z, X, Y, Z̄, . . . D, D^2, D^3 . . ψ
6
∞
← Super non-compact Spin-chain
with long range interactions at higher loops
S^{CD}_{AB}
1 16
+ . . . .
L



S → S^cd_ab × S^ċḋ_ȧḃ
16x16 matrix
PSU(2,2|4)
{Q, S} = R + L + D
susy
R-sym
Lorentz
Hamilt.

$\underline{\underline{E(p)}}$ $\quad S \to S_{ab}^{cd} \times S_{\dot a \dot b}^{\dot c \dot d}$

16x16 matrix

$PSU(2,2|4)$

$\underbrace{Z, X, Y, \bar{Z}, \ldots}_{6} , \underbrace{D, D, D, \ldots \psi}_{\infty}$ with

$$\{Q, S\} = \mathcal{R} + \mathcal{L} + \mathcal{D}$$

susy

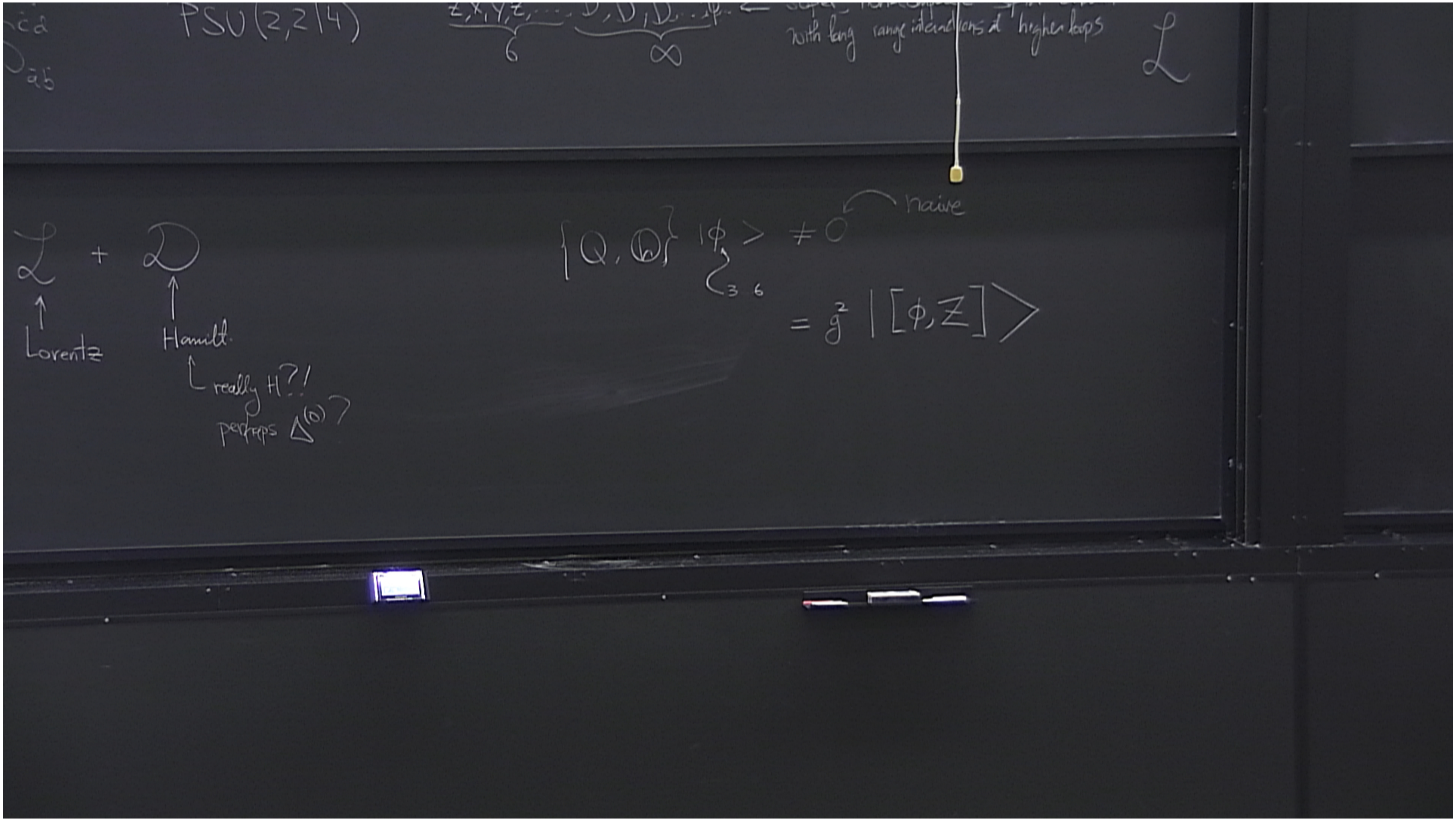
R-sym

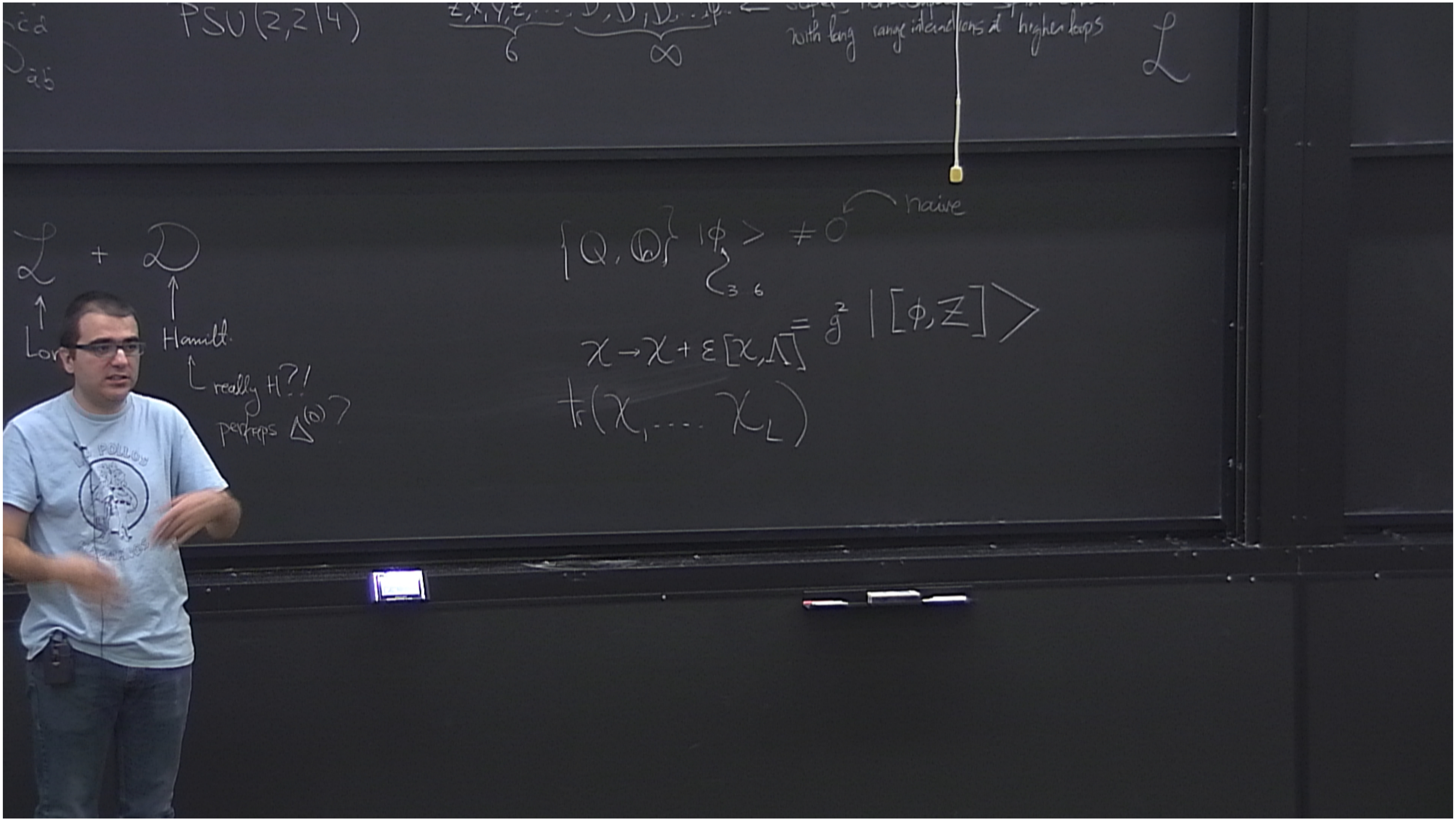
Lorentz

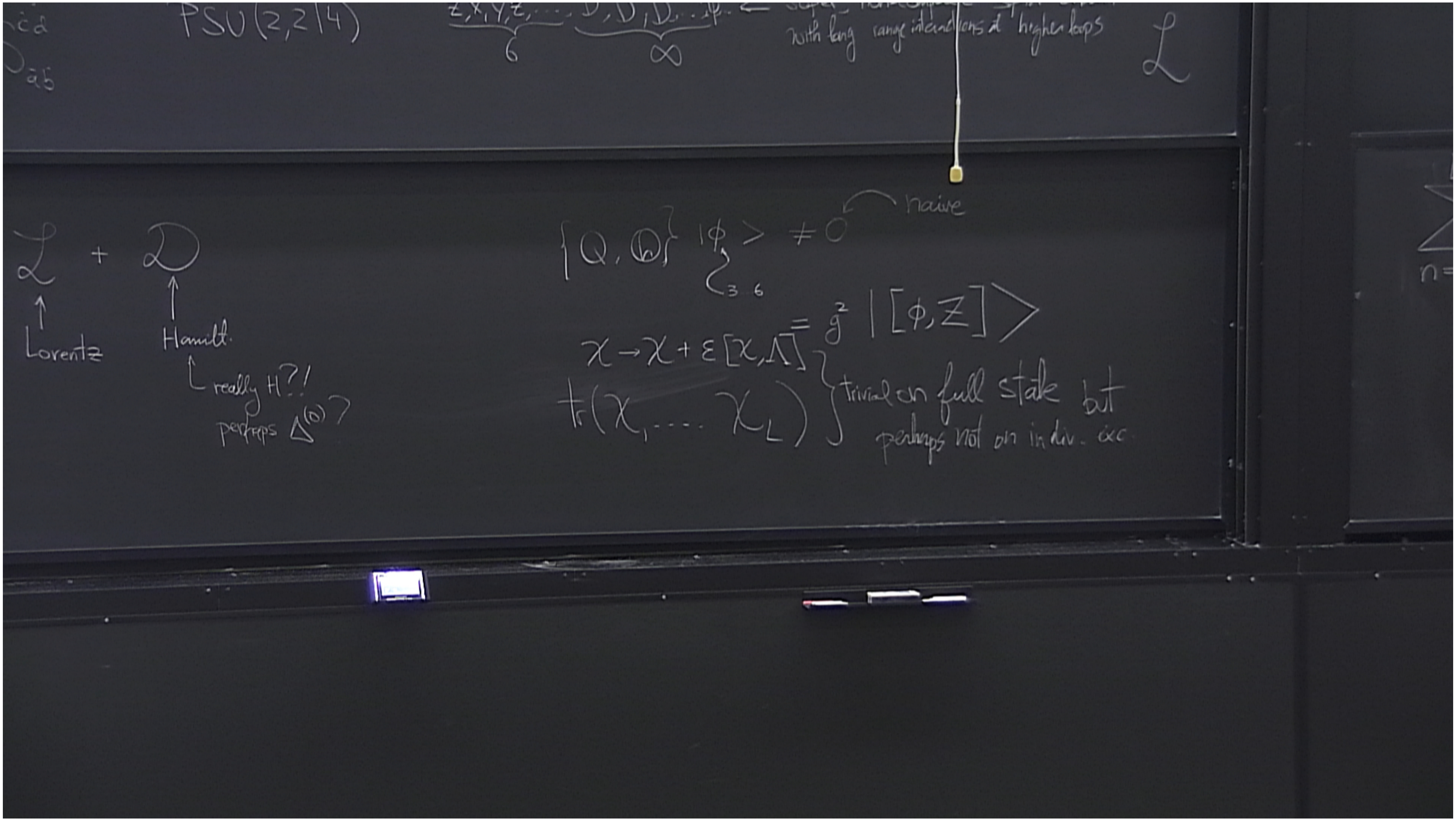
Hamilt.

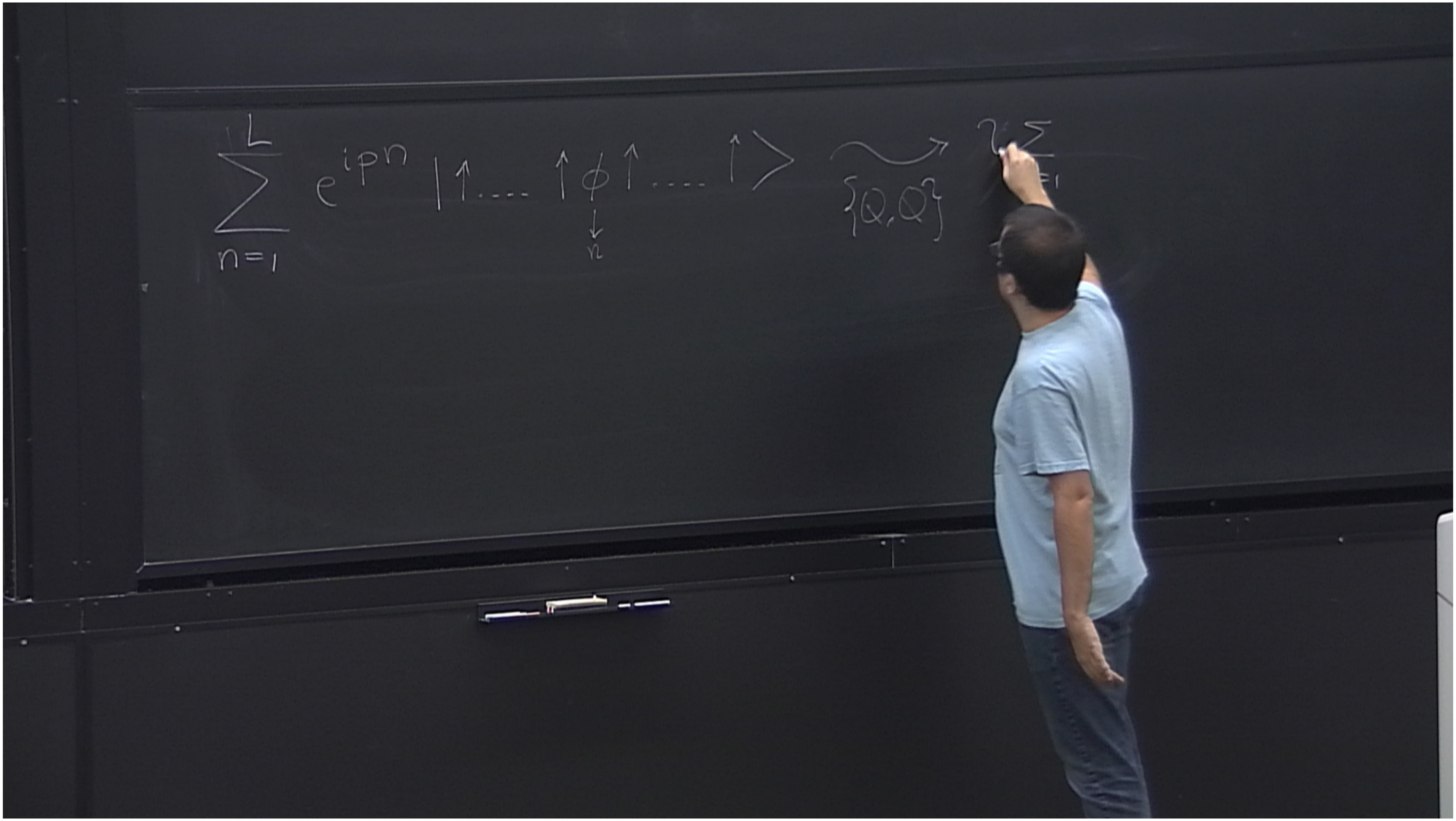
really H?!

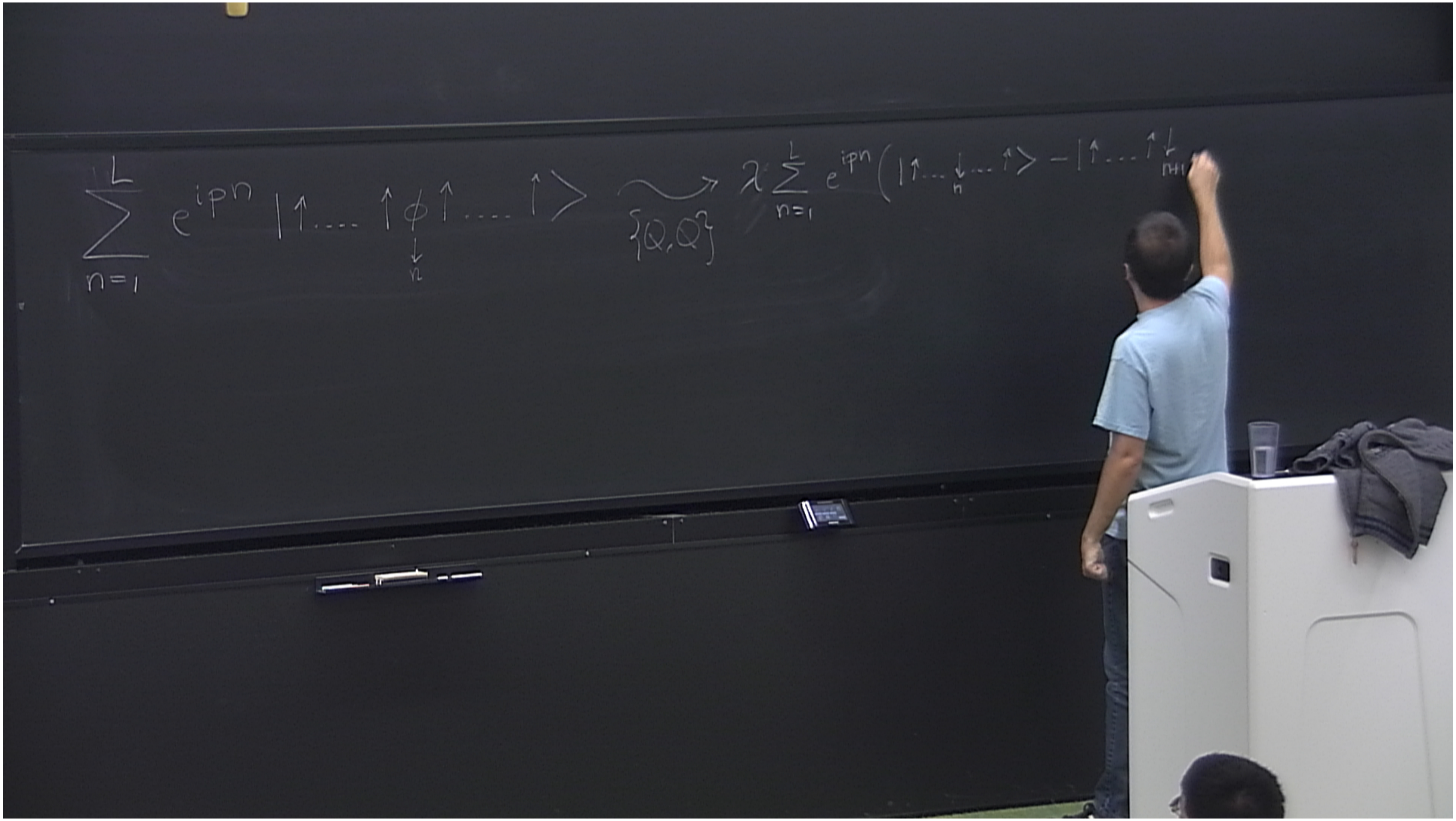
perhaps $\Delta^{(0)}$?

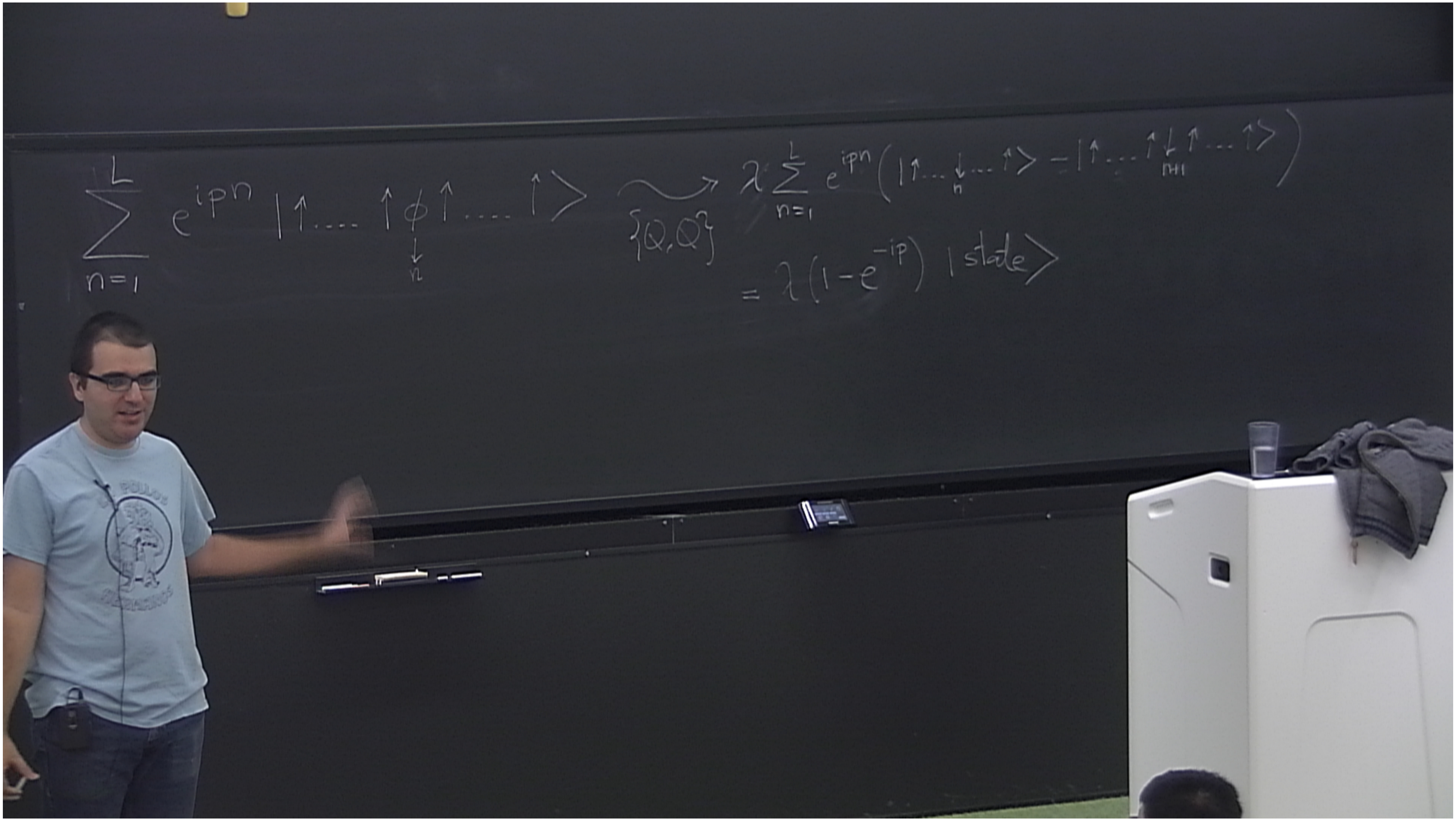

PSU(2,2|4)
with long range interactions at higher loops
naive
$\{Q, Q\} |\phi\rangle \neq 0$
$= g^2 |[\phi, Z]\rangle$
$\mathcal{L} + \mathcal{D}$
Lorentz
Hamilt.
really H?!
perhaps $\Delta^{(0)}$?

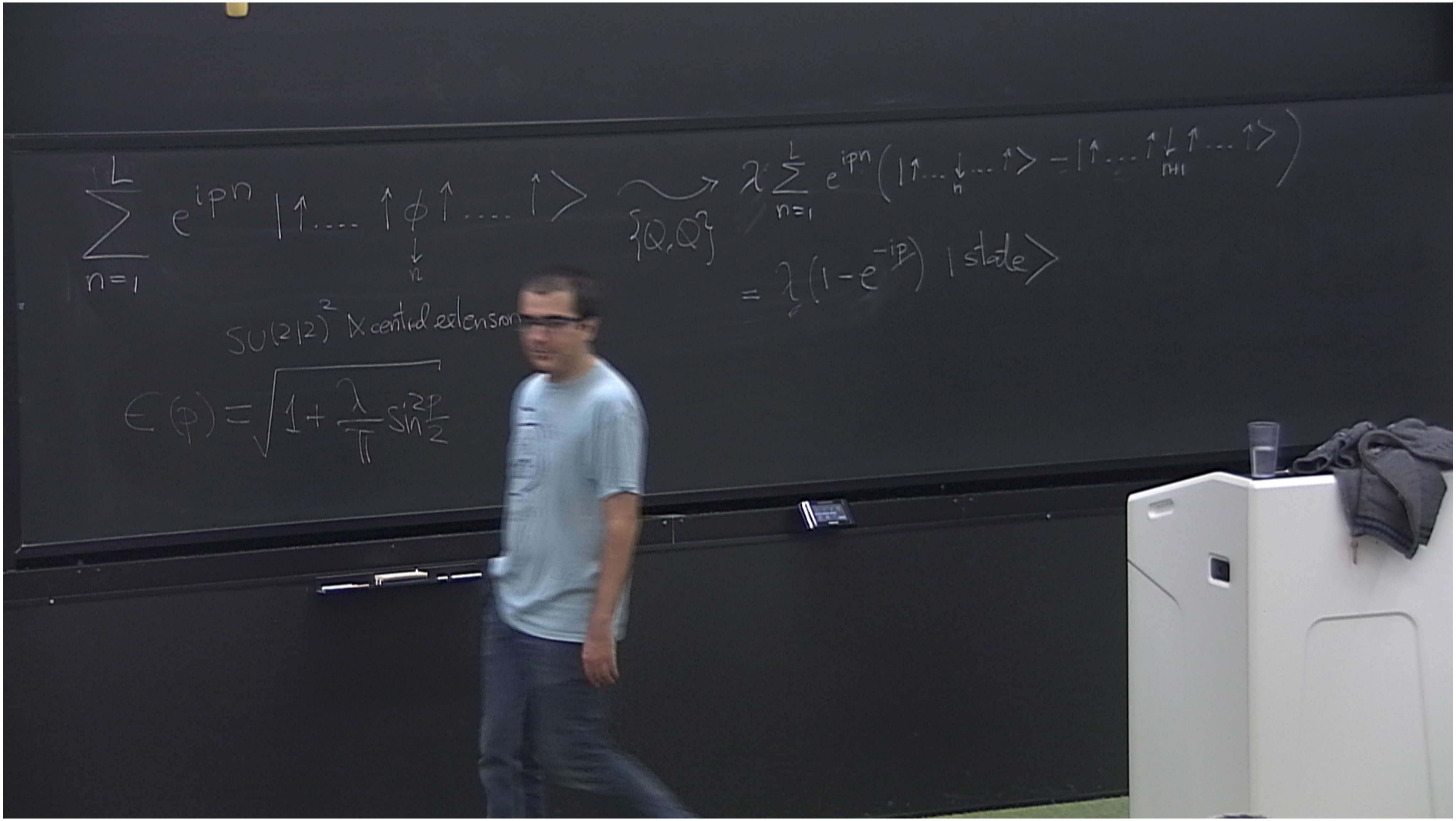

PSU(2,2|4)
with long range interactions at higher loops
$\mathcal{L} + \mathcal{D}$
Hamilt.
really H?!
perhaps $\Delta^{(0)}$?
naive
$\{Q, \mathcal{Q}\} |\phi\rangle \neq 0$
$= g^2 |[\phi, Z]\rangle$
$\chi \to \chi + \varepsilon[\chi, \Lambda]$
$\mathrm{tr}(\chi_1 \dots \chi_L)$

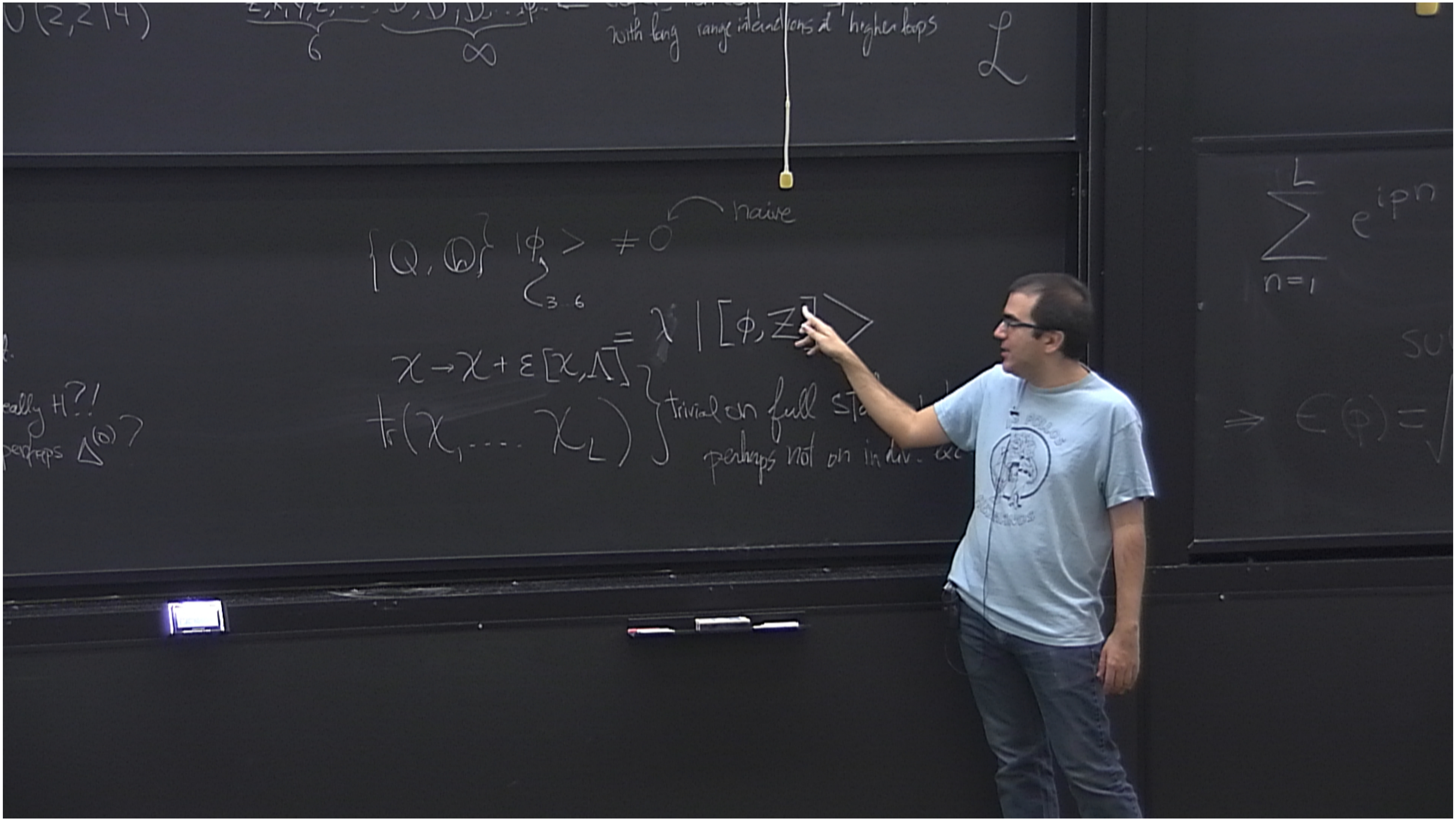

PSU(2,2|4)
with long range interactions at higher loops
naive
Lorentz
Hamilt.
really H?!
perhaps
trivial on full state but
perhaps not on indiv. exc.

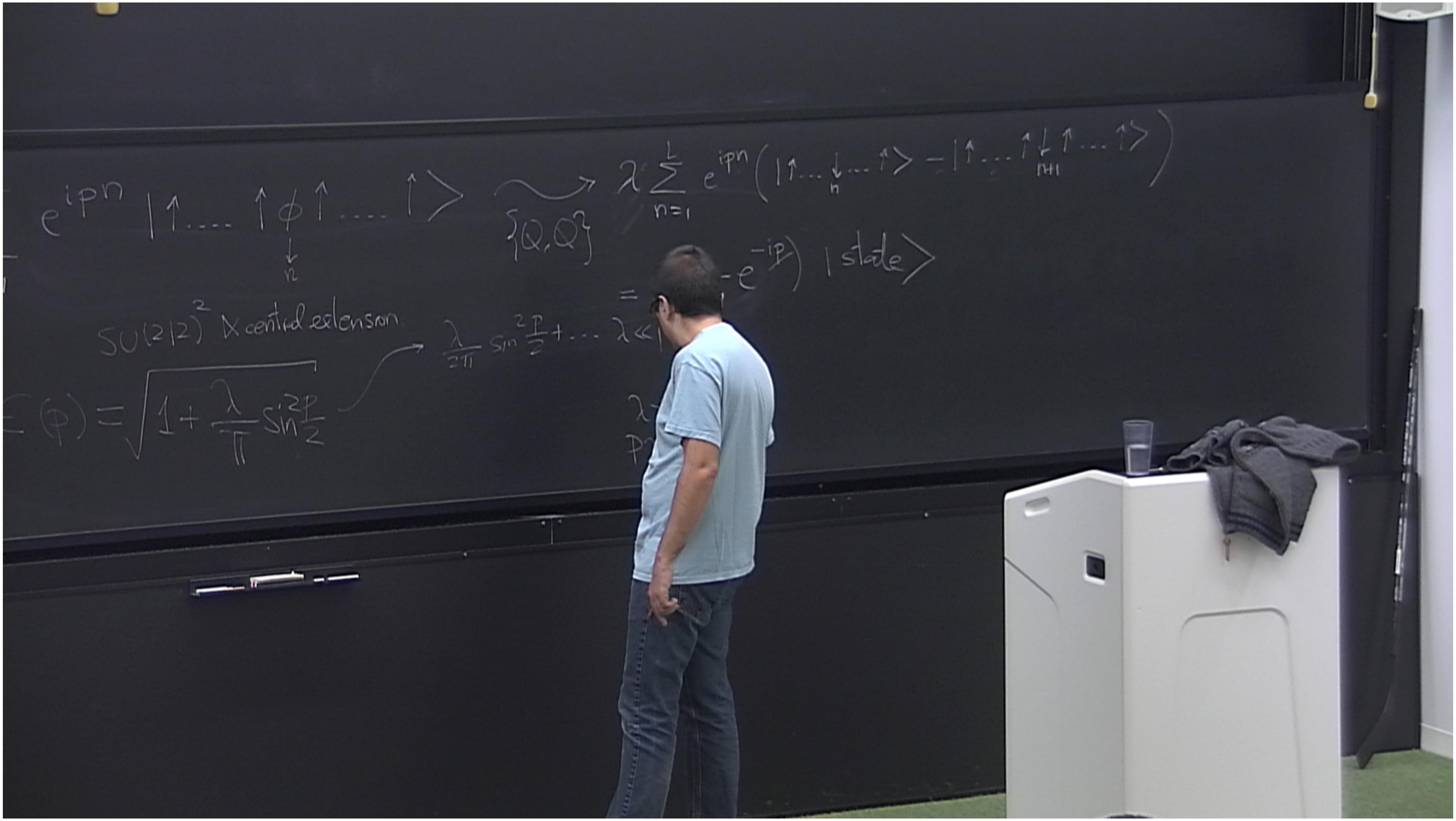

$\sum_{n=1}^{L} e^{ipn} |\uparrow \dots \uparrow \phi \uparrow \dots \uparrow \rangle$
n
$\{Q, Q\}$

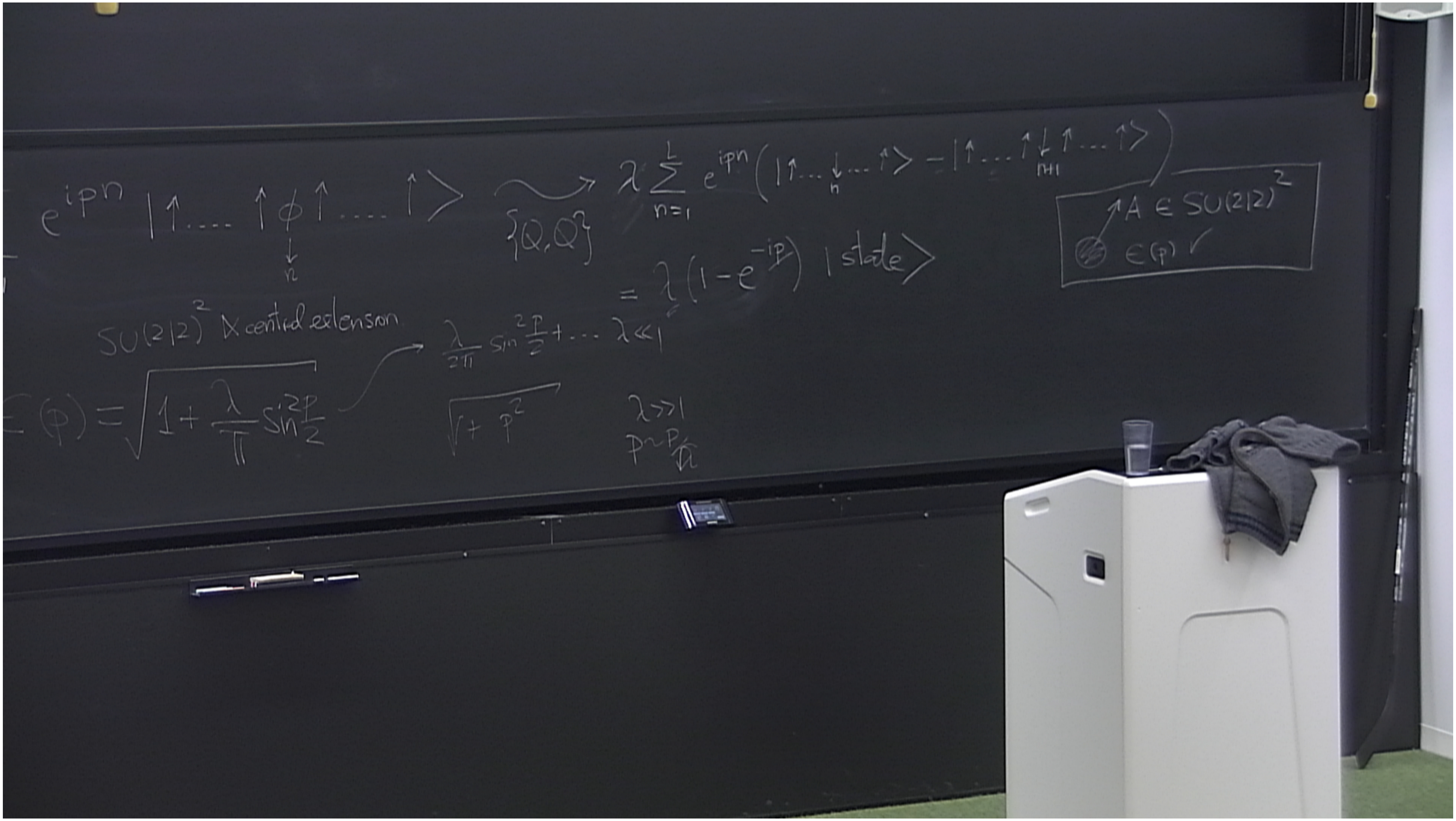

$\sum_{n=1}^{L} e^{ipn} |\uparrow \ldots \uparrow \underset{n}{\phi} \uparrow \ldots \uparrow\rangle$
$\{Q,Q\}$
$\lambda \sum_{n=1}^{L} e^{ipn} \big(|\uparrow \ldots \underset{n}{\downarrow} \ldots \uparrow\rangle - |\uparrow \ldots \uparrow \underset{n+1}{\downarrow}$

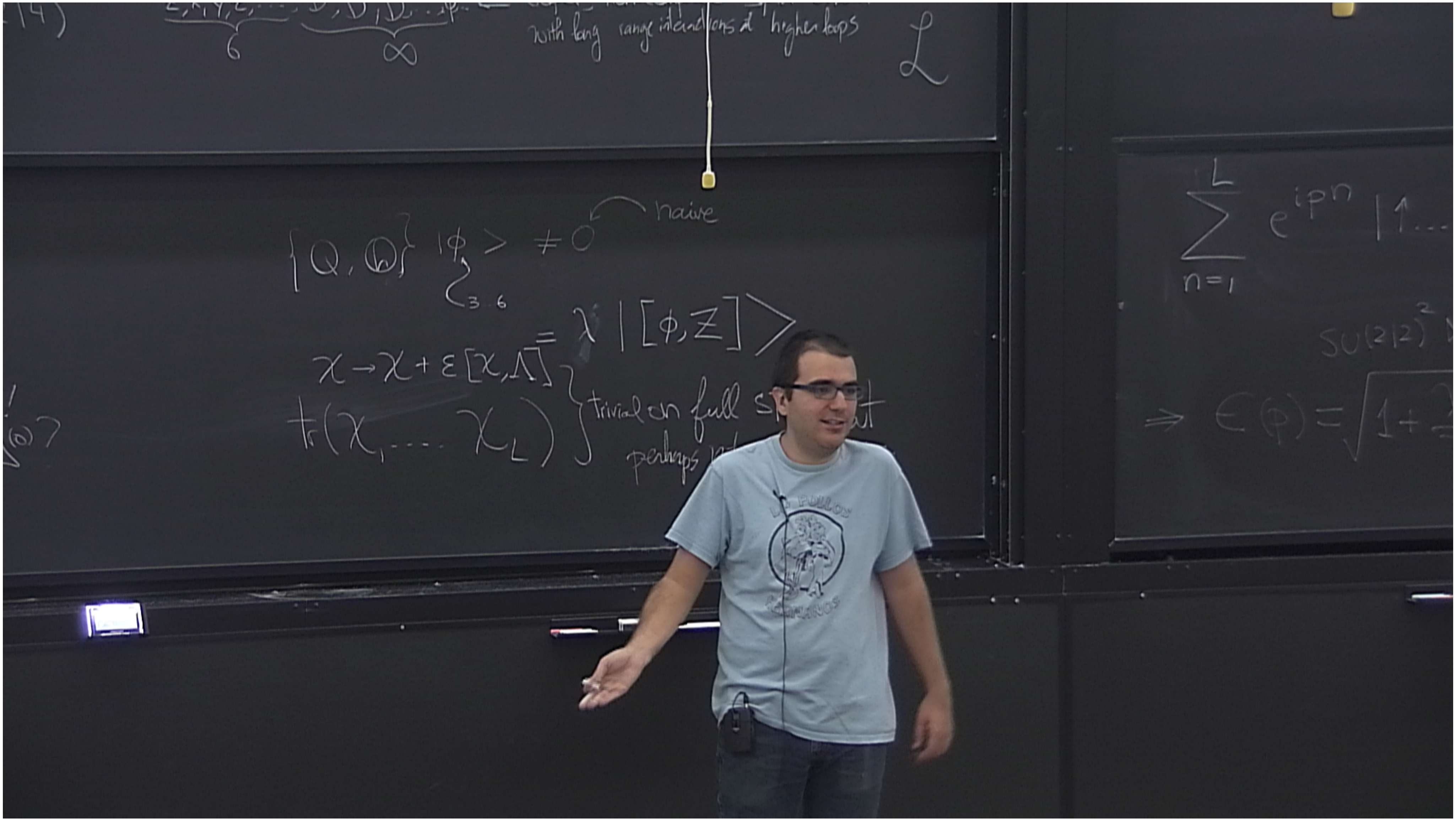

$\sum_{n=1}^{L} e^{ipn} |\uparrow \dots \uparrow \underset{n}{\phi} \uparrow \dots \uparrow\rangle \xrightarrow{\{Q,Q\}} \lambda \sum_{n=1}^{L} e^{ipn} \left(|\uparrow \dots \underset{n}{\downarrow} \dots \uparrow\rangle - |\uparrow \dots \uparrow \underset{n+1}{\downarrow} \uparrow \dots \uparrow\rangle \right)$
$= \lambda (1 - e^{-ip}) |state\rangle$


{Q,Q}
SU(2|2)^2 ⋉ central extension
= λ(1 − e^{−ip}) |state>

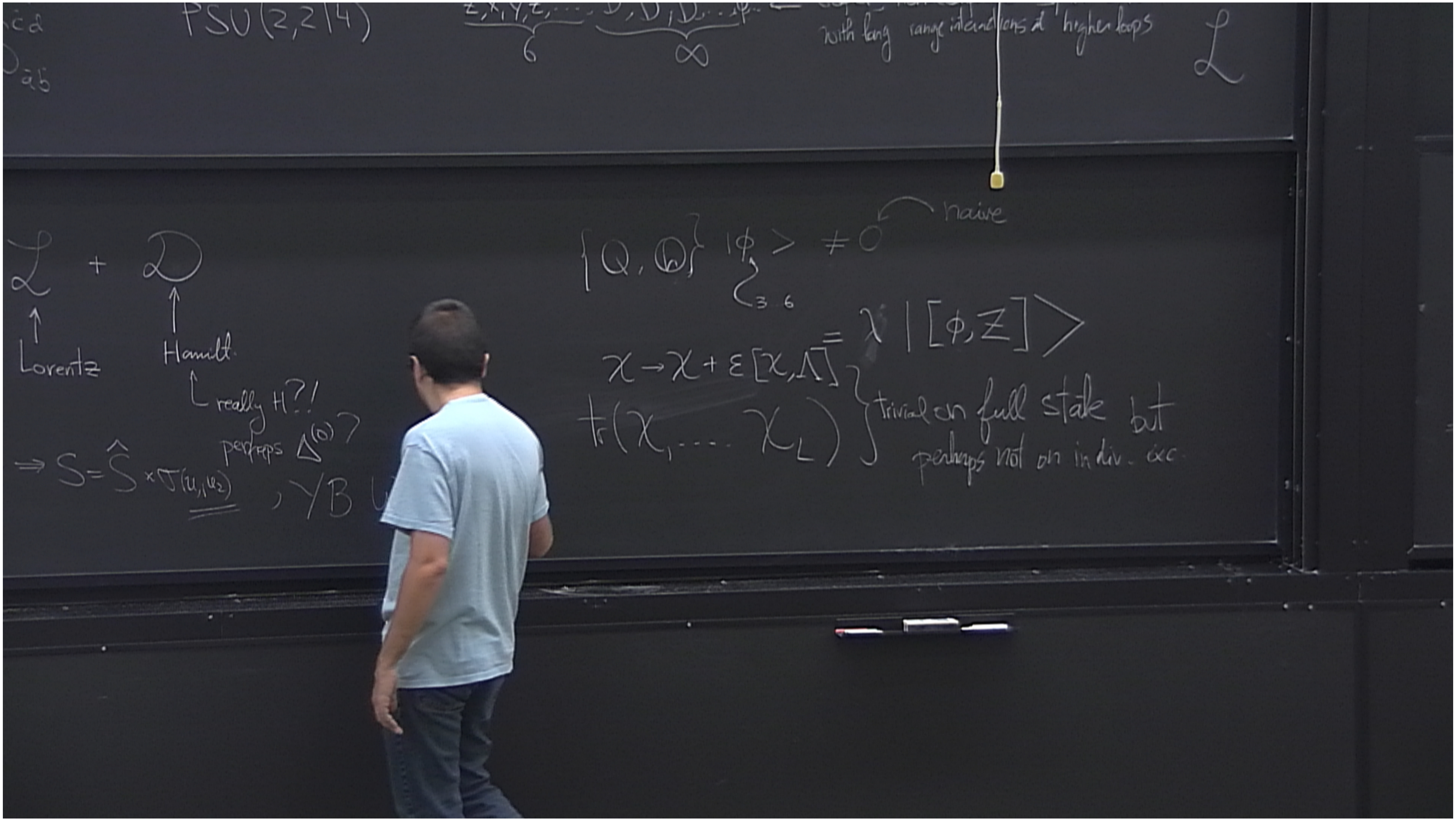

with long range interactions at higher loops
naive
trivial on full
perhaps not on indiv.

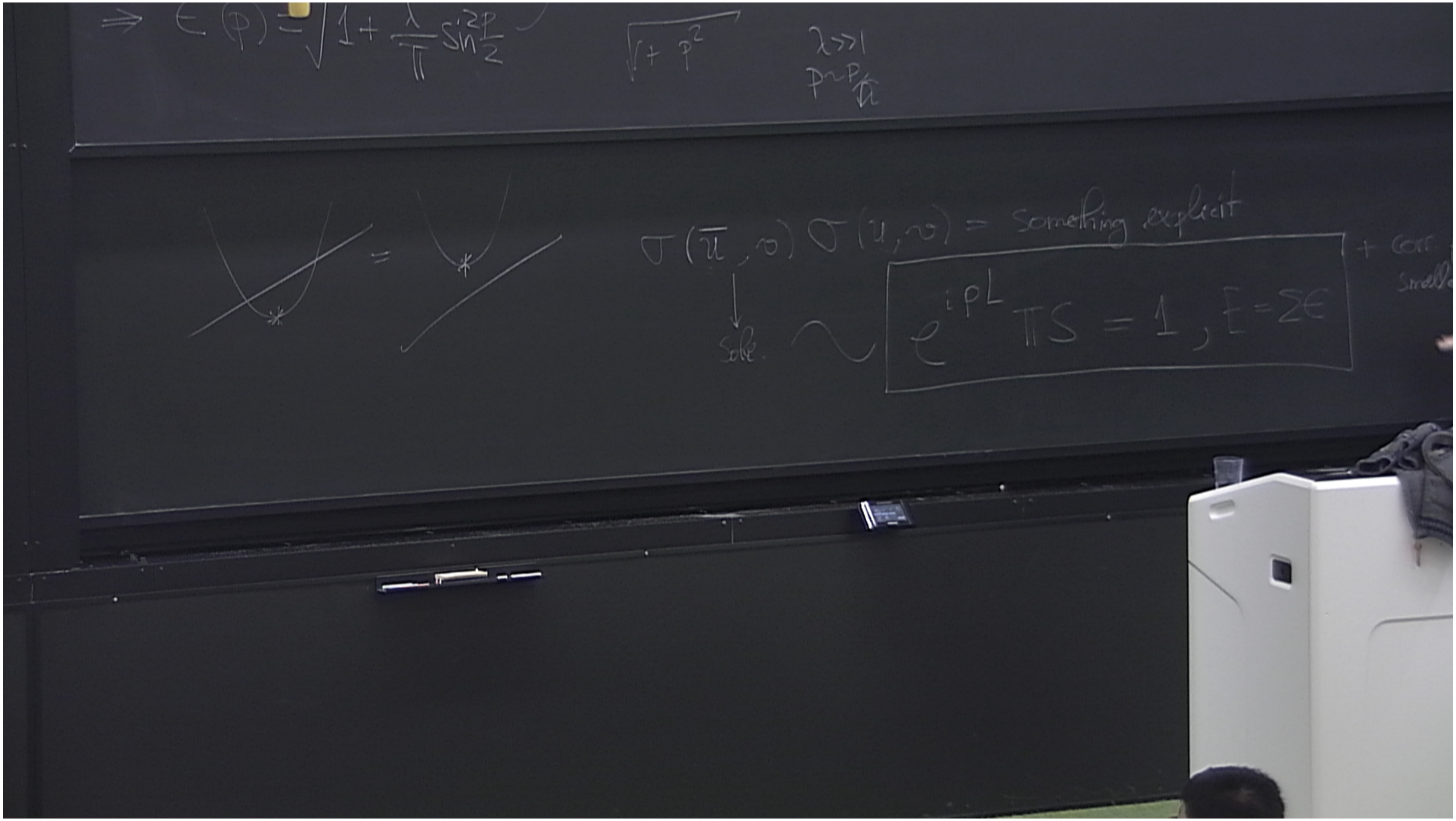

e^{ipn} |↑.... ↑φ↑.... ↑>
{Q,Q}
λ Σ_{n=1}^{L} e^{ipn} (|↑...↓...↑> − |↑...↑↓↑...↑>)
|state>
SU(2|2)^2 ⋉ central extension
λ/2π sin^2 p/2 + ... λ≪1
E(p) = √(1 + λ/π sin^2 p/2)

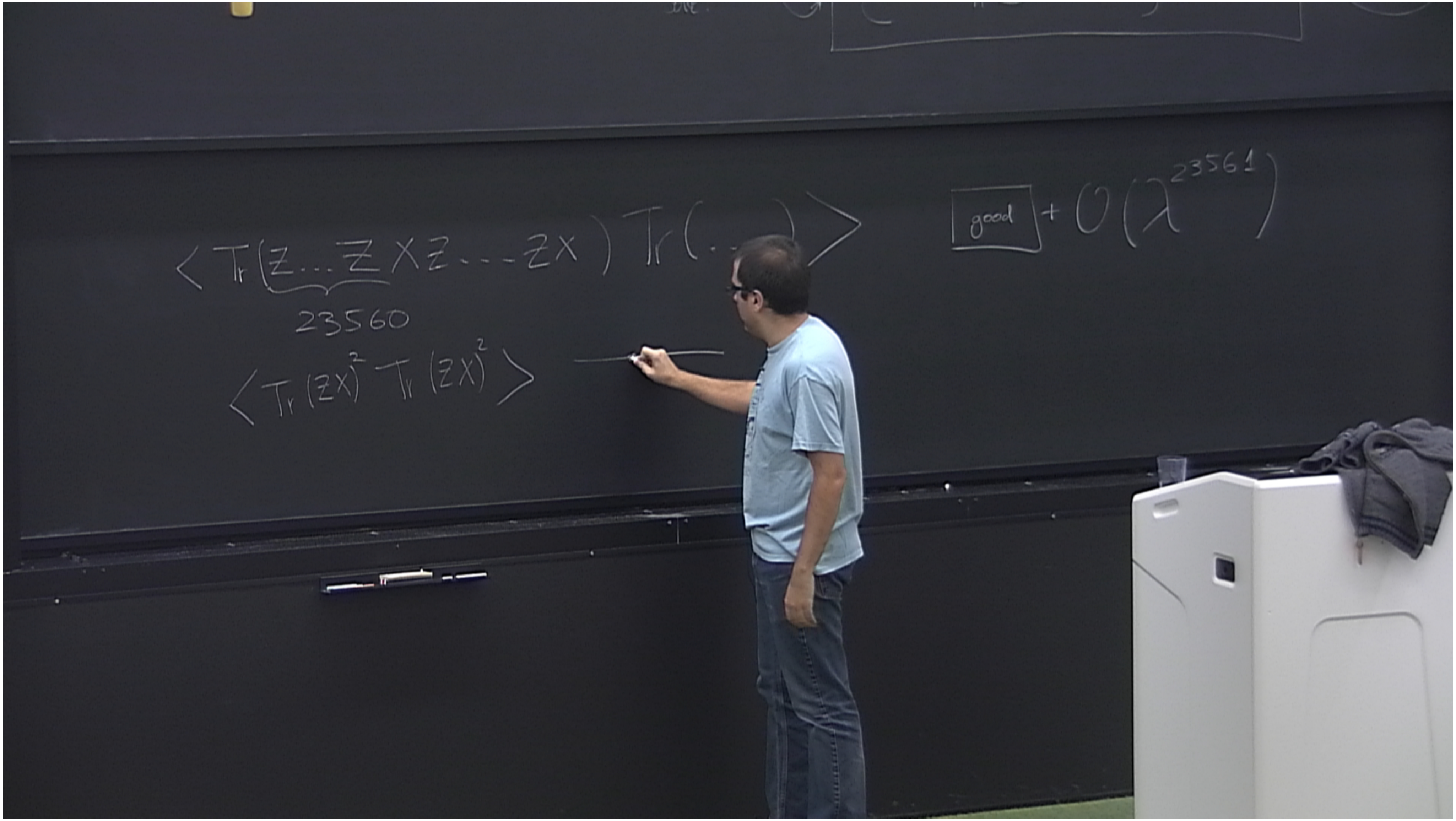

e^{ipn} |↑.... ↑ φ ↑ .... ↑>
{Q,Q}
λ Σ_{n=1}^{L} e^{ipn} (|↑... ↓ ... ↑> − |↑ ... ↑ ↓ ↑ ... ↑>)
= λ (1 − e^{−ip}) |state>
A ∈ SU(2|2)^2
∈(p) ✓
SU(2|2)^2 ⋉ central extension
ε(φ) = √(1 + λ/π sin^2 p/2)
λ/2π sin^2 p/2 + ... λ≪1
√(1 + p^2)
λ≫1
p~p/√λ

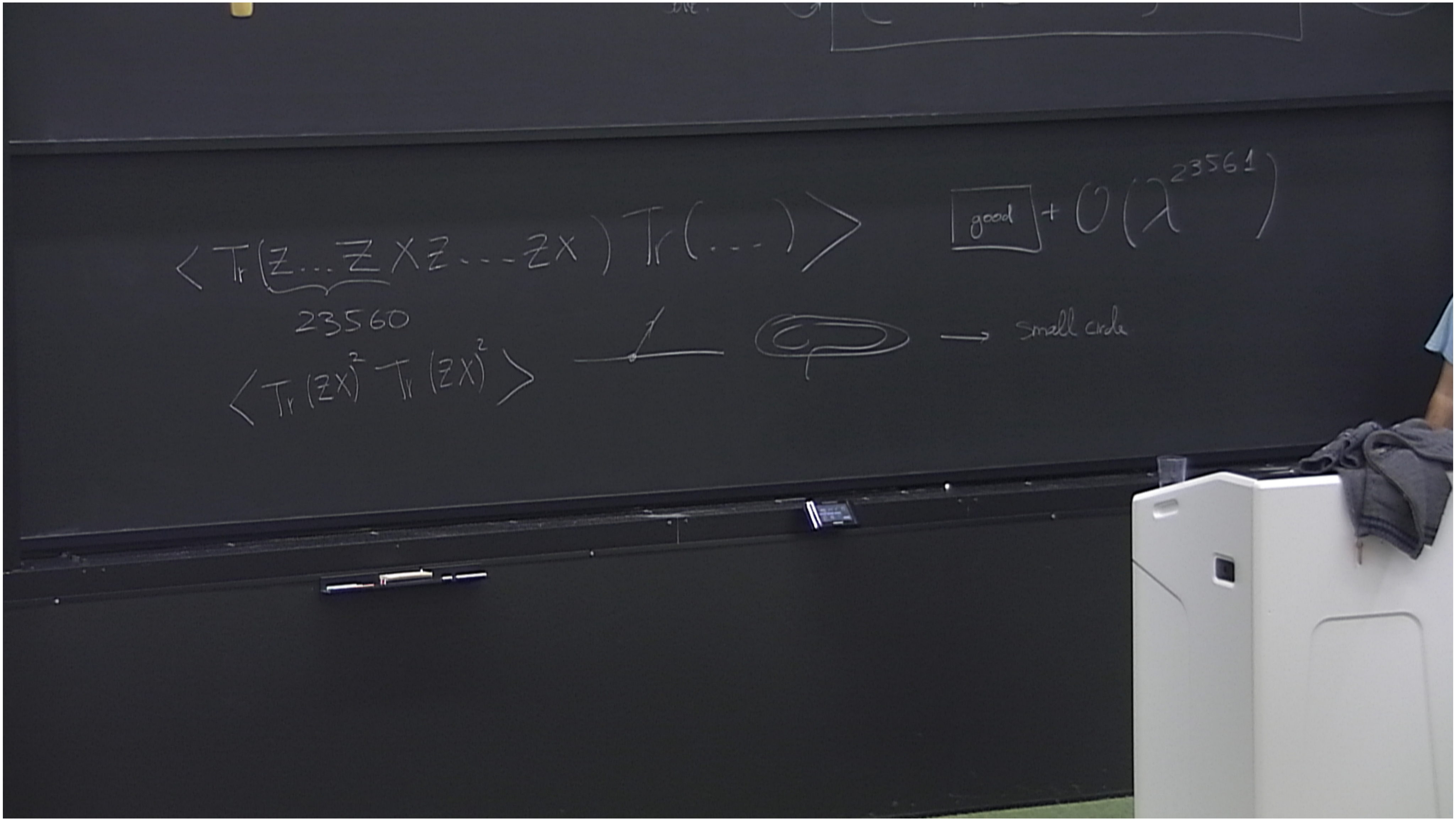


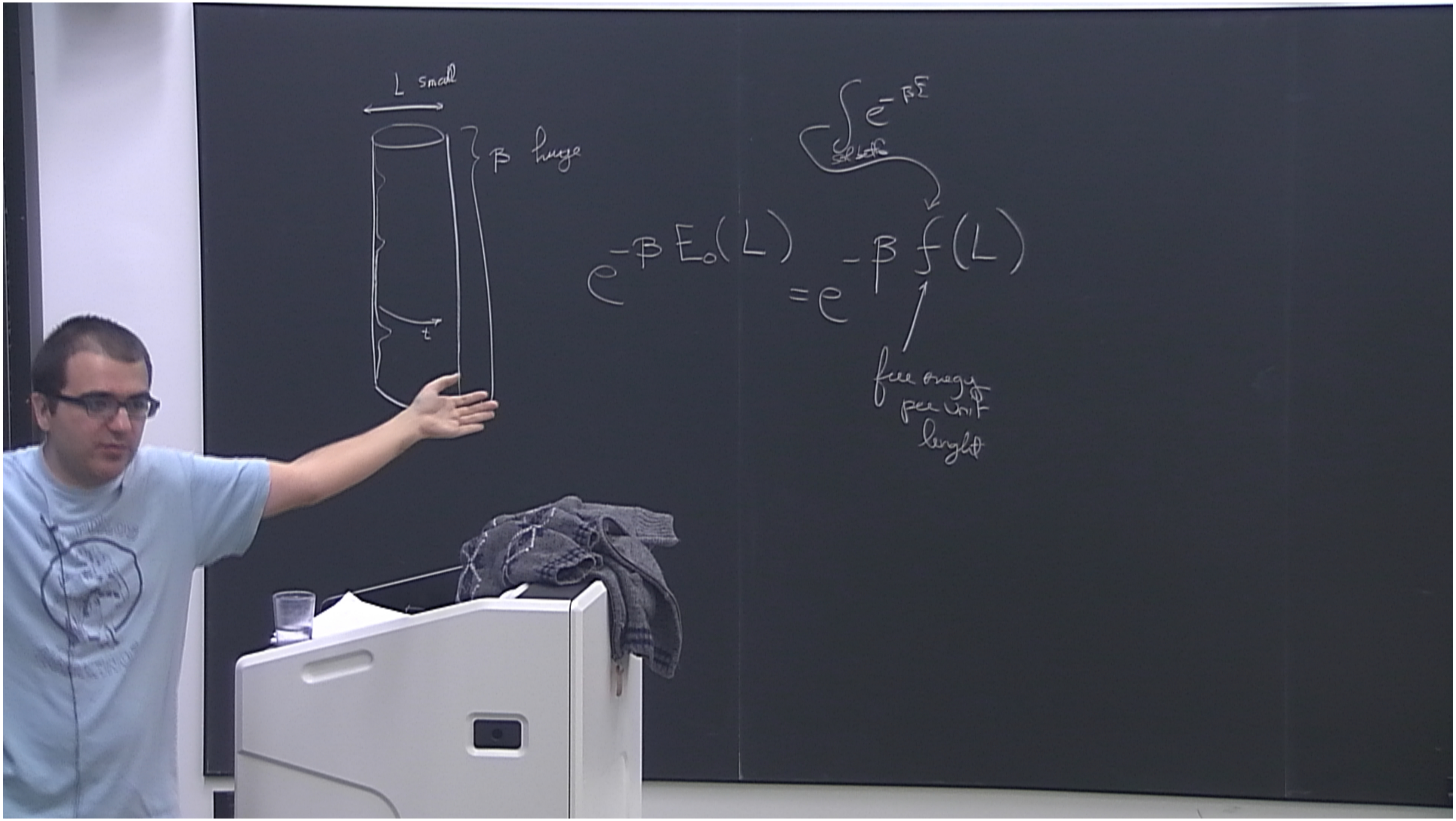
with long range interactions & higher loops
naive
trivial on full s
perhaps


PSU(2,2|4)
with long range interactions at higher loops
naive
{Q, 𝒪} |φ> ≠ 0
= λ |[φ, Z]>
Lorentz
Hamilt.
really H?!
perhaps Δ(0)?
χ → χ + ε[χ, Λ]
tr(χ1 .... χL)
trivial on full state but
perhaps not on indiv. exc.
⇒ S = Ŝ × σ(u1, u2)
, YB


λ>>1
σ(ū, v) σ(u, v) = something explicit
+ corr. smaller
ΠS = 1 , E = Σε


< Tr(Z...Z X Z...ZX) Tr(...) >
23560
good + O(λ^23561)
< Tr(ZX)^2 Tr(ZX)^2 >


$\langle \mathrm{Tr}(\underbrace{Z\ldots Z}_{23560} X Z \ldots Z X)\,\mathrm{Tr}(\ldots)\rangle$
$\boxed{\text{good}} + O(\lambda^{23561})$
$\langle \mathrm{Tr}(ZX)^2\,\mathrm{Tr}(ZX)^2\rangle$
→ small circle


L small
β huge
t
$e^{-\beta E_0(L)} = e^{-\beta f(L)}$
$\int e^{-\beta E}$
free energy
per unit
lenght