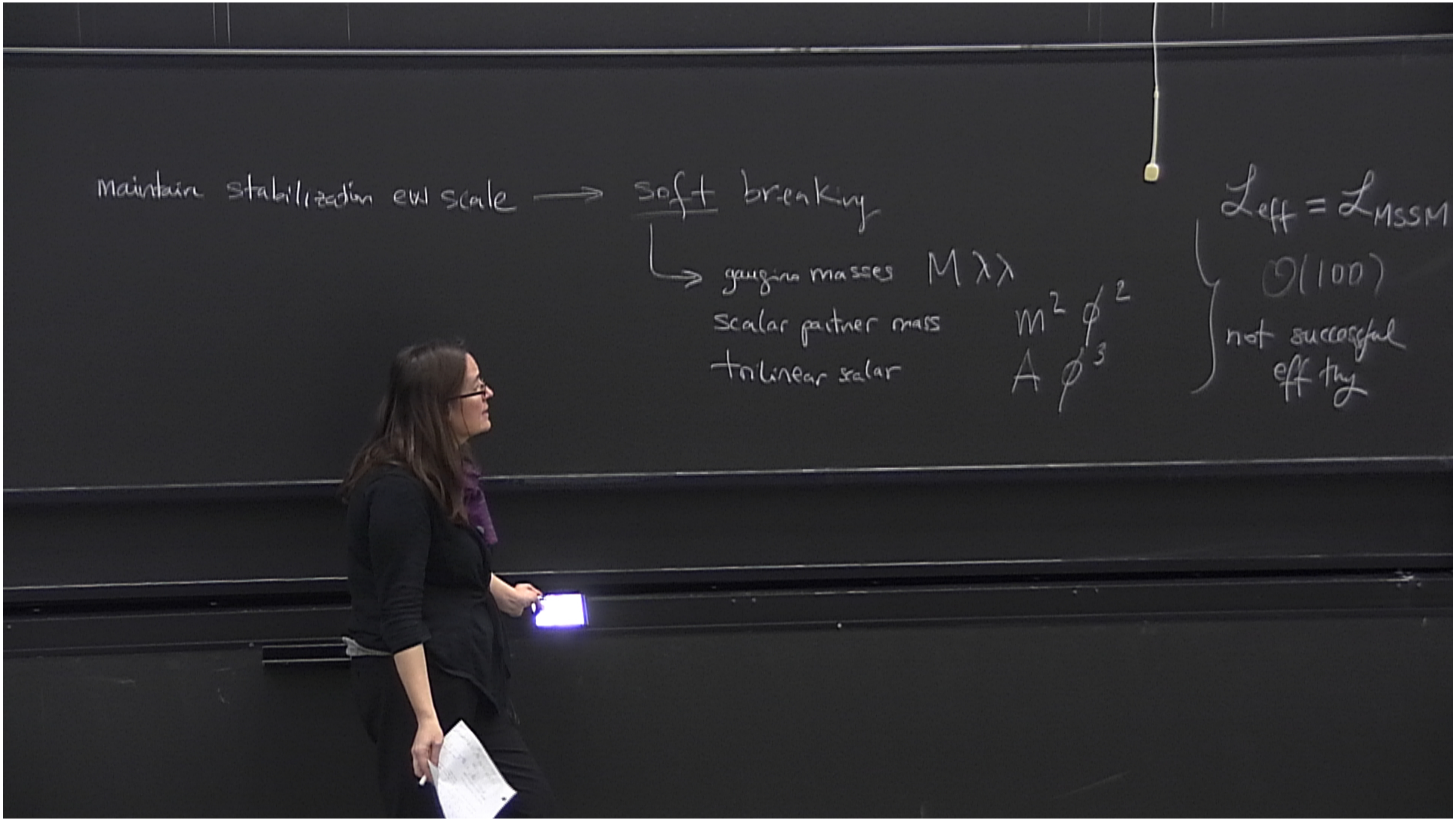
Title: Beyond the Standard Model (Review) - Lecture 10

Date: Feb 27, 2012 09:00 AM

URL: http://pirsa.org/12020091

Abstract:


maintain stabilization ewk scale → soft breaking
gaugino masses M λλ
scalar partner mass m² φ²
trilinear scalar A φ³
L_eff = L_MSSM
O(100)
not successful
eff thy

maintain stabilization ew scale $\longrightarrow$ soft breaking

$\hookrightarrow$ gaugino masses $M\lambda\lambda$

scalar partner mass $m^2 \phi^2$

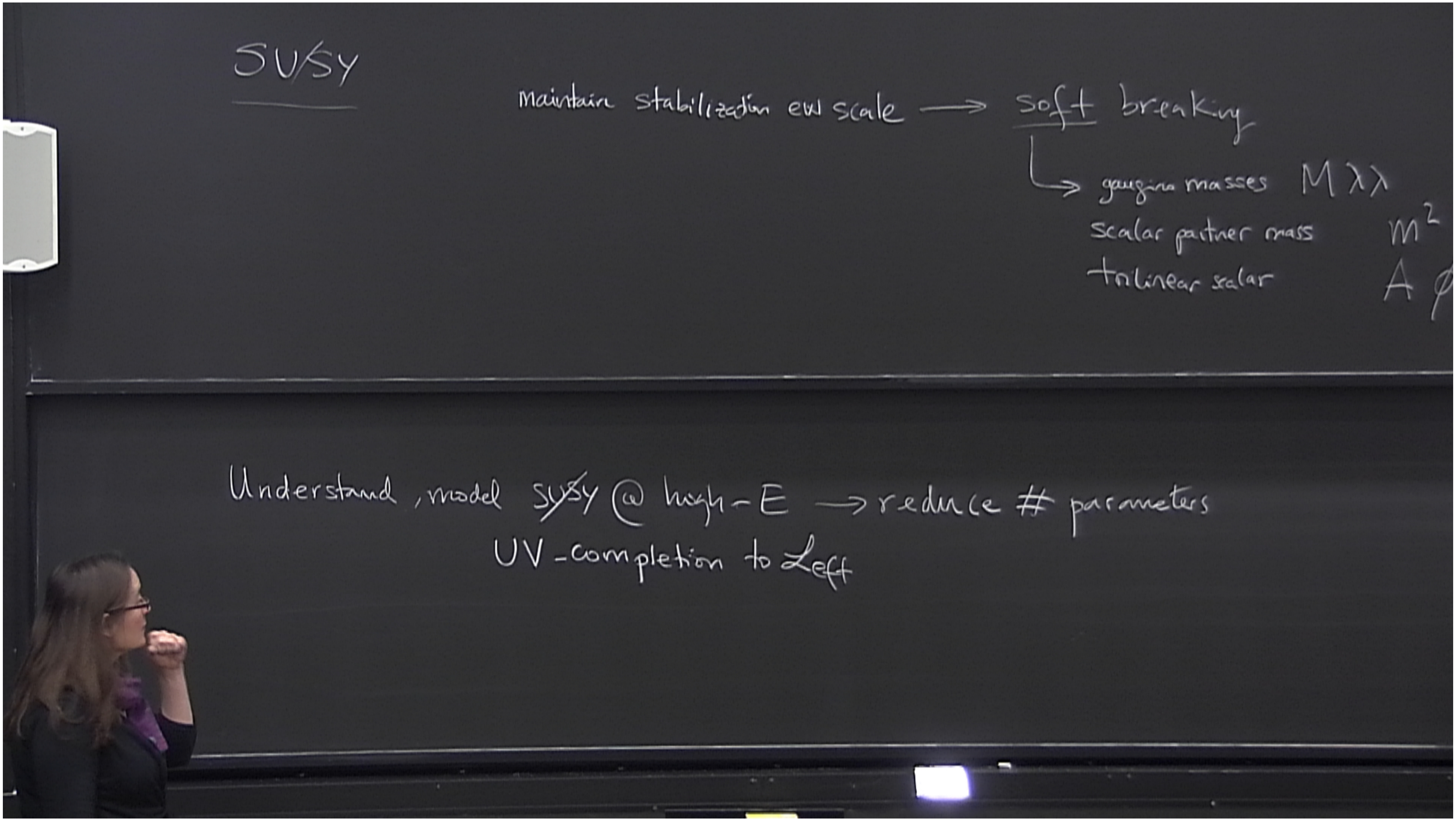
trilinear scalar $A\phi^3$

$\mathcal{L}_{eff} = \mathcal{L}_{MSSM}$

$\mathcal{O}(100)$

not successful eff thy

el ~~SUSY~~ @ high-E $\longrightarrow$ reduce # p



SUSY
maintain stabilization ew scale $\longrightarrow$ soft breaking
$\hookrightarrow$ gaugino masses $M\lambda\lambda$
scalar partner mass m^2
trilinear scalar $A\phi$
Understand, model $\cancel{SUSY}$ @ high-E $\longrightarrow$ reduce # parameters
UV-completion to $\mathcal{L}_{eff}$

Understand, model $\cancel{\text{SUSY}}$ @ high-E $\longrightarrow$ reduce # parameters

UV-completion to $\mathcal{L}_{eff}$

SUSY model building

Spontaneous $\cancel{\text{SUSY}}$

$\mathcal{L}_{susy}$ but $\cancel{|0\rangle}$

SUSY $\quad Q|0\rangle = \bar{Q}|0\rangle = 0$

$\{Q, \bar{Q}\} = 2\sigma_\mu P^\mu \longrightarrow$

Understand, model $\cancel{\text{SUSY}}$ @ high-E $\rightarrow$ reduce # parameters

UV-completion to $\mathcal{L}_{eff}$

SUSY model building

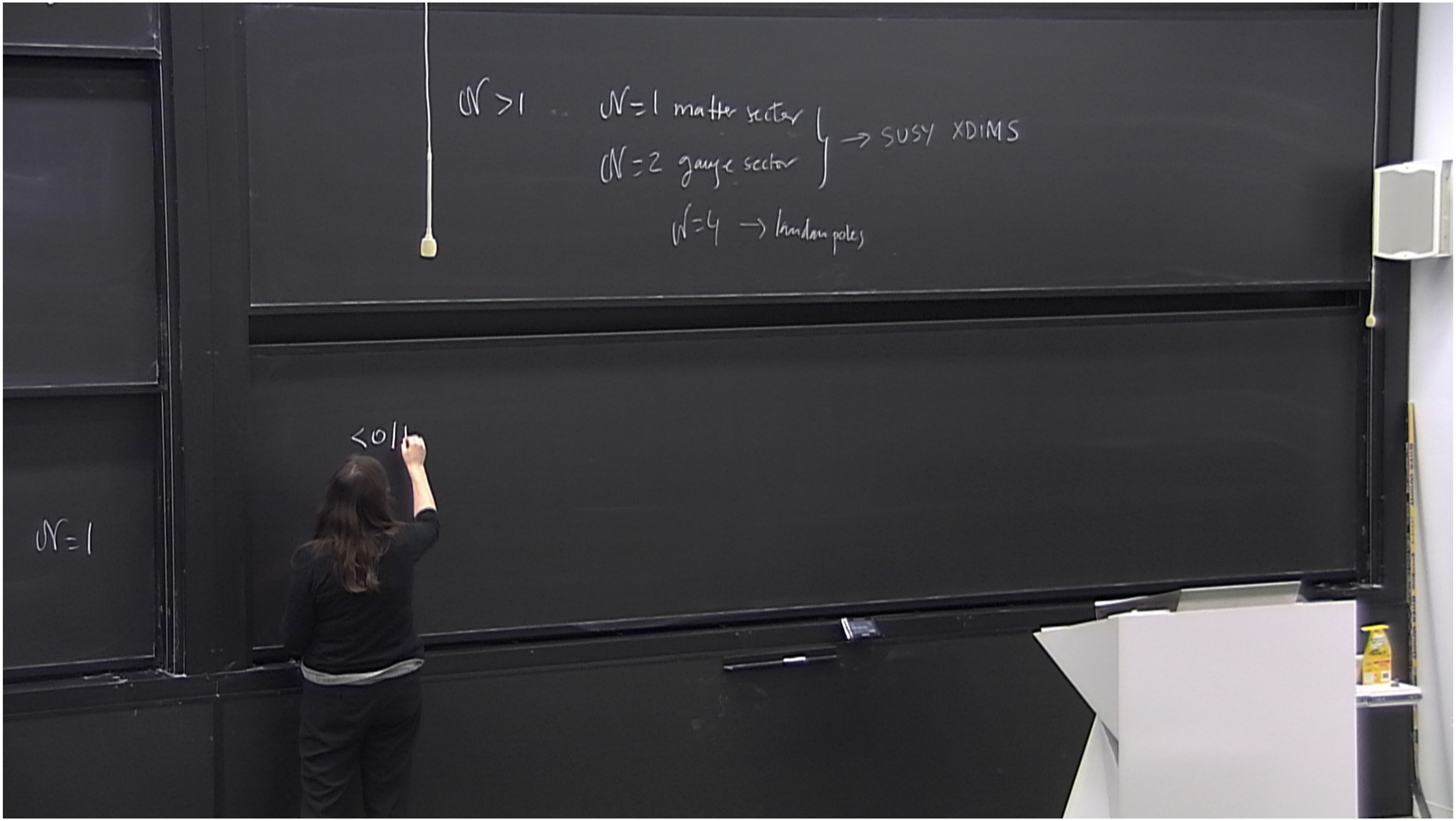
Spontaneous $\cancel{\text{SUSY}}$

$\mathcal{L}_{susy}$ but $\cancel{|0\rangle}$

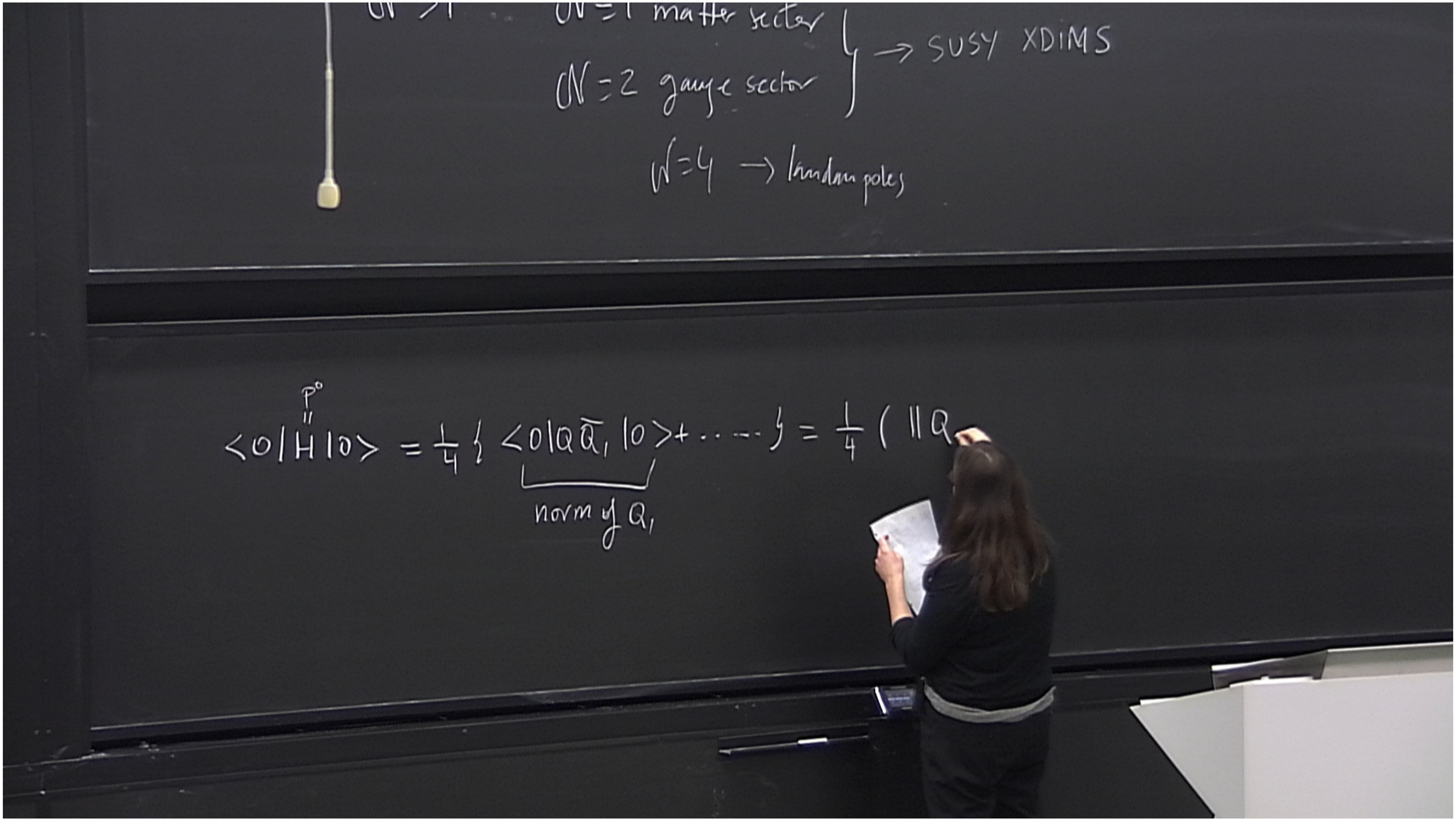
SUSY $\quad Q|0\rangle = \bar{Q}|0\rangle = 0$

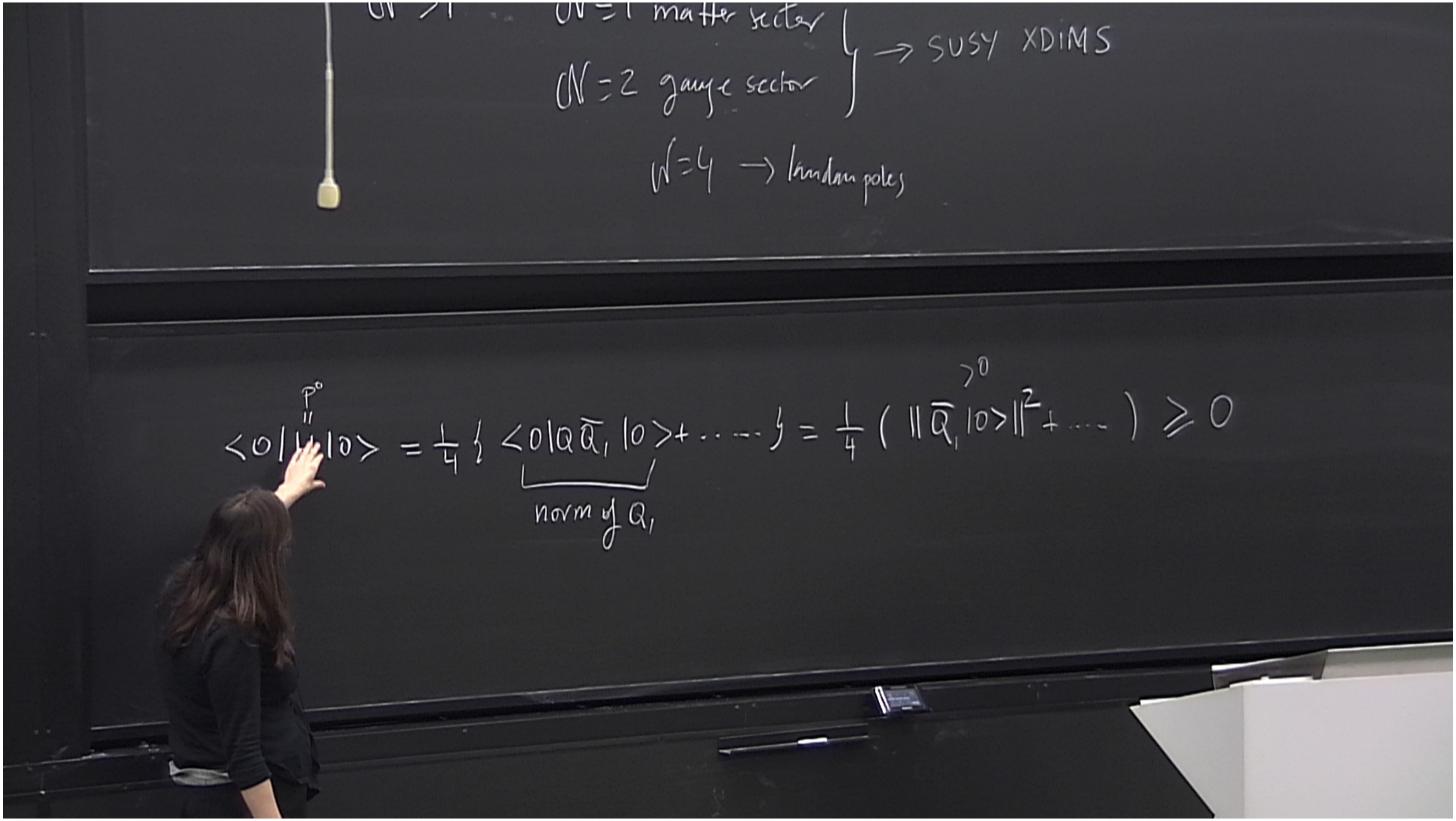
$$\{Q, \bar{Q}\} = 2\sigma_\mu P^\mu \xrightarrow[\sigma_\mu \bar{\sigma}_\mu]{} P^\mu = \frac{1}{4} \bar{\sigma}^\mu \{Q, \bar{Q}\}$$

$$P^0 = \frac{1}{4}\{Q_1 \bar{Q}_1 + \bar{Q}_1 Q_1 + Q_2 \bar{Q}_2 + \bar{Q}_2 Q_2\}$$

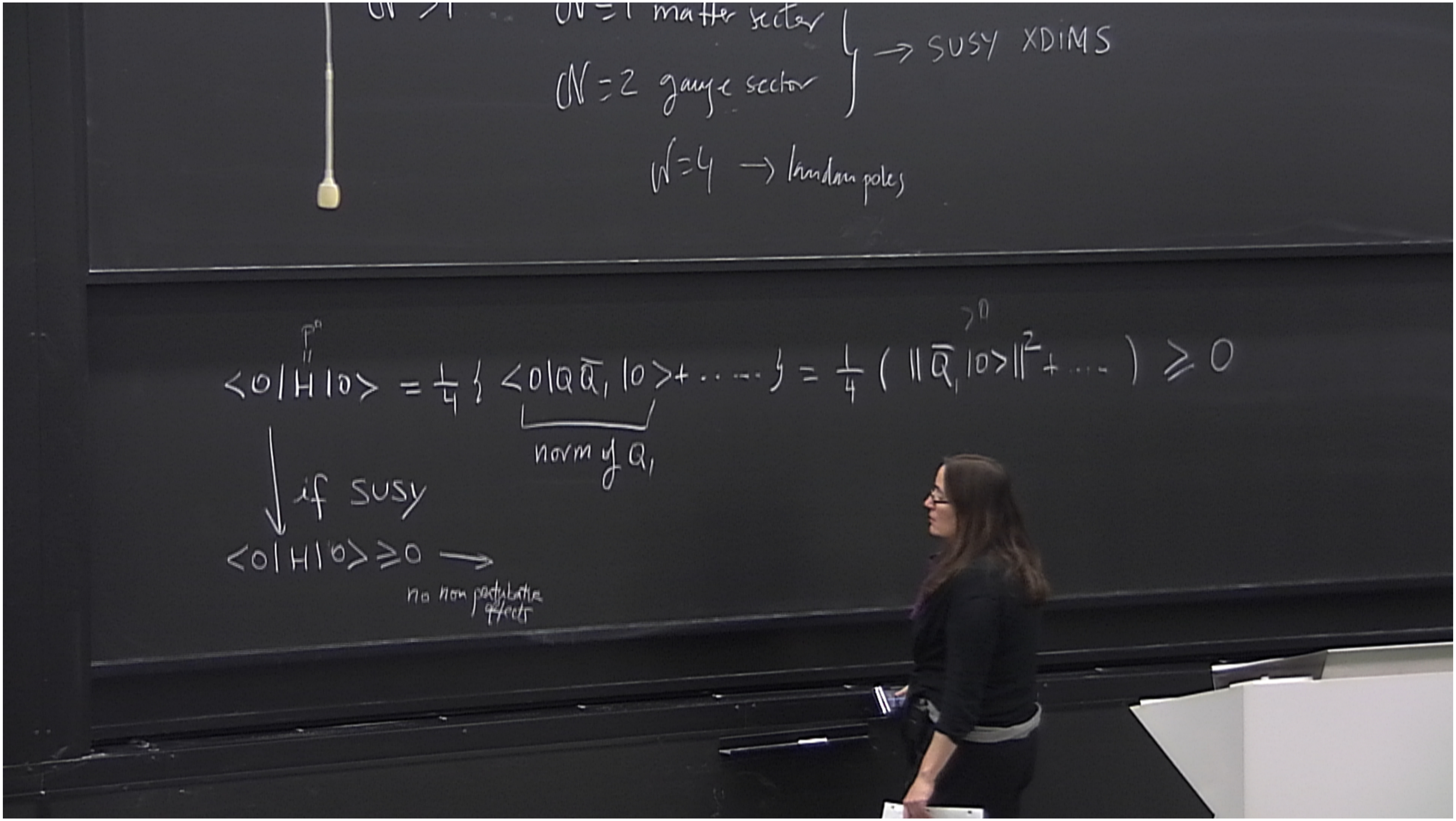


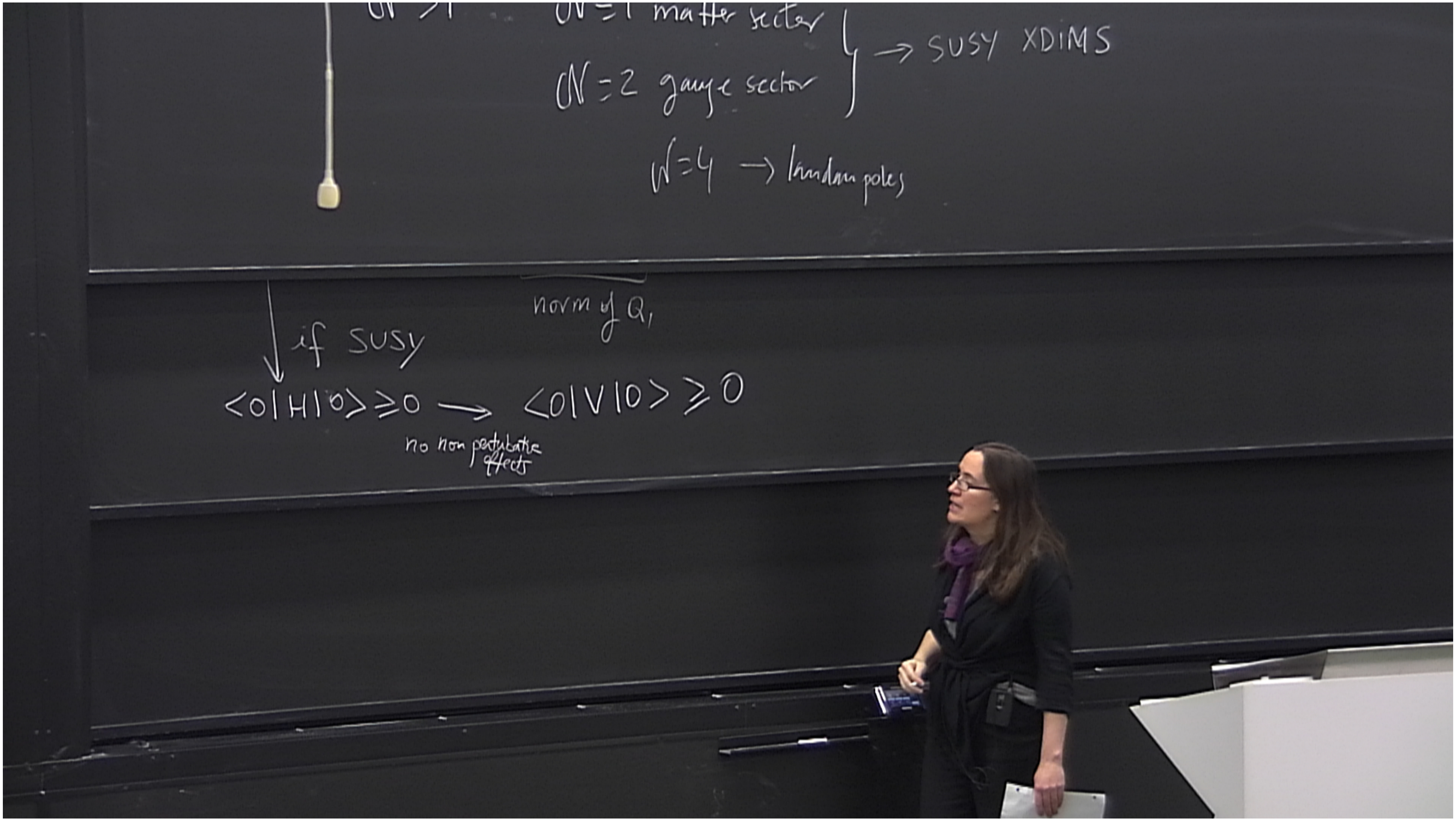
N > 1 ..
N = 1 matter sector
N = 2 gauge sector
→ SUSY XDIMS
N = 4 → landau poles
<0|
N = 1

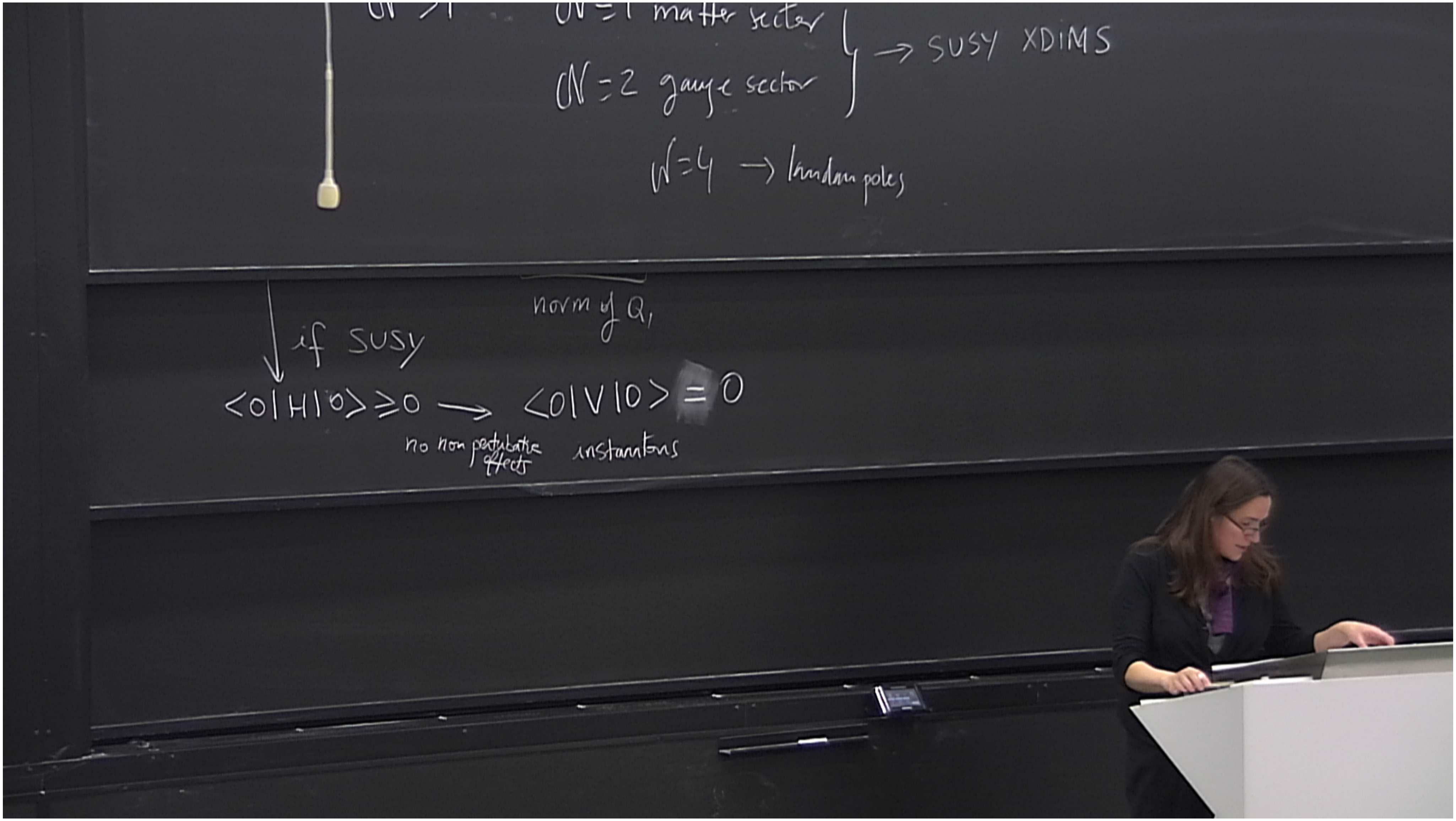

matter sector
N = 2 gauge sector
→ SUSY XDIMS
N = 4 → landau poles
P°
<0|H|0> = 1/4 { <0|Q Q̄₁|0> + ... } = 1/4 (||Q
norm of Q₁

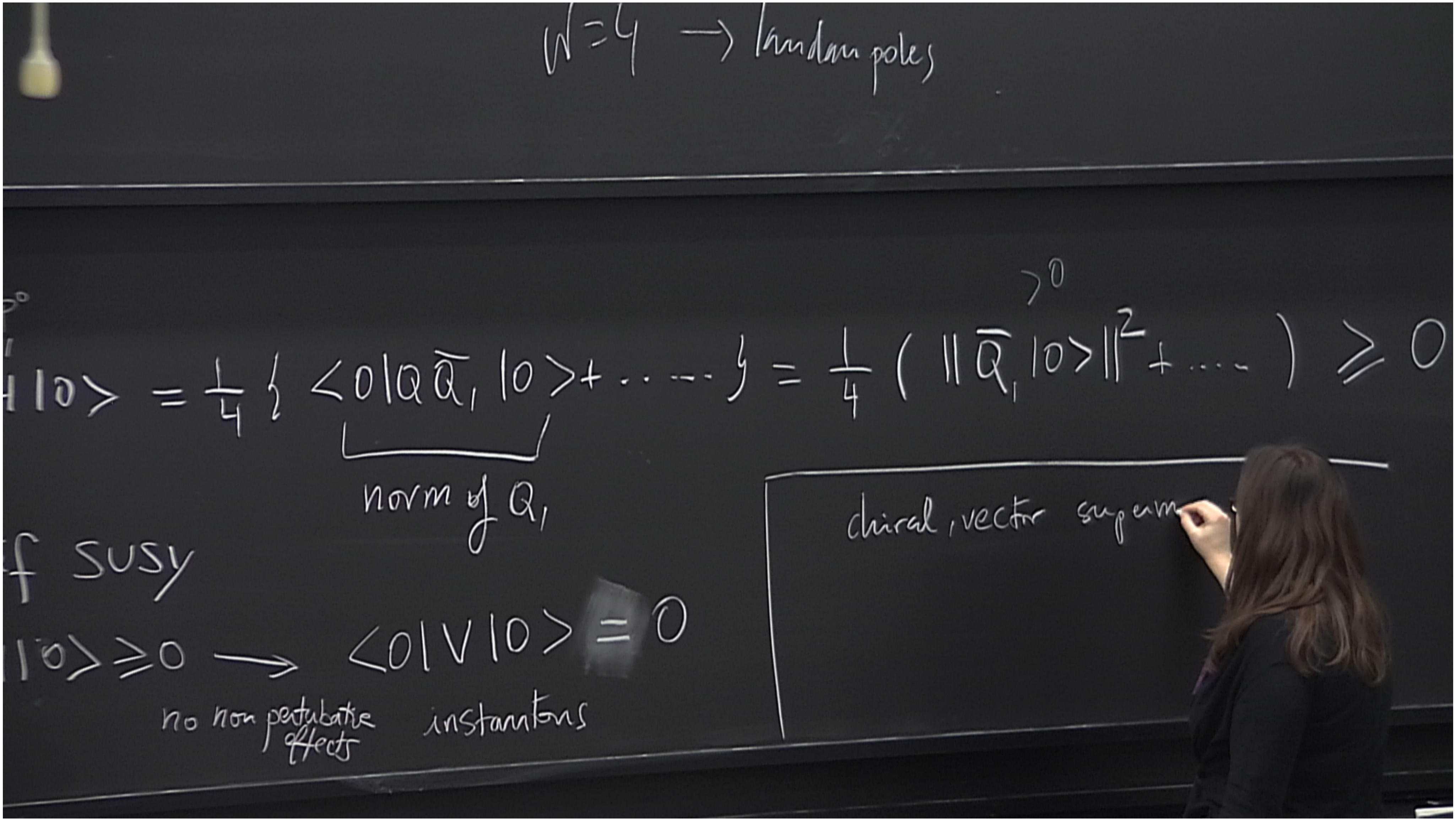


N = 1 matter sector
N = 2 gauge sector
→ SUSY XDIMS
N = 4 → landau poles
P°
<0|H|0> = 1/4 { <0|Q Q̄₁|0> + ... } = 1/4 (||Q̄₁|0>||² + . . .) ≥ 0
>0
norm of Q₁


$\mathcal{N}=1$ matter sector
$\mathcal{N}=2$ gauge sector
→ SUSY XDIMS
$\mathcal{N}=4$ → landau poles
$\langle 0|H|0\rangle = \frac{1}{4}\{\langle 0|Q\bar{Q}_1|0\rangle + \dots\} = \frac{1}{4}(\|\bar{Q}_1|0\rangle\|^2 + \dots) \geq 0$
norm of Q_1
if SUSY
$\langle 0|H|0\rangle \geq 0$ →
no non perturbative effects


N = 2 gauge sector
→ SUSY XDIMS
N=4 → landau poles
norm of Q1
if SUSY
<0|H|0> ≥ 0 → <0|V|0> ≥ 0
no non perturbative effects


N = 1 matter sector
N = 2 gauge sector
→ SUSY XDIMS
N = 4 → landau poles
norm of Q1
if SUSY
<0|H|0> ≥ 0 → <0|V|0> = 0
no non perturbative effects
instantons


$N=4 \rightarrow$ landau poles
>0
$H|0\rangle = \frac{1}{4}\{\underbrace{\langle 0|Q\bar{Q}_1|0\rangle}_{\text{norm of } Q_1} + \ldots\ldots\} = \frac{1}{4}(\|\bar{Q}_1|0\rangle\|^2 + \ldots\ldots) \geq 0$
chiral, vector superm
f SUSY
$|0\rangle \geq 0 \longrightarrow \langle 0|V|0\rangle = 0$
no non perturbative effects
instantons

$$\langle 0|\overset{P^0}{\overset{\shortparallel}{H}}|0\rangle = \frac{1}{4}\Big\{ \underbrace{\langle 0|Q\bar{Q}_1|0\rangle}_{\text{norm of } Q_1} + \cdots\cdots \Big\} = \frac{1}{4}\Big(\overset{>0}{\| \bar{Q}_1|0\rangle \|^2} + \cdots \Big) \geq 0$$

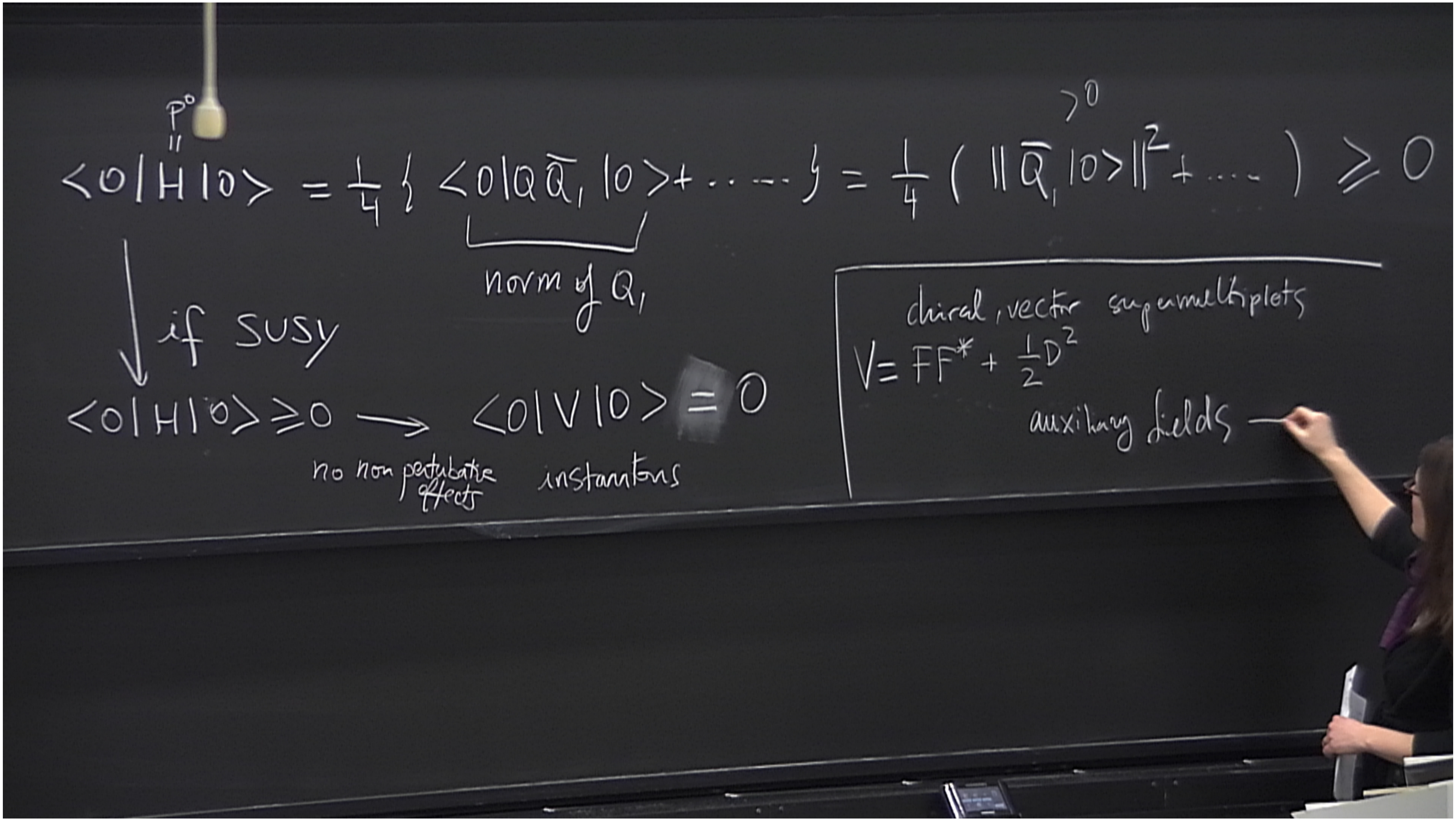
$\big\downarrow$ if SUSY

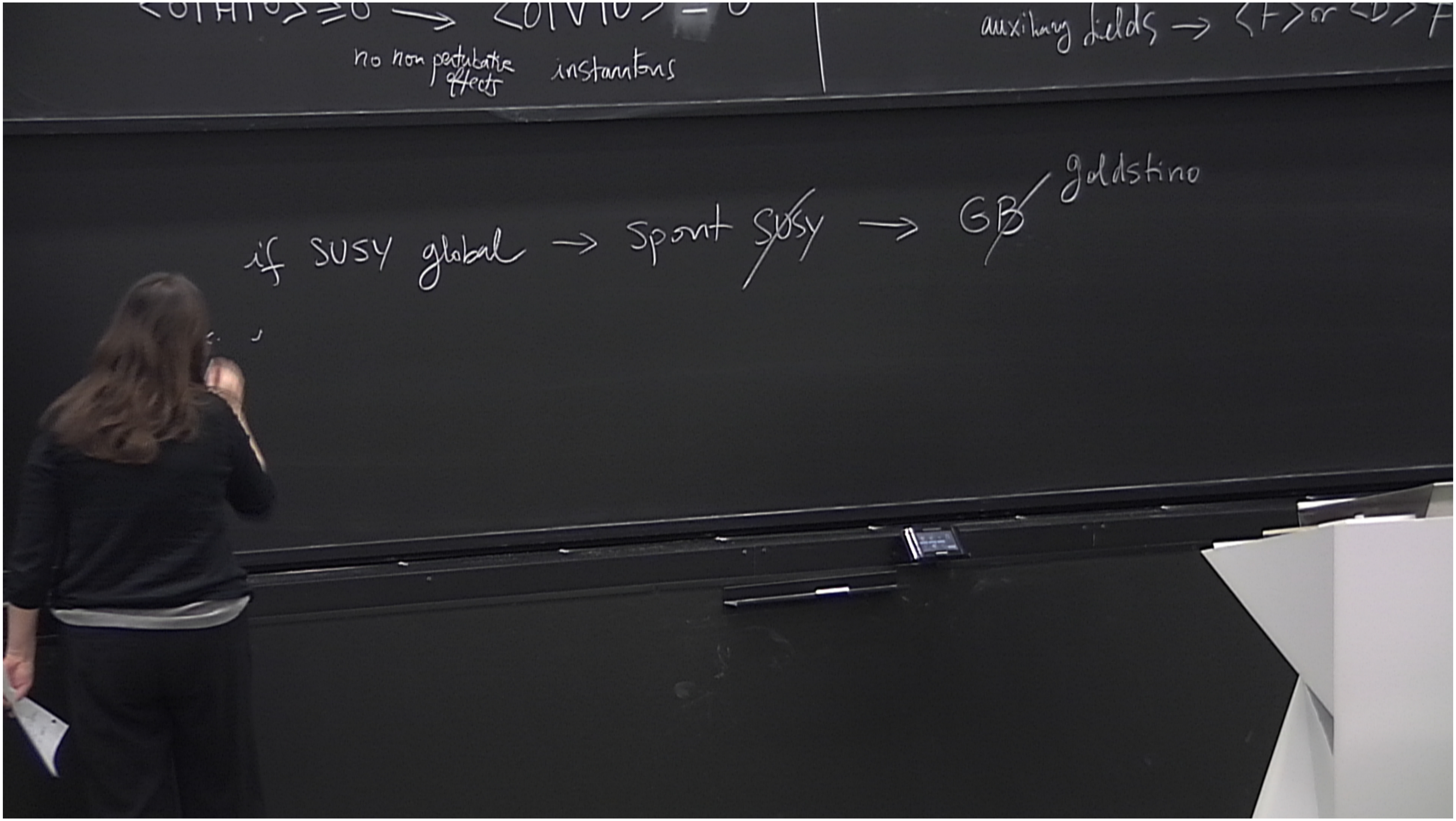
$$\langle 0|H|0\rangle \geq 0 \longrightarrow \langle 0|V|0\rangle = 0$$

no non perturbative effects   instantons

chiral, vector supermultiplets

$$V = FF^* + \frac{1}{2}D^2$$


$\langle 0|\underset{P^0}{\overset{\shortparallel}{H}}|0\rangle = \frac{1}{4}\{\underbrace{\langle 0|Q\bar{Q}_1|0\rangle}_{\text{norm of } Q_1} + \dots\} = \frac{1}{4}(\|\bar{Q}_1|0\rangle\|^2 + \dots) \geq 0$
>0
if SUSY
$\langle 0|H|0\rangle \geq 0 \longrightarrow \langle 0|V|0\rangle = 0$
no non perturbative effects
instantons
chiral, vector supermultiplets
$V = FF^* + \frac{1}{2}D^2$
auxiliary fields


no non perturbative effects
instantons
auxiliary fields → ⟨F⟩ or ⟨D⟩
if SUSY global → spont ~~SUSY~~ → ~~GB~~ goldstino

$\langle 0|H|0\rangle = \frac{1}{4}\{\underbrace{\langle 0|Q\bar{Q}_1|0\rangle}_{\text{norm of } Q_1} + \dots\} = \frac{1}{4}(\|\bar{Q}_1|0\rangle\|^2 + \dots) \geq 0$

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$\langle 0|H|0\rangle \geq 0 \longrightarrow \langle 0|V|0\rangle = 0$

no non perturbative effects instantons

chiral, vector supermultiplets

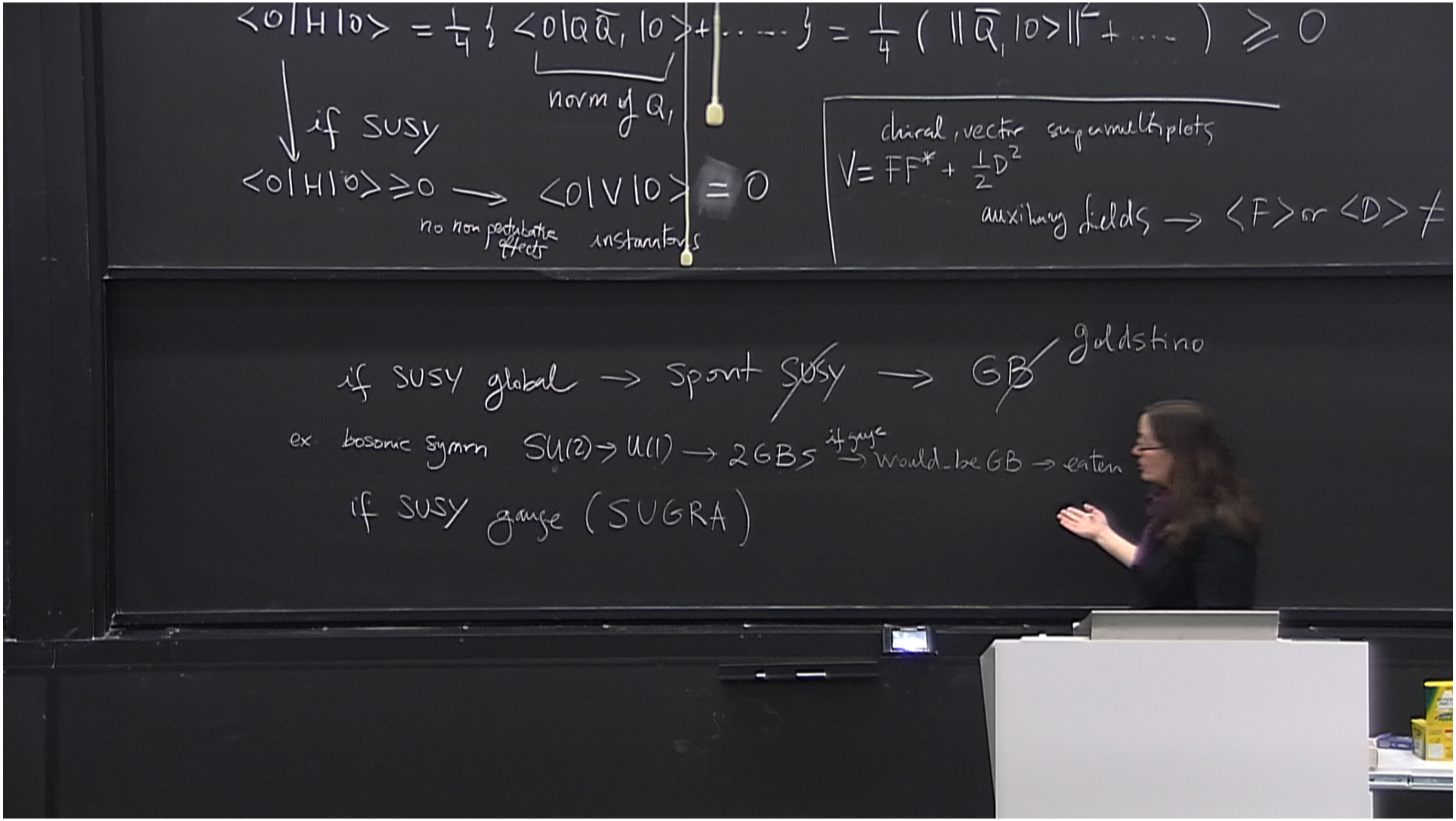
$V = FF^* + \frac{1}{2}D^2$

auxiliary fields $\rightarrow \langle F\rangle$ or $\langle D\rangle \neq$

if SUSY global $\rightarrow$ spont ~~SUSY~~ $\rightarrow$ ~~GB~~ goldstino

ex bosonic symm $SU(2) \rightarrow U(1) \rightarrow 2$ GBs

if SUSY gauge (



<0|H|0> = 1/4 { <0|Q Q̄₁ |0> + ... } = 1/4 (||Q̄₁ |0>||² + ...) ≥ 0
norm of Q₁
if SUSY
<0|H|0> ≥ 0 → <0|V|0> = 0
no non perturbative effects
instantons
chiral, vector supermultiplets
V = FF* + 1/2 D²
auxiliary fields → <F> or <D> ≠
goldstino
if SUSY global → spont SUSY → GB
ex. bosonic symm SU(2) → U(1) → 2 GBs
if gauge
would-be GB → eaten
if SUSY gauge (SUGRA)

$$\langle 0|H|0\rangle = \frac{1}{4}\{ \underbrace{\langle 0|Q\bar{Q}_1|0\rangle}_{\text{norm of } Q_1} + \cdots \} = \frac{1}{4}\left(\|\bar{Q}_1|0\rangle\|^2 + \cdots \right) \geq 0$$

$\downarrow$ if SUSY

$$\langle 0|H|0\rangle \geq 0 \longrightarrow \langle 0|V|0\rangle = 0$$

no non perturbative effects   instantons

chiral, vector supermultiplets

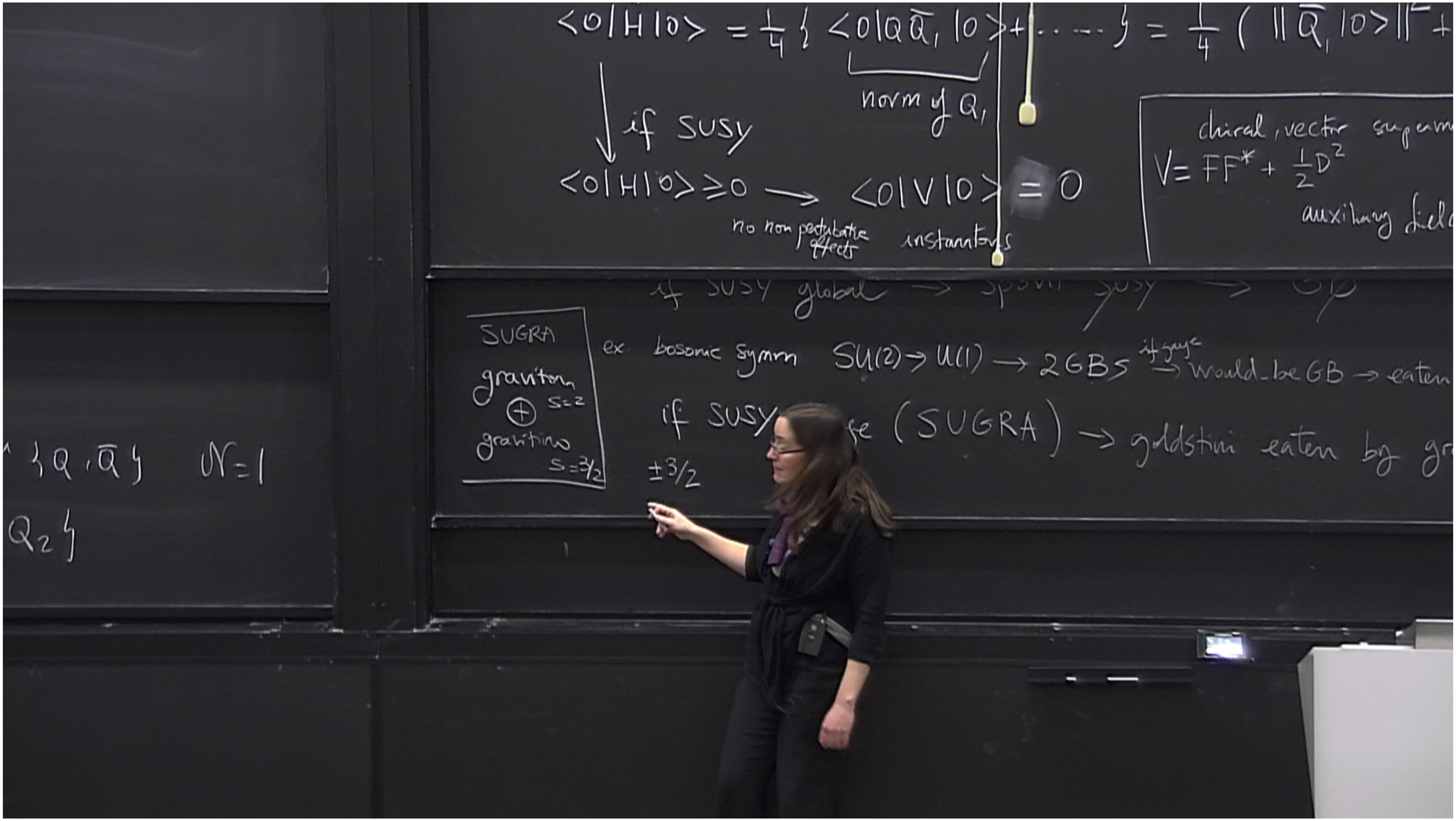
$$V = FF^* + \frac{1}{2}D^2$$

auxiliary fields $\longrightarrow \langle F\rangle$ or $\langle D\rangle \neq$

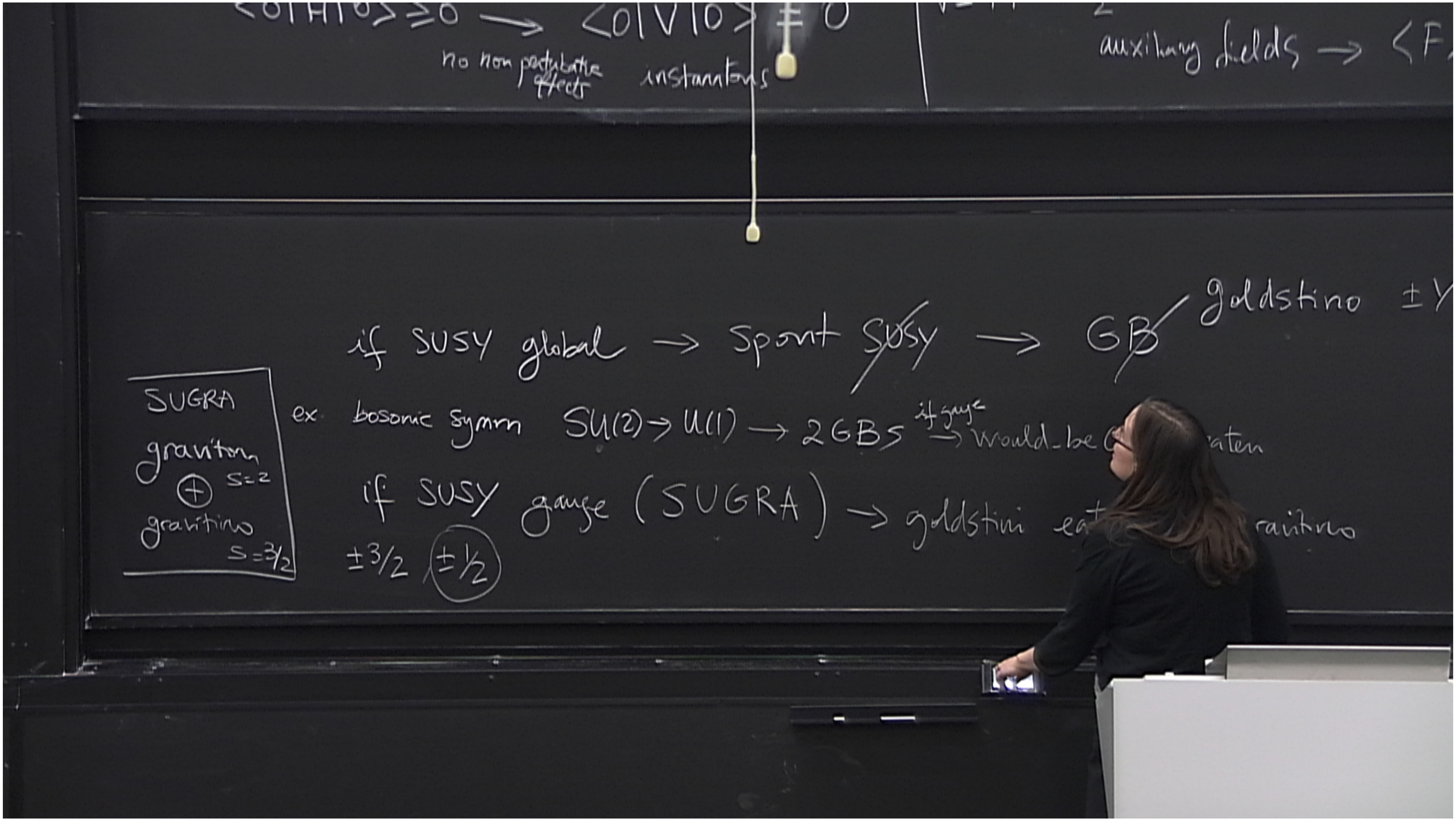
if SUSY global $\longrightarrow$ spont $\cancel{\text{SUSY}}$ $\longrightarrow$ $\cancel{\text{GB}}$ goldstino

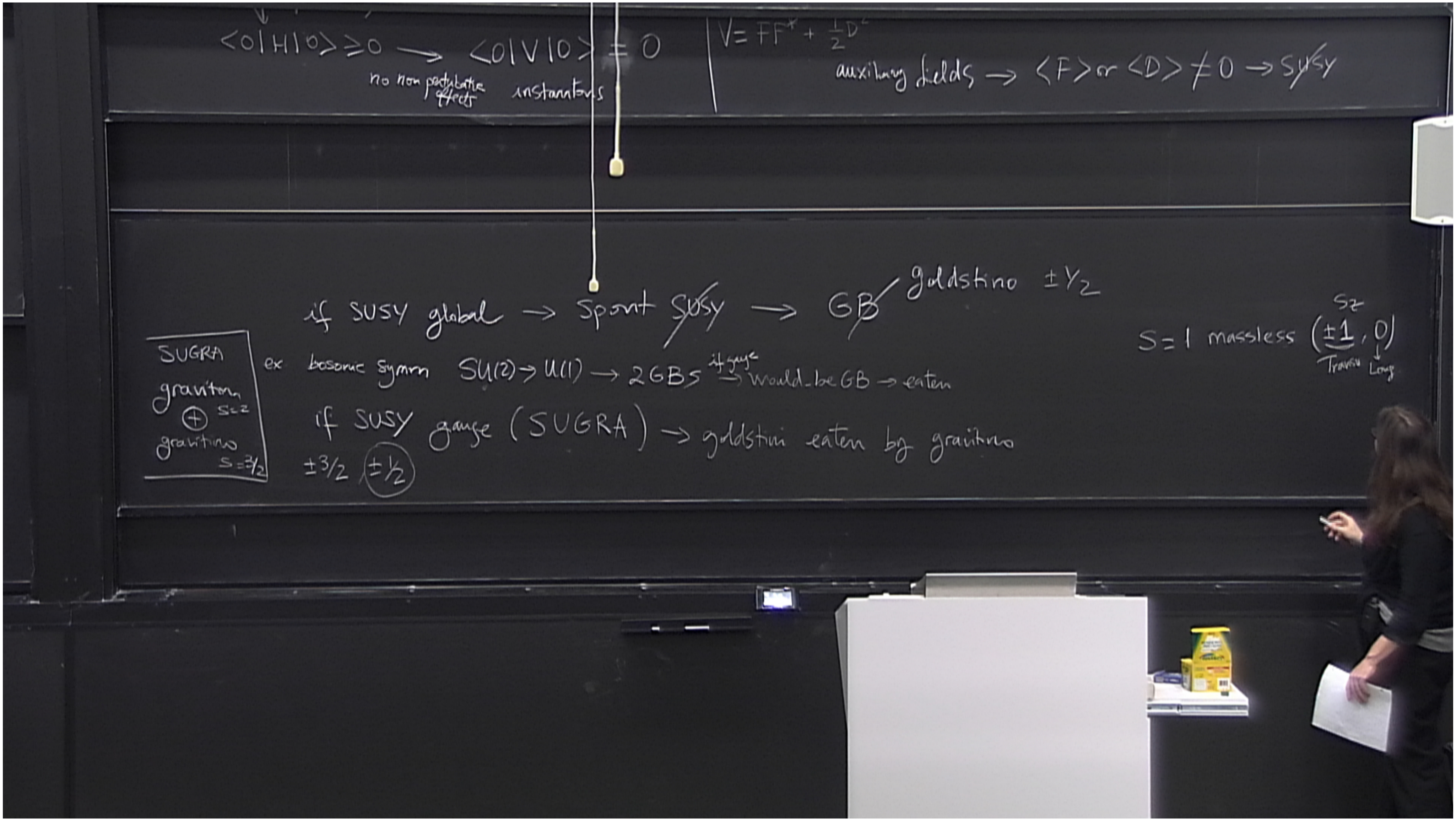
ex. bosonic symm $SU(2) \to U(1) \longrightarrow 2$ GBs $\xrightarrow{\text{if gauge}}$ would-be GB $\to$ eaten

if SUSY gauge (SUGRA) $\longrightarrow$ goldstini eaten

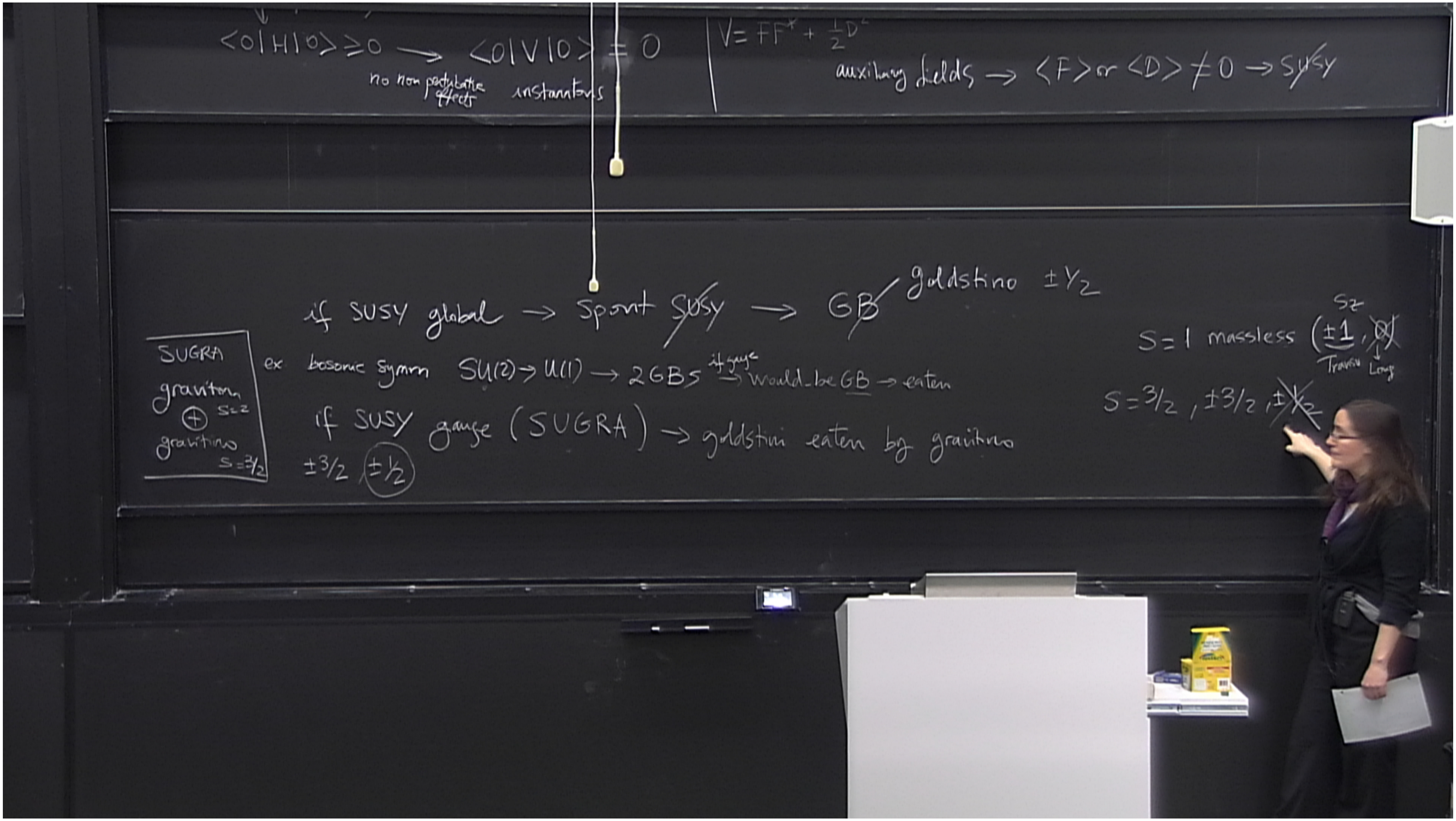


$\langle 0|H|0\rangle = \frac{1}{4}\{\langle 0|Q\bar{Q}_1|0\rangle + \cdots\} = \frac{1}{4}(\|\bar{Q}_1|0\rangle\|^2 +$
norm of Q_1
if SUSY
$\langle 0|H|0\rangle \geq 0 \longrightarrow \langle 0|V|0\rangle = 0$
no non perturbative effects
instantons
chiral, vector
$V = FF^* + \frac{1}{2}D^2$
auxiliary field
if SUSY global
SUGRA
graviton $s=2$
$\oplus$
gravitino $s=3/2$
ex bosonic symm $SU(2) \to U(1) \to 2\,GBs \xrightarrow{\text{if gauge}}$ would-be GB $\to$ eaten
if SUSY (SUGRA) $\to$ goldstini eaten by
$\pm 3/2$
$\{Q, \bar{Q}\}$ $\mathcal{N}=1$
$Q_2\}$


no non perturbative effects
instantons
auxiliary fields → <F
if SUSY global → spont SUSY → GB goldstino ±1/2
SUGRA
graviton s=2
⊕
gravitino s=3/2
ex. bosonic symm SU(2) → U(1) → 2 GBs
if gauge → would-be
eaten
if SUSY gauge (SUGRA) → goldstini
gravitino
±3/2 ±1/2



<0|H|0> ≥ 0 → <0|V|0> = 0
no non perturbative effects
instantons
V = FF* + 1/2 D²
auxiliary fields → <F> or <D> ≠ 0 → SUSY
goldstino ±1/2
if SUSY global → spont SUSY → GB
Sz
S = 1 massless (±1, 0)
Transv Long
SUGRA
graviton S=2
⊕
gravitino S=3/2
ex bosonic symm SU(2) → U(1) → 2 GBs if gauge → would-be GB → eaten
if SUSY gauge (SUGRA) → goldstini eaten by gravitino
±3/2 ±1/2


$\langle 0|H|0\rangle \geq 0 \rightarrow \langle 0|V|0\rangle \neq 0$
no non perturbative effects
instantons
$V = FF^* + \frac{1}{2}D^2$
auxiliary fields $\rightarrow \langle F\rangle$ or $\langle D\rangle \neq 0 \rightarrow$ ~~SUSY~~
if SUSY global $\rightarrow$ spont ~~SUSY~~ $\rightarrow$ ~~GB~~ goldstino $\pm 1/2$
SUGRA
graviton
$\oplus$
gravitino
S_z
$S = 3/2$
ex bosonic symm $SU(2) \rightarrow U(1) \rightarrow 2$ GBs $\xrightarrow{\text{if gauge}}$ would-be GB $\rightarrow$ eaten
if SUSY gauge (SUGRA) $\rightarrow$ goldstini eaten by gravitino
$\pm 3/2$, $\pm 1/2$
S_z
$S = 1$ massless $(\pm 1, \cancel{0})$
Transv
Long
$S = 3/2$, $\pm 3/2$, $\cancel{\pm 1/2}$

$\langle 0|H|0\rangle \geq 0 \longrightarrow \langle 0|V|0\rangle = 0$

no non perturbative effects   instantons

$V = FF^* + \frac{1}{2}D^2$

auxiliary fields $\rightarrow \langle F\rangle$ or $\langle D\rangle \neq 0 \rightarrow$ ~~SUSY~~

$\boxed{\text{SUGRA: graviton } (S_z = 2) \oplus \text{gravitino } (S = 3/2)}$

if SUSY global $\rightarrow$ spont ~~SUSY~~ $\rightarrow$ ~~GB~~ goldstino $\pm 1/2$

ex bosonic symm $SU(2) \rightarrow U(1) \rightarrow 2$ GBs $\xrightarrow{\text{if gauge}}$ would-be GB $\rightarrow$ eaten

if SUSY gauge (SUGRA) $\rightarrow$ goldstini eaten by gravitino

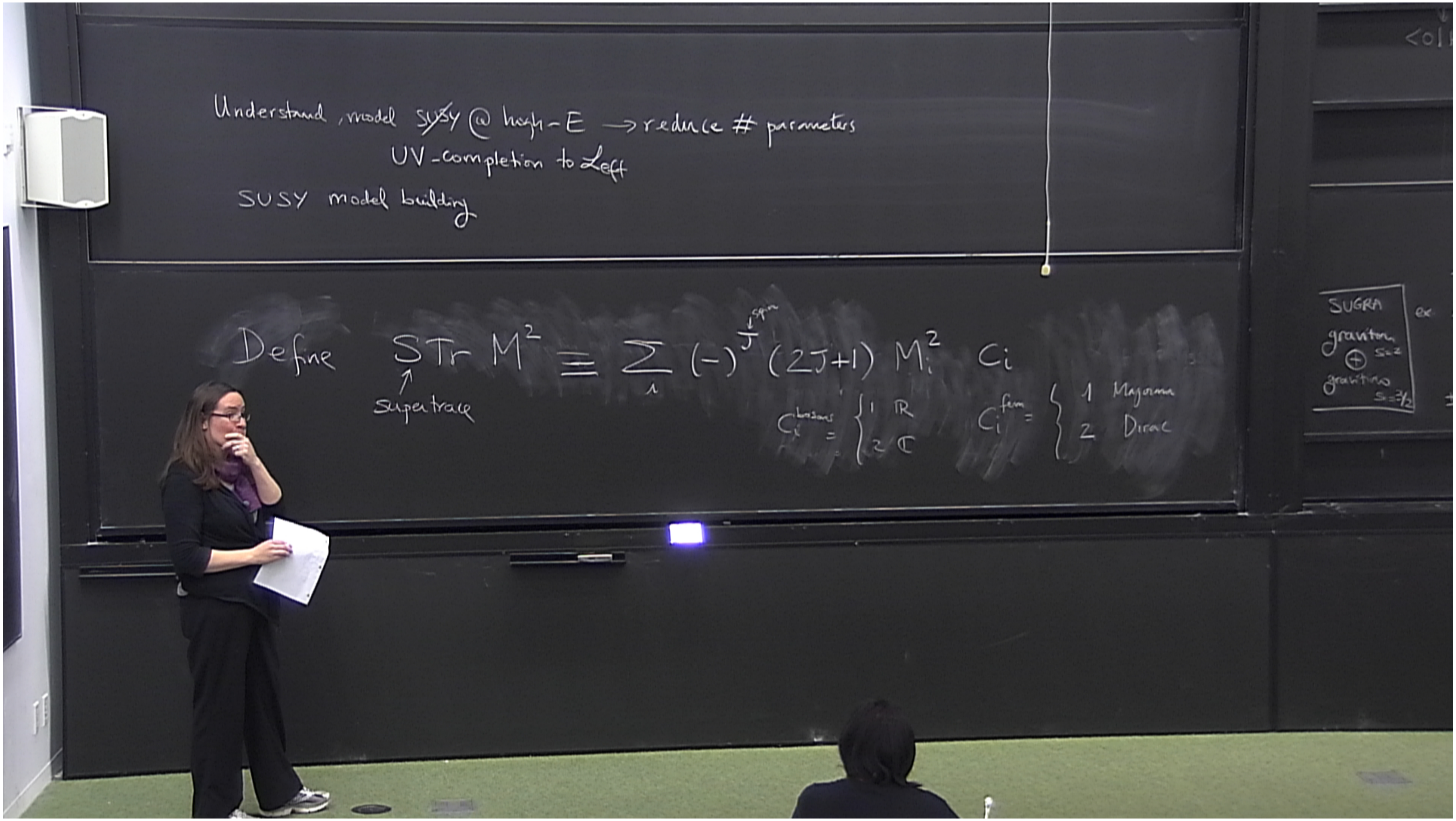
$\pm 3/2 \quad \pm 1/2 \qquad \varepsilon(x^\mu)$

S_z

$S = 1$ massless $(\underset{\text{Transv}}{\pm 1}, \underset{\text{Long}}{\cancel{0}})$

$S = 3/2, \ \pm 3/2, \cancel{\pm 1/2}$

super Higgs mech   goldstini


Understand, model SUSY @ high-E → reduce # parameters
UV-completion to $\mathcal{L}_{eff}$
SUSY model building
Define $\mathrm{STr}\, M^2 \equiv \sum_i (-)^J (2J+1) M_i^2 \, C_i$
spin
supertrace
$C_i^{bosons} = \begin{cases} 1 & \mathbb{R} \\ 2 & \mathbb{C} \end{cases}$
$C_i^{ferm} = \begin{cases} 1 & \text{Majorana} \\ 2 & \text{Dirac} \end{cases}$
SUGRA
ex
graviton s=2
⊕
gravitino s=3/2

Understand, model ~~SUSY~~ SUSY @ high-E $\rightarrow$ reduce # parameters

UV-completion to $\mathcal{L}_{eff}$

SUSY model building

Define $\underset{\text{supertrace}}{\mathrm{STr}}\, M^2 \equiv \sum_i (-1)^{\overset{\text{spin}}{J}} (2J+1)\, M_i^2 \; C_i$

$C_i^{bosons} = \begin{cases} 1 & \mathbb{R} \\ 2 & \mathbb{C} \end{cases}$ $\qquad C_i^{ferm} = \begin{cases} 1 & \text{Majorana} \\ 2 & \text{Dirac} \end{cases}$

$\langle 0 |$

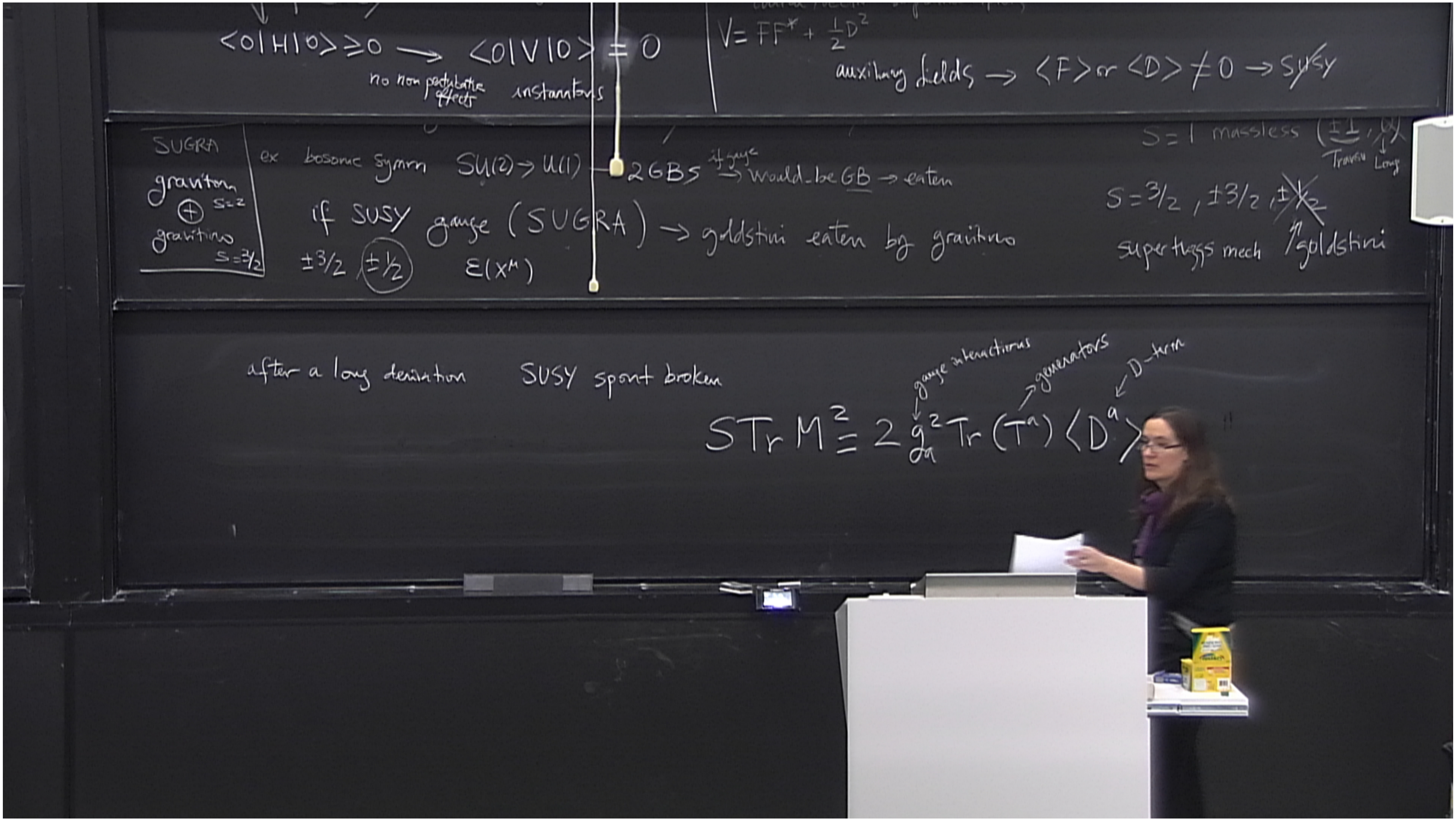
SUGRA

graviton $s=2$

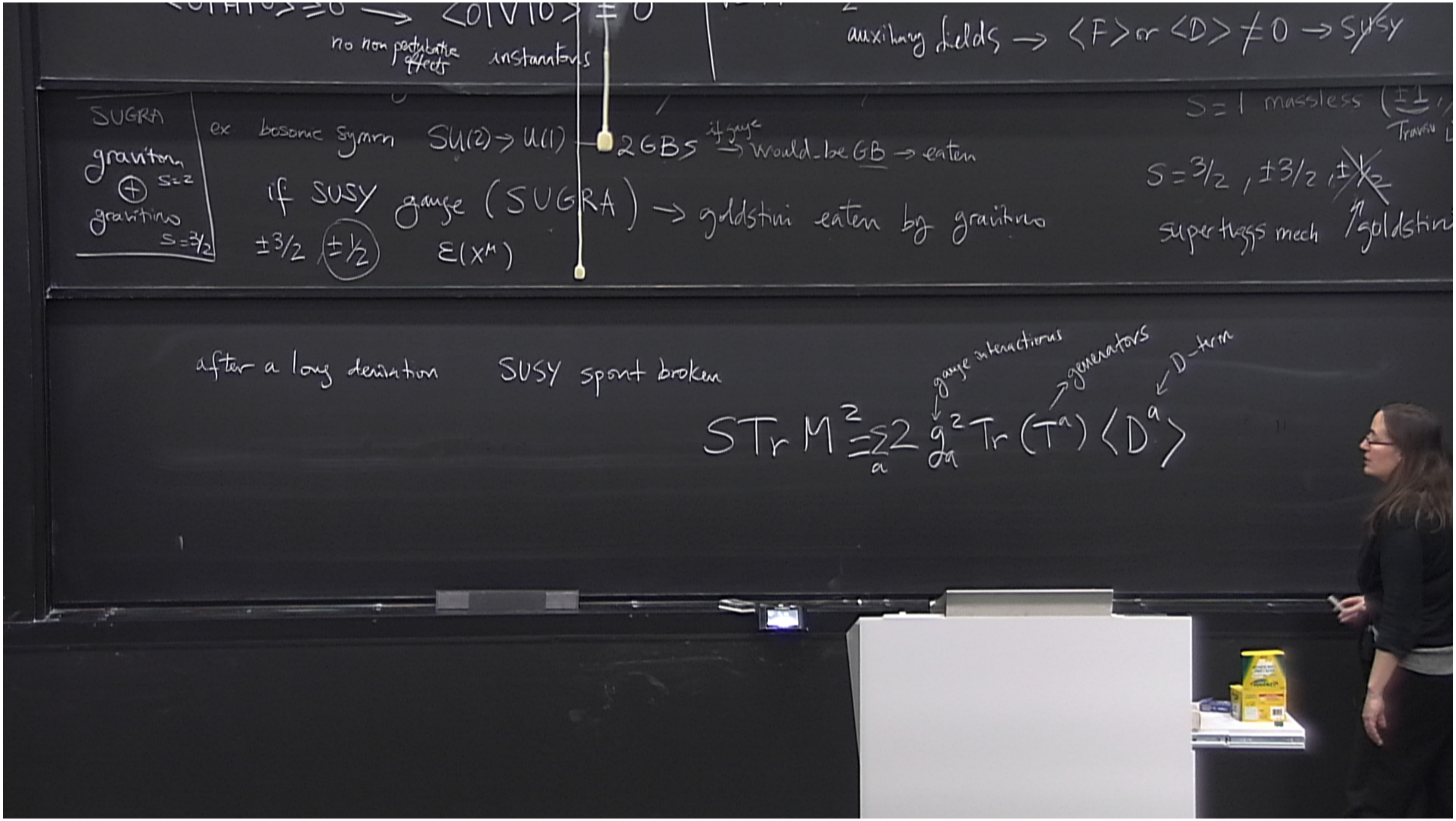
$\oplus$

gravitino $s=3/2$

after



<0|H|0> ≥ 0 → <0|V|0> = 0
no non perturbative effects
instantons
V = FF* + ½D²
auxiliary fields → <F> or <D> ≠ 0 → SUSY
SUGRA
graviton
S=2
⊕
gravitino
S=3/2
ex bosonic symm SU(2) → U(1) 2 GBs
if gauge → would-be GB → eaten
if SUSY gauge (SUGRA) → goldstini eaten by gravitino
±3/2 ±1/2
ε(x^μ)
S=1 massless
Transv
Long
S=3/2 , ±3/2 , ±1/2
super Higgs mech
goldstini
after a long derivation
SUSY spont broken
gauge interactions
generators
D-term
STr M² = 2 g_a² Tr (T^a) ⟨D^a⟩


auxiliary fields → ⟨F⟩ or ⟨D⟩ ≠ 0 → SUSY
no non perturbative effects
instantons
SUGRA
graviton ⊕ S=2
gravitino S=3/2
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±3/2 ±1/2
ε(x^μ)
S=1 massless
S=3/2, ±3/2, ±1/2
super Higgs mech
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after a long derivation SUSY spont broken
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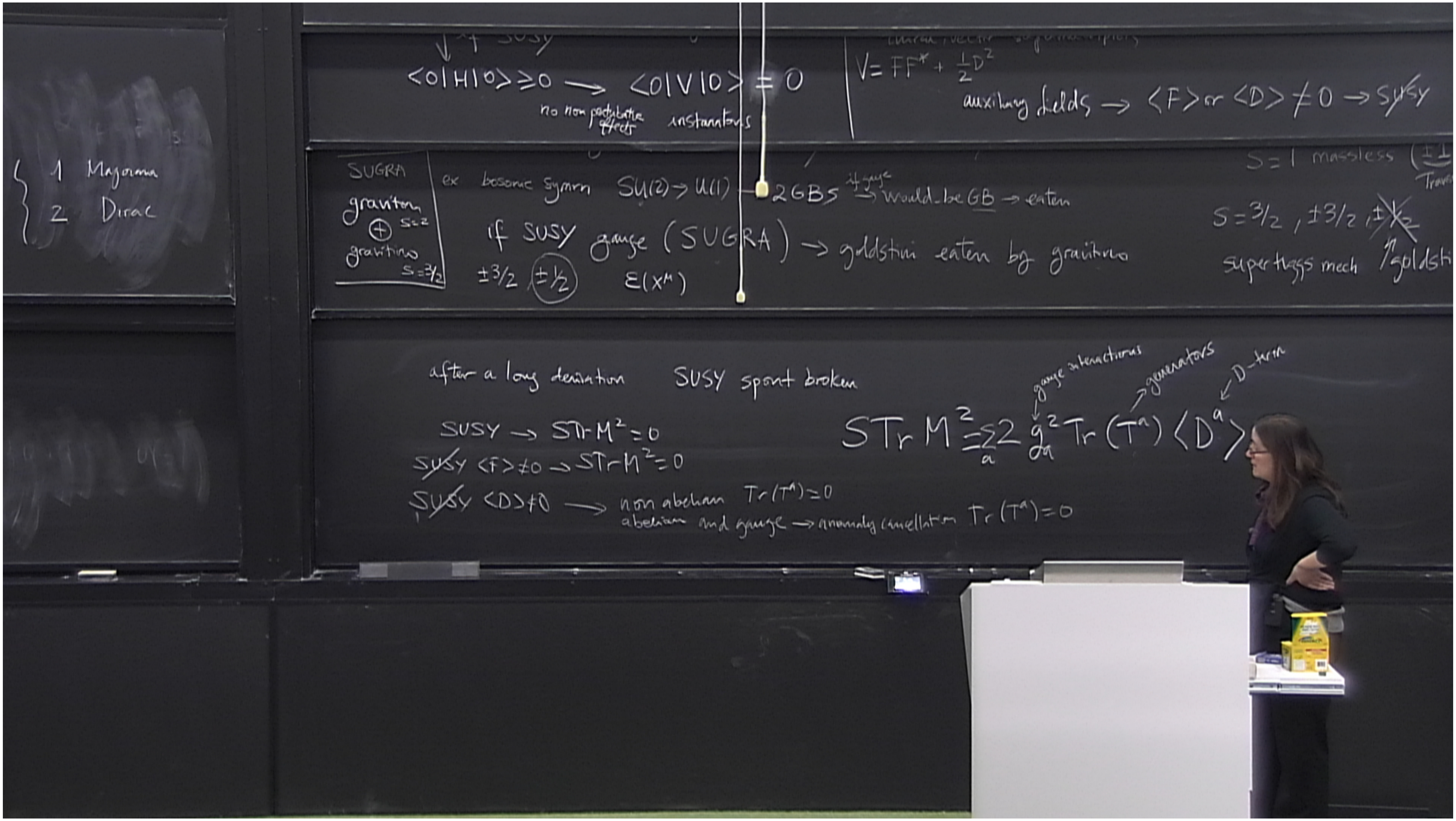
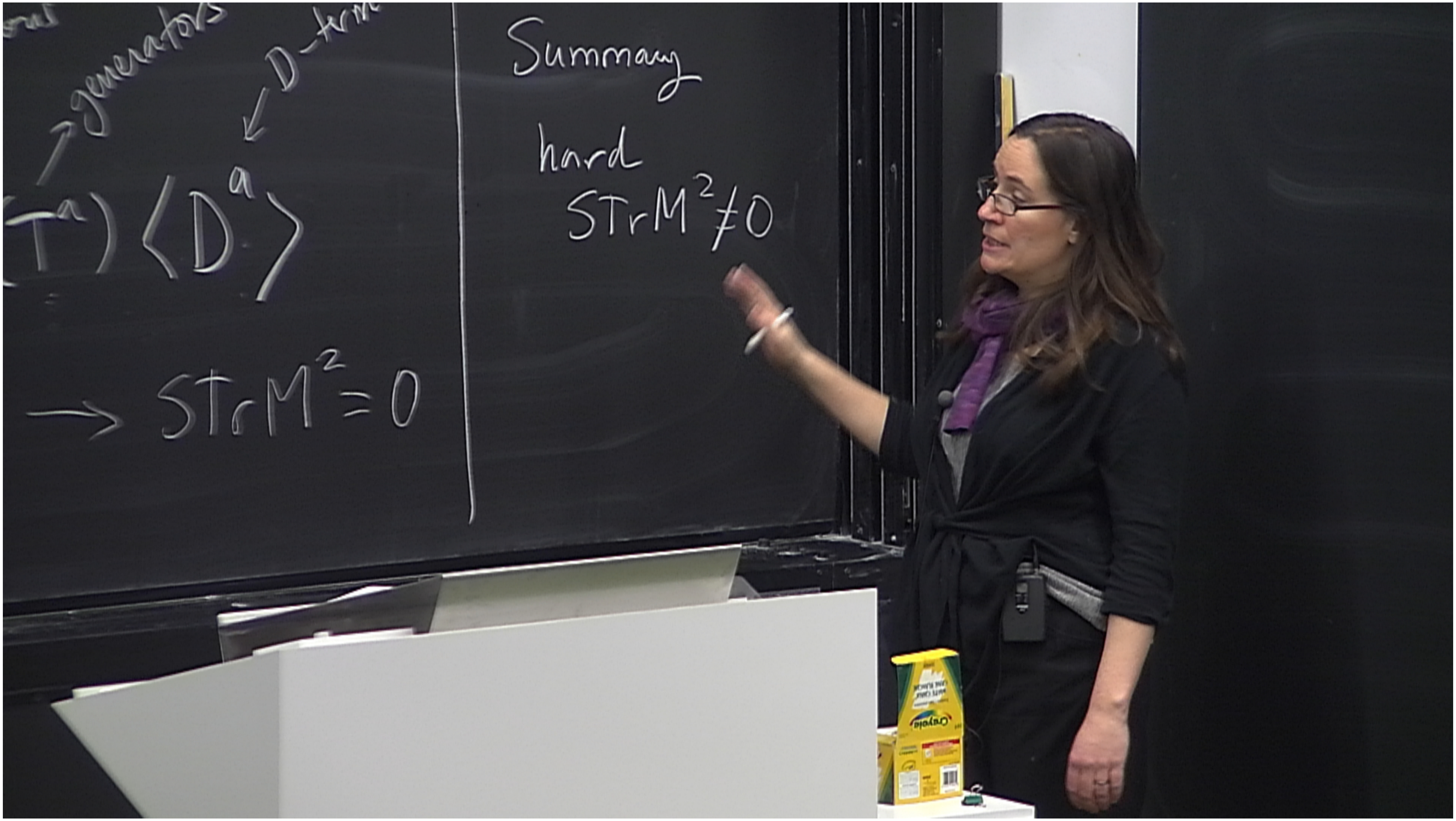
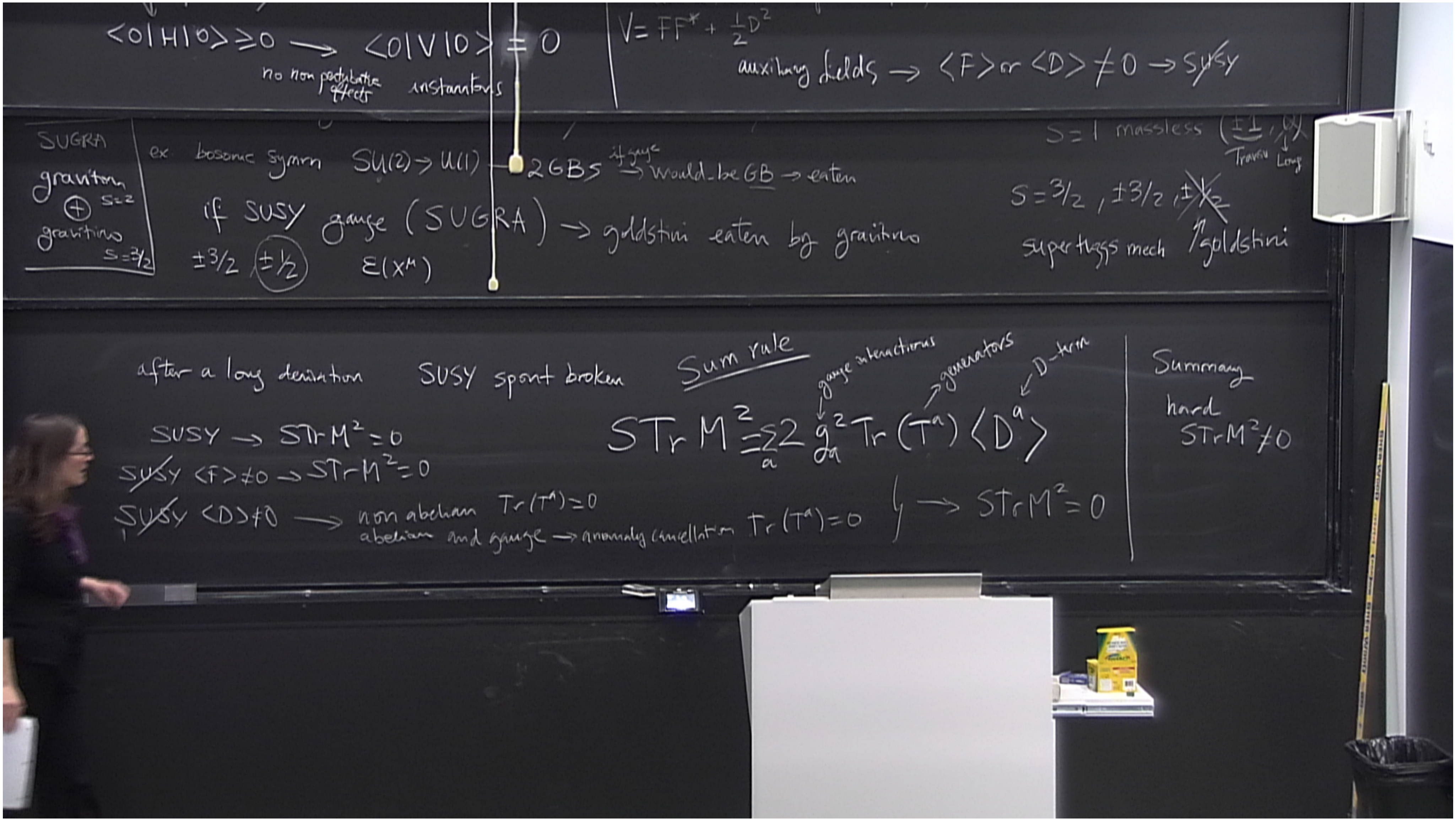
STr M² = Σ_a 2 g_a² Tr(T^a) ⟨D^a⟩



<0|H|0> ≥ 0 → <0|V|0> = 0
no non perturbative effects instantons
V = FF* + 1/2 D²
auxiliary fields → <F> or <D> ≠ 0 → SUSY
1 Majorana
2 Dirac
SUGRA
graviton ⊕ S=2
gravitino S=3/2
ex bosonic symm SU(2) → U(1) 2GBs if gauge → would-be GB → eaten
if SUSY gauge (SUGRA) → goldstini eaten by gravitino
±3/2 ±1/2 ε(x^μ)
S=1 massless
S=3/2, ±3/2, ±1/2
super higgs mech
after a long derivation SUSY spont broken
SUSY → STr M² = 0
SUSY <F> ≠ 0 → STr M² = 0
SUSY <D> ≠ 0 → non abelian Tr(T^a) = 0
abelian and gauge → anomaly cancellation Tr(T^a) = 0
STr M² = Σ_a 2 g_a² Tr(T^a) <D^a>
gauge interactions
generators
D-term


generators
D-term
$(T^a)\langle D^a\rangle$
$\rightarrow \mathrm{STr}M^2 = 0$
Summary
hard
$\mathrm{STr}M^2 \neq 0$


<0|H|0> ≥ 0 → <0|V|0> ≠ 0
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V = FF* + 1/2 D²
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SUGRA
graviton S=2
⊕
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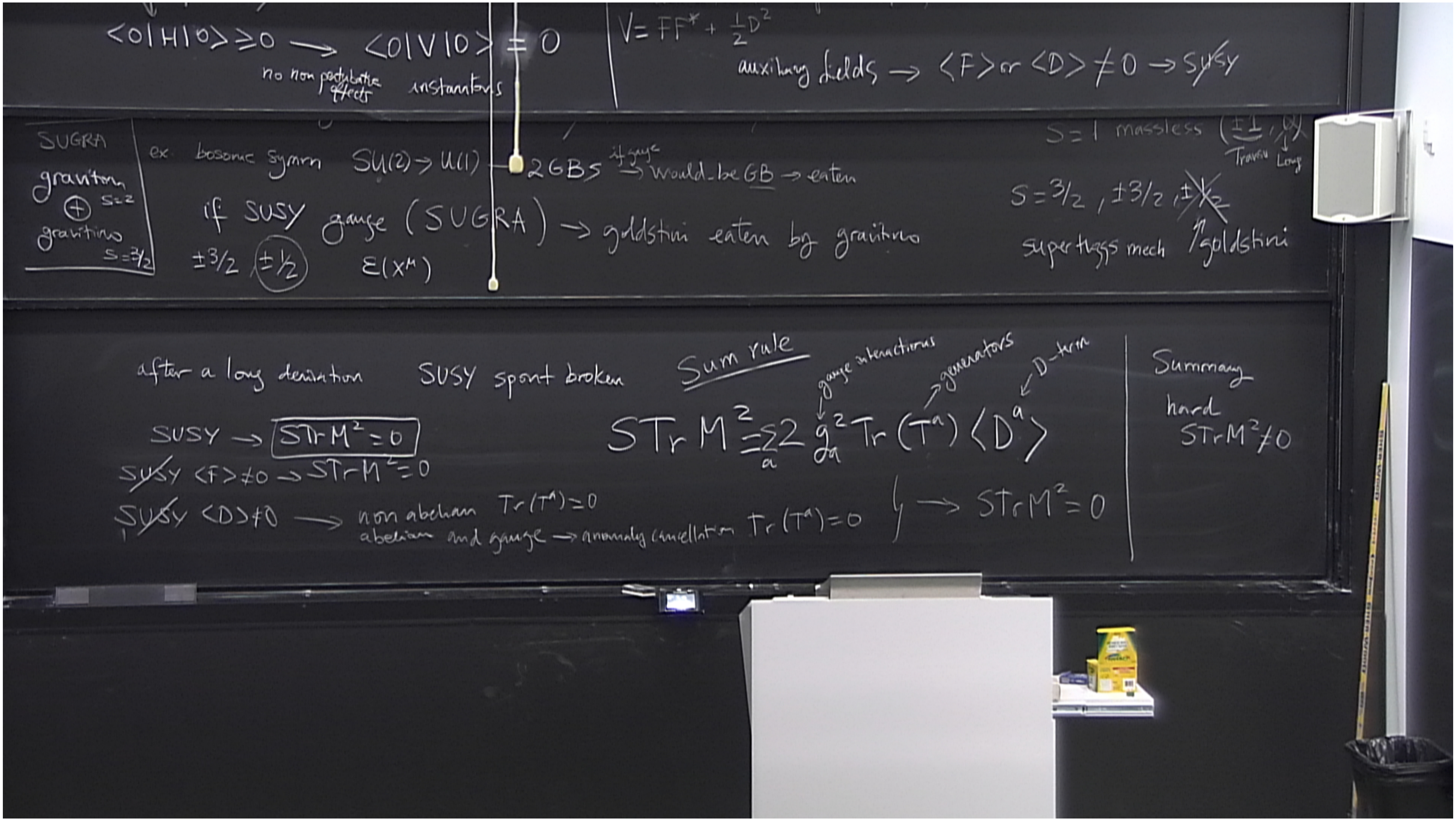
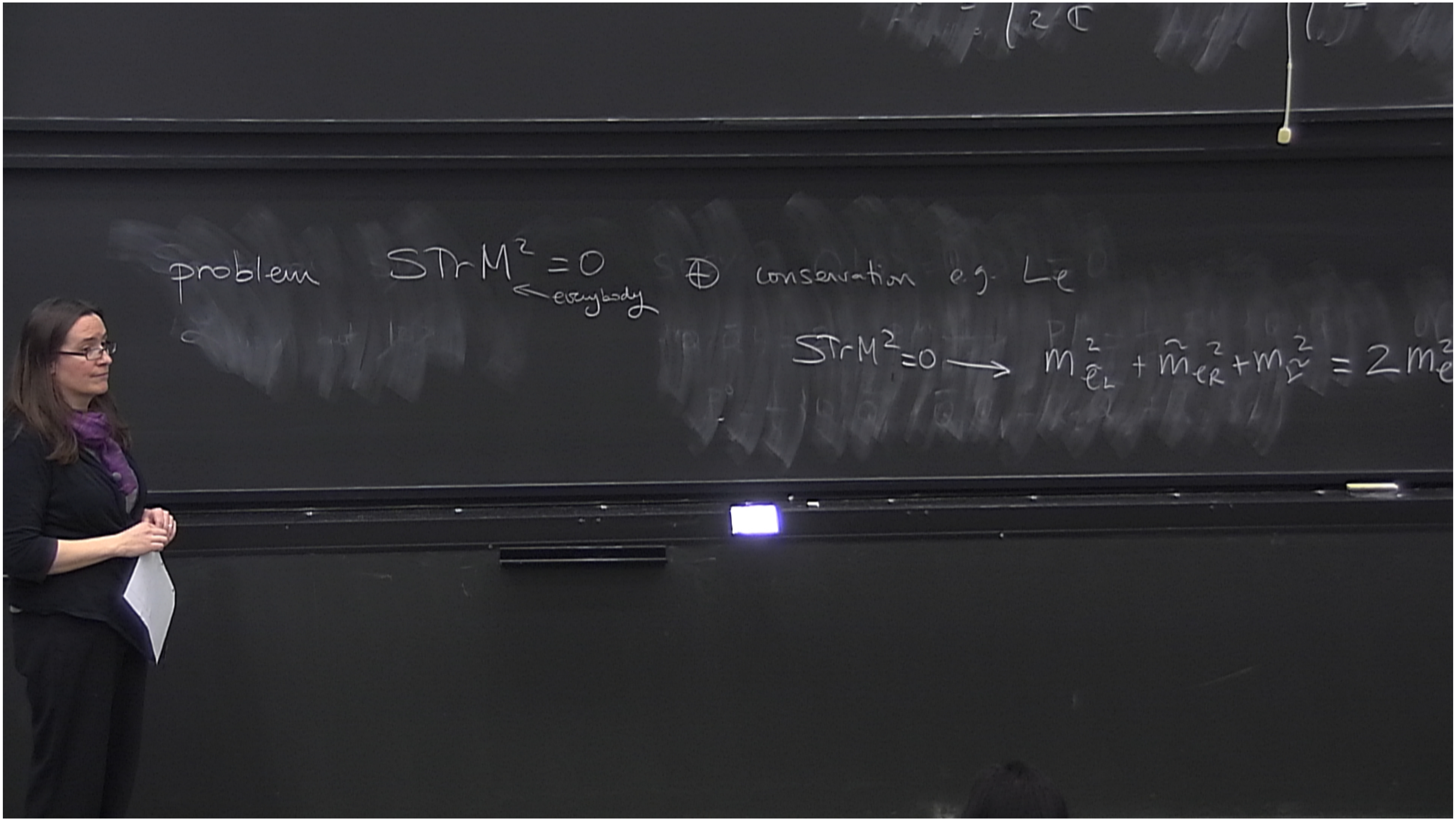
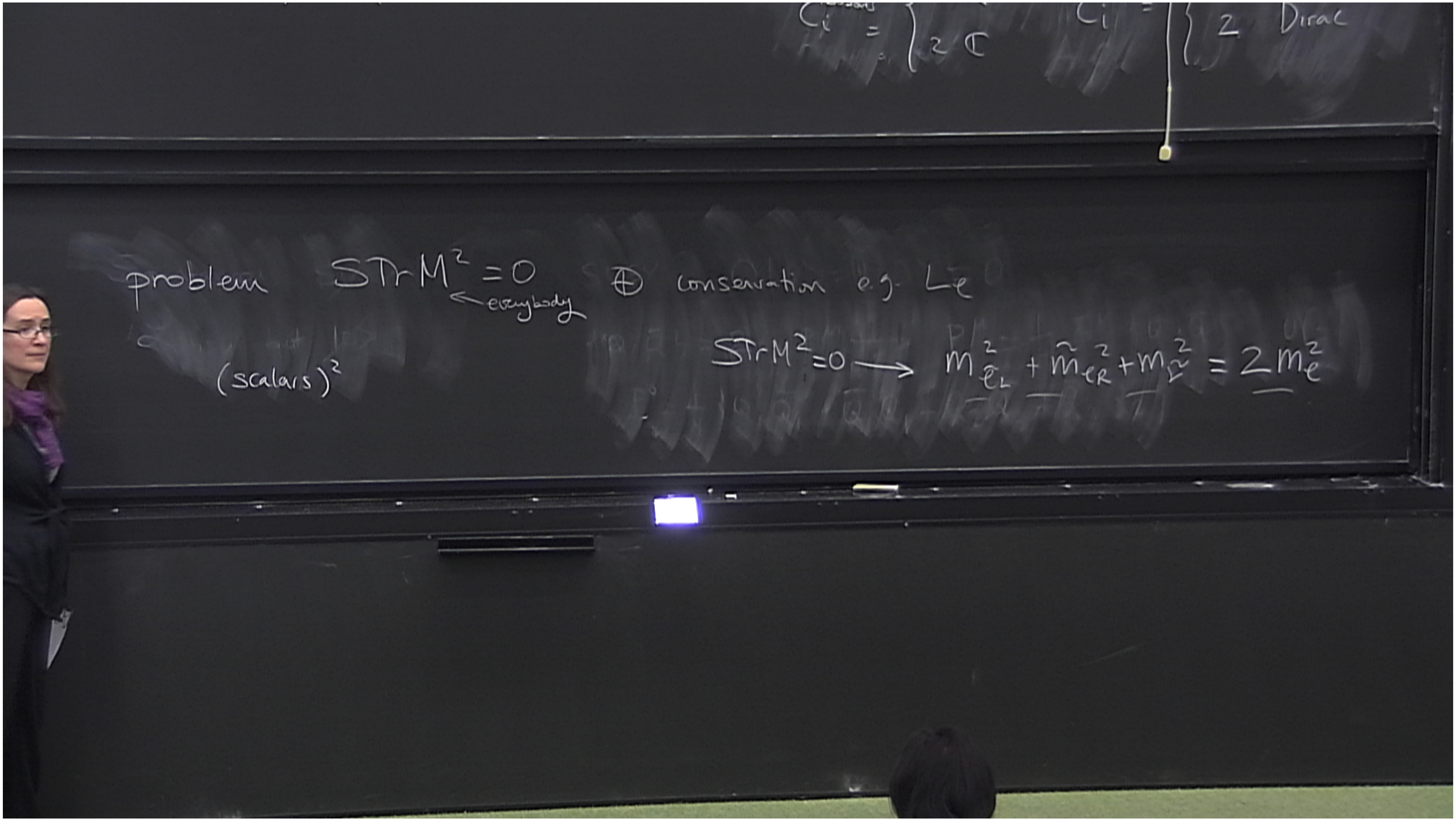
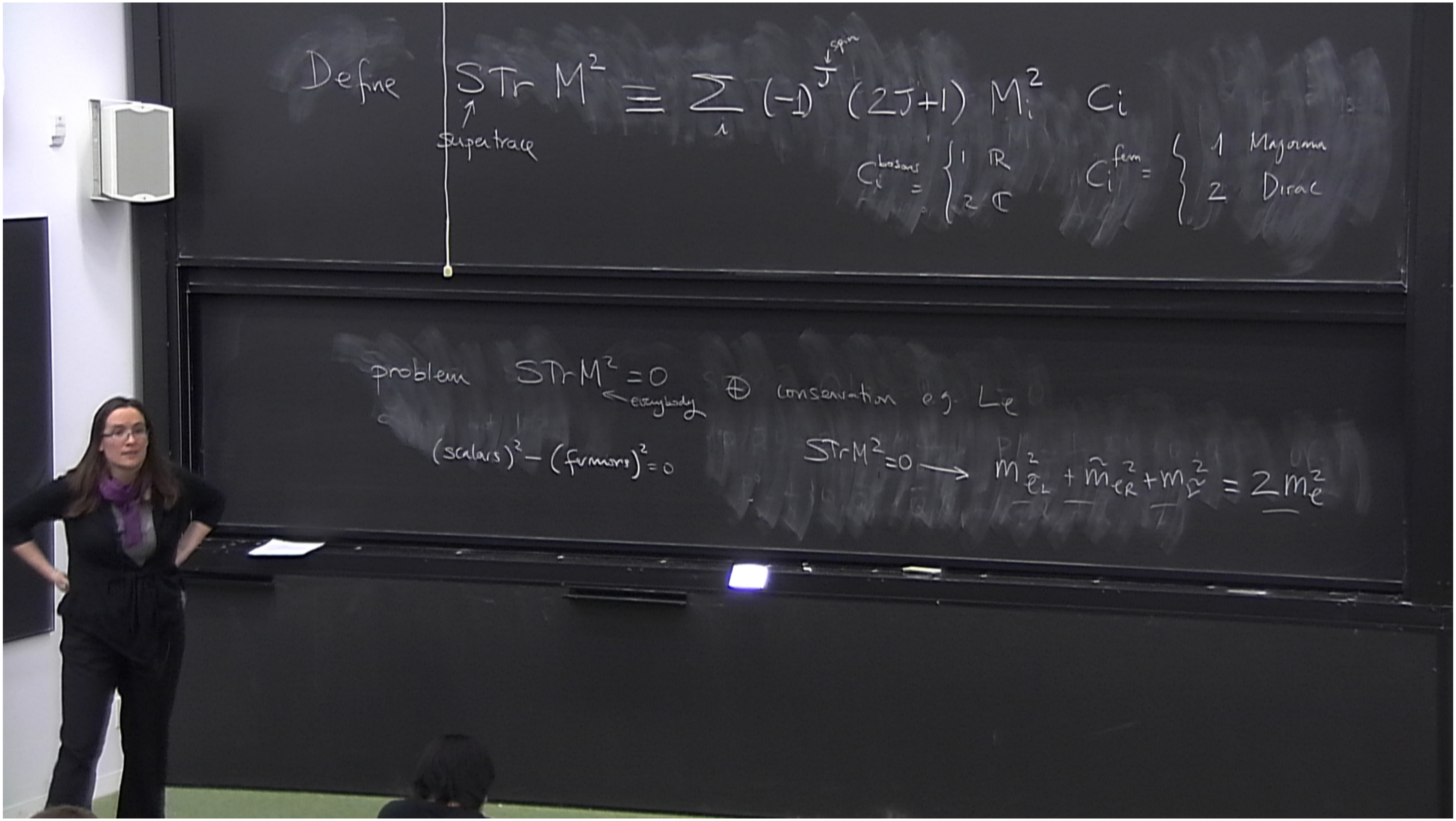
ex. bosonic symm SU(2) → U(1) → 2 GBs
if gauge → would-be GB → eaten
if SUSY gauge (SUGRA) → goldstini eaten by gravitino
±3/2 ±1/2
ε(x^μ)
S=1 massless (±1, 0)
Transv Long
S=3/2, ±3/2, ±1/2
super Higgs mech
goldstini
after a long derivation
SUSY spont broken
Sum rule
gauge interactions
generators
D-term
SUSY → STr M² = 0
SUSY <F> ≠ 0 → STr M² = 0
SUSY <D> ≠ 0 → non abelian Tr(T^a) = 0
abelian and gauge → anomaly cancellation Tr(T^a) = 0
STr M² = Σ_a 2 g_a² Tr(T^a) <D^a>
→ STr M² = 0
Summary
hard
STr M² ≠ 0


⟨0|H|0⟩ ≥ 0 → ⟨0|V|0⟩ = 0
no non perturbative effects instantons
V = FF* + ½D²
auxiliary fields → ⟨F⟩ or ⟨D⟩ ≠ 0 → ~~SUSY~~
SUGRA
graviton S=2
⊕
gravitino S=3/2
ex. bosonic symm SU(2) → U(1) 2 GBs if gauge → would-be GB → eaten
if SUSY gauge (SUGRA) → goldstini eaten by gravitino
±3/2 ±½
ε(x^μ)
S=1 massless (±1, 0) Transv Long
S=3/2, ±3/2, ±½
super-Higgs mech goldstini
after a long derivation SUSY spont broken
Sum rule
gauge interactions
generators
D-term
STr M² = Σ_a 2 g_a² Tr(T^a) ⟨D^a⟩
SUSY → STr M² = 0
~~SUSY~~ ⟨F⟩ ≠ 0 → STr M² = 0
~~SUSY~~ ⟨D⟩ ≠ 0 → non abelian Tr(T^a) = 0
abelian and gauge → anomaly cancellation Tr(T^a) = 0
→ STr M² = 0
Summary
hard
STr M² ≠ 0


problem STrM² = 0 ⊕ conservation e.g. Le
everybody
STrM²=0 → m²ẽL + m̃²eR + m²ν̃ = 2m²e


2 Dirac
problem $\mathrm{STr}\, M^2 = 0$ ← everybody
⊕ conservation e.g. L_e
$(\text{scalars})^2$
$\mathrm{STr}\, M^2 = 0 \longrightarrow m^2_{\tilde{e}_L} + \tilde{m}^2_{e_R} + m^2_{\tilde{\nu}} = 2 m_e^2$


Define $\mathrm{STr}\, M^2 \equiv \sum_i (-1)^J (2J+1)\, M_i^2\, C_i$
spin
supertrace
$C_i^{\text{bosons}} = \begin{cases} 1 & \mathbb{R} \\ 2 & \mathbb{C} \end{cases}$
$C_i^{\text{fem}} = \begin{cases} 1 & \text{Majorana} \\ 2 & \text{Dirac} \end{cases}$
problem $\mathrm{STr} M^2 = 0$ ← everybody
⊕ conservation e.g. Le
$(\text{scalars})^2 - (\text{fermions})^2 = 0$
$\mathrm{STr} M^2 = 0 \longrightarrow m^2_{\tilde{e}_L} + \tilde{m}^2_{e_R} + m^2_{\tilde{\nu}} = 2 m_e^2$

$$= \sum_i (-1)^{\ldots} (2j+1) M_i^2 \, C_i$$

Supertrace

$$C_i^{\text{bosons}} = \begin{cases} 1 & \mathbb{R} \\ 2 & \mathbb{C} \end{cases} \qquad C_i^{\text{fem}} = \begin{cases} 1 & \text{Majorana} \\ 2 & \text{Dirac} \end{cases}$$

problem $\mathrm{STr}\, M^2 = 0$ ← everybody

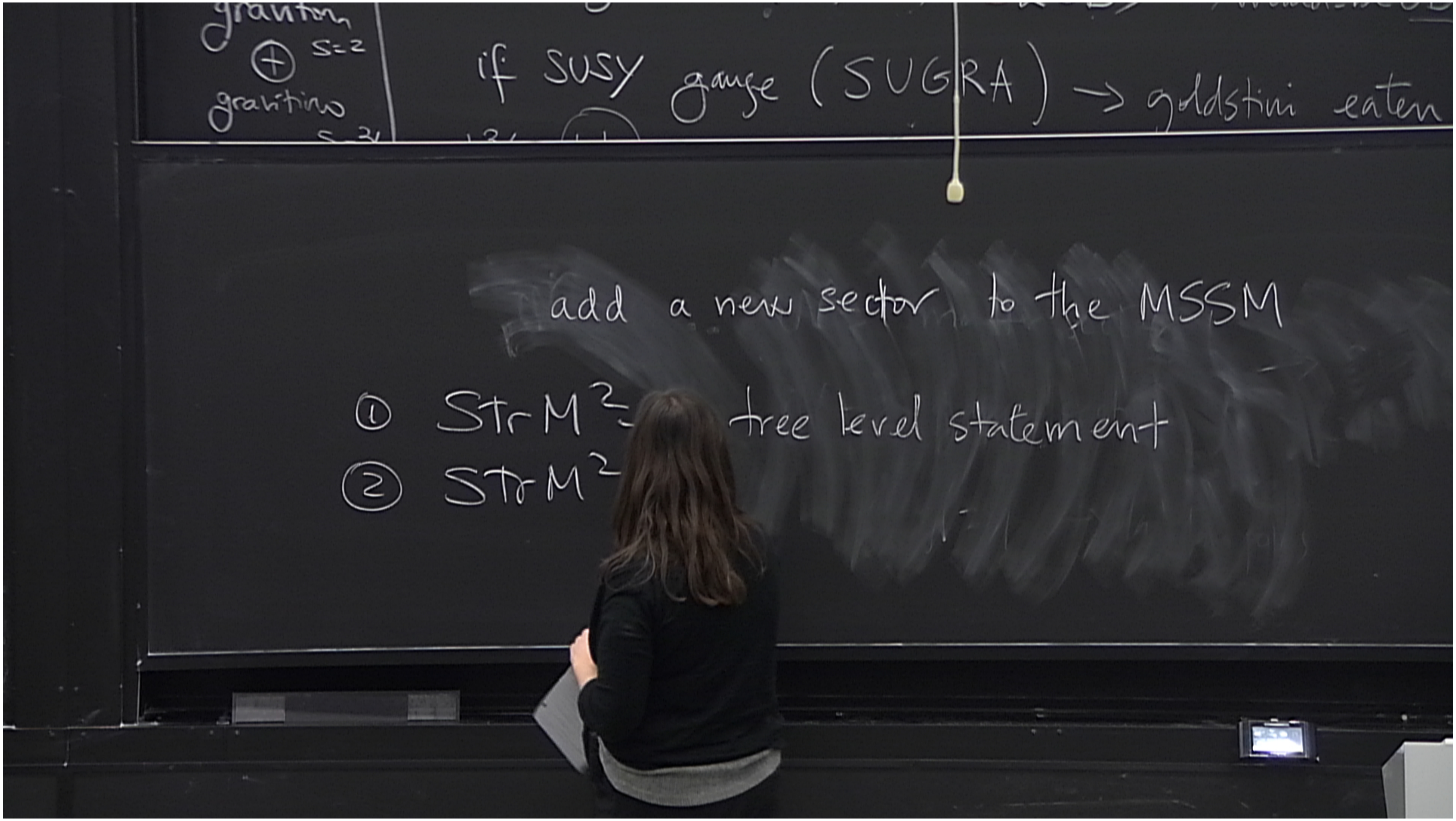
⊕ conservation e.g. L_e

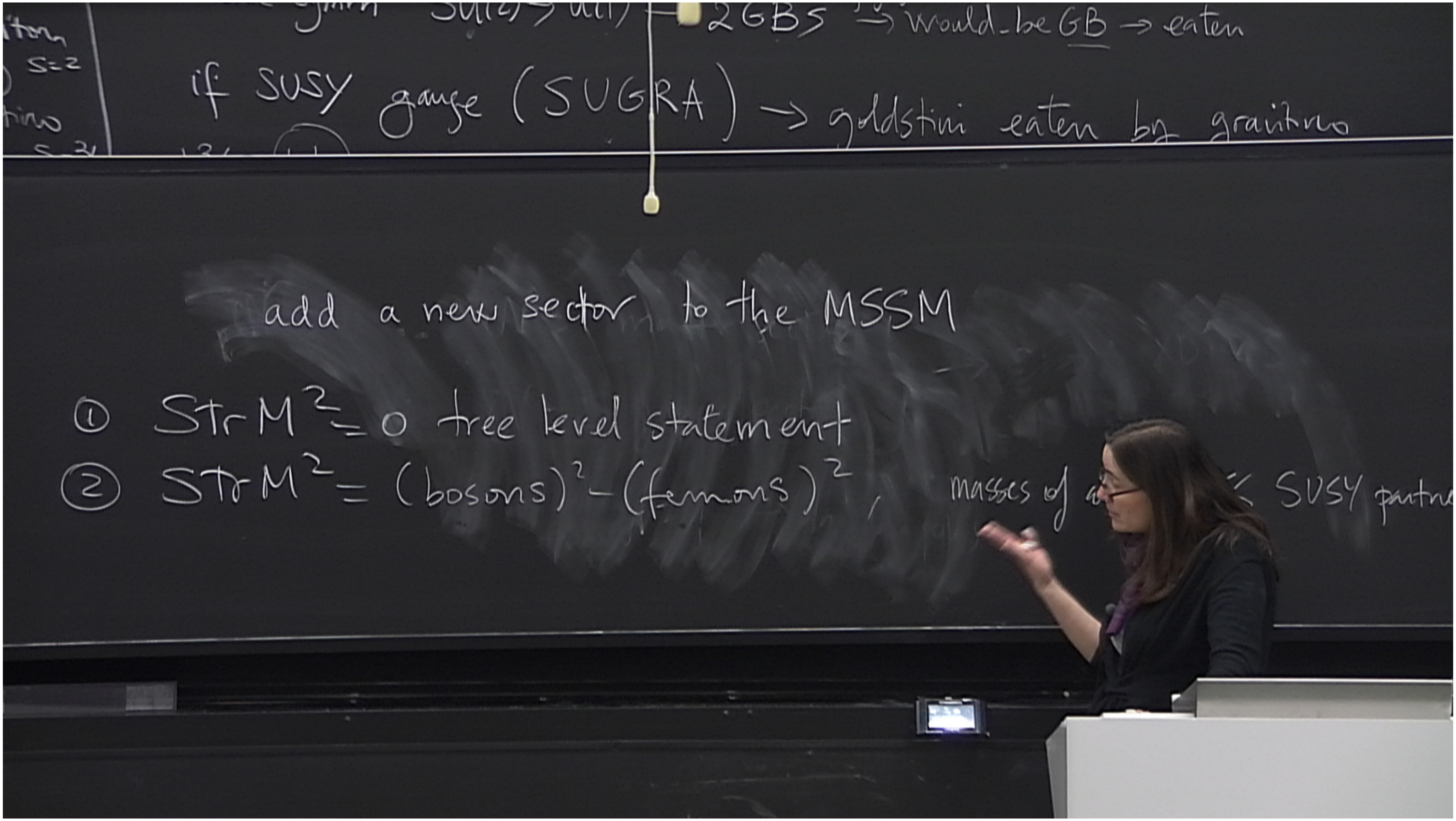
$(\text{scalars})^2 - (\text{fermions})^2 = 0$

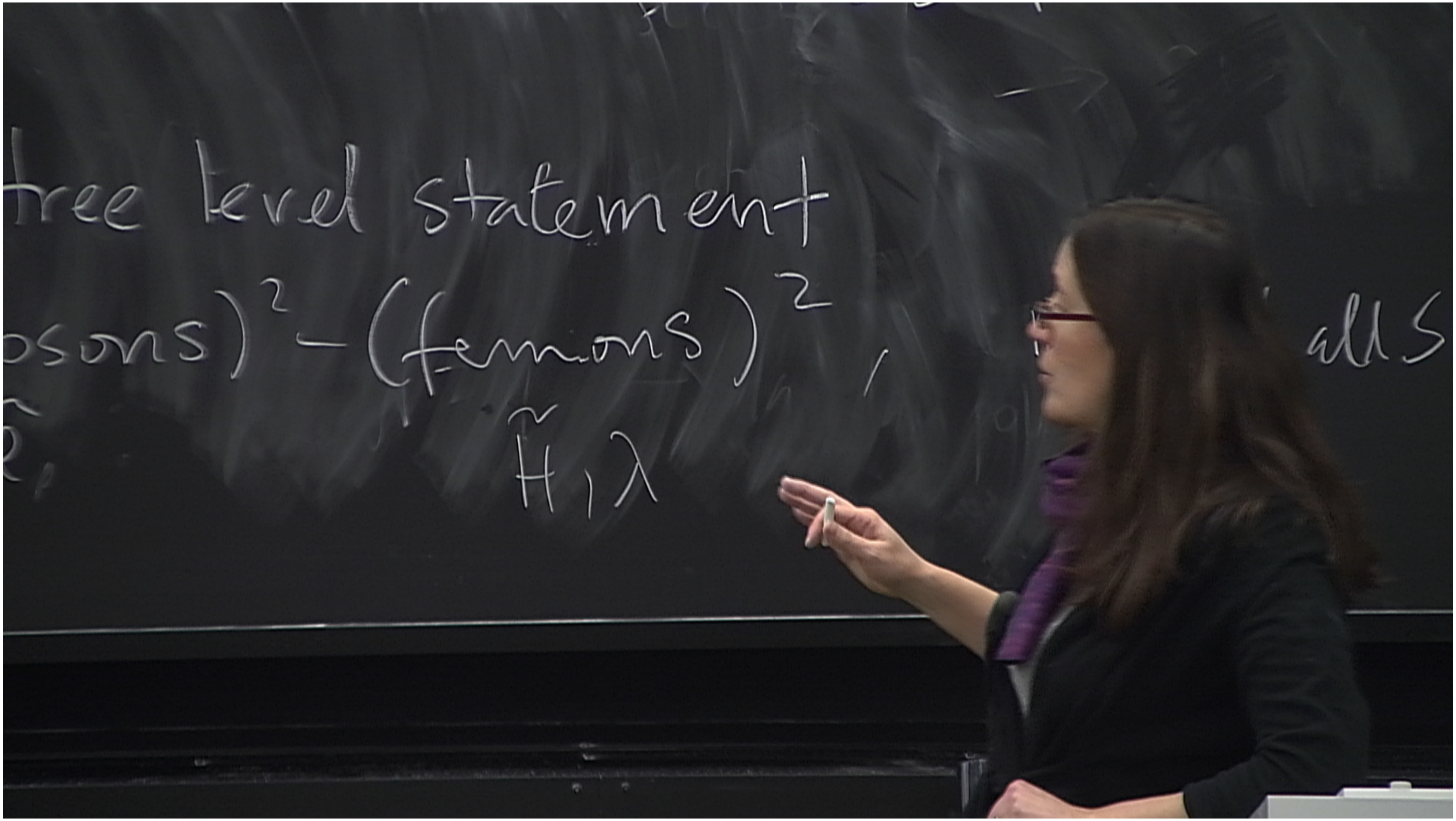
only MSSM

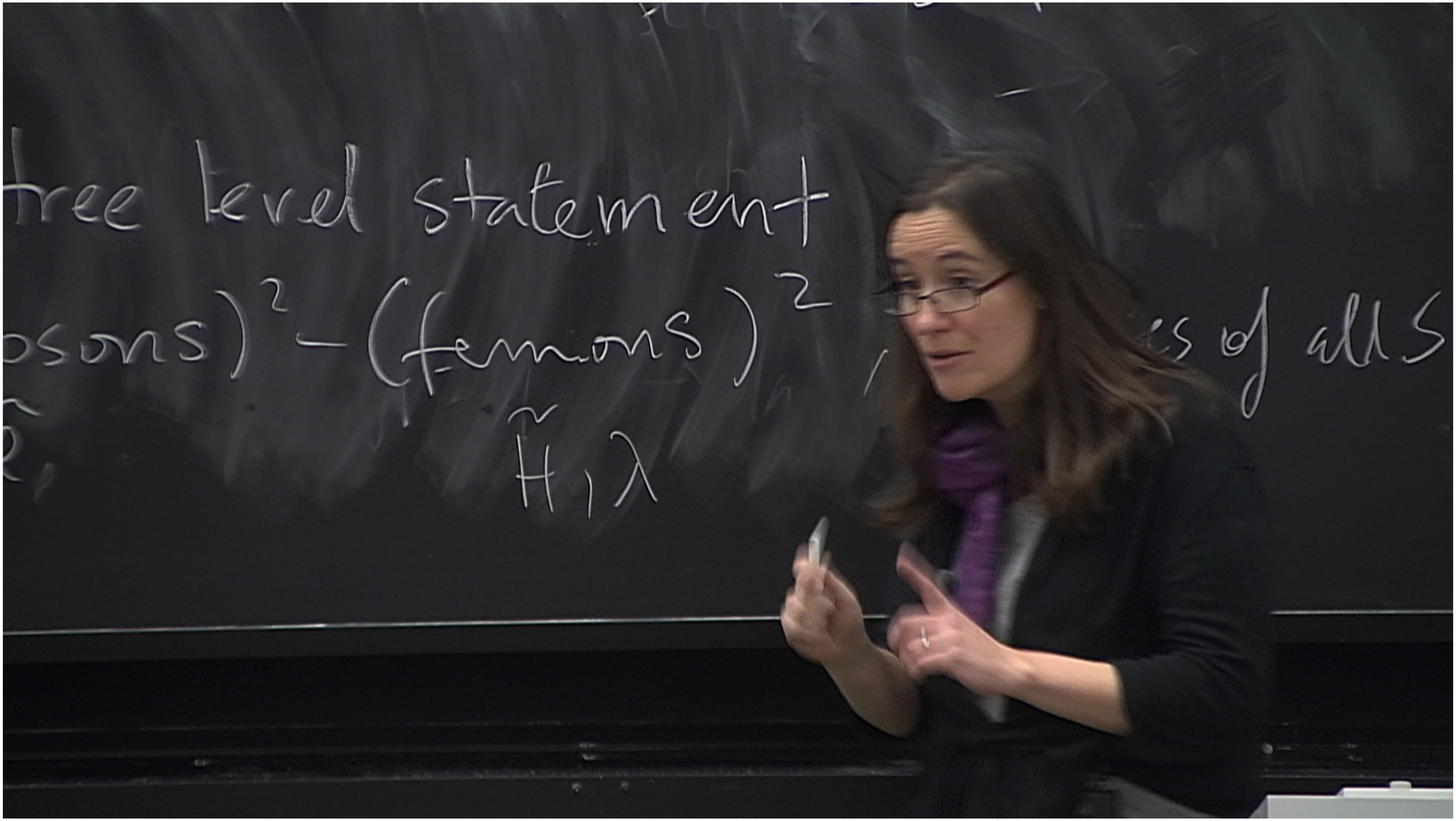
$$\mathrm{STr}\, M^2 = 0 \longrightarrow m_{\tilde{e}_L}^2 + \tilde{m}_{e_R}^2 + m_{\tilde{\nu}}^2 = 2 m_e^2 + \ldots$$

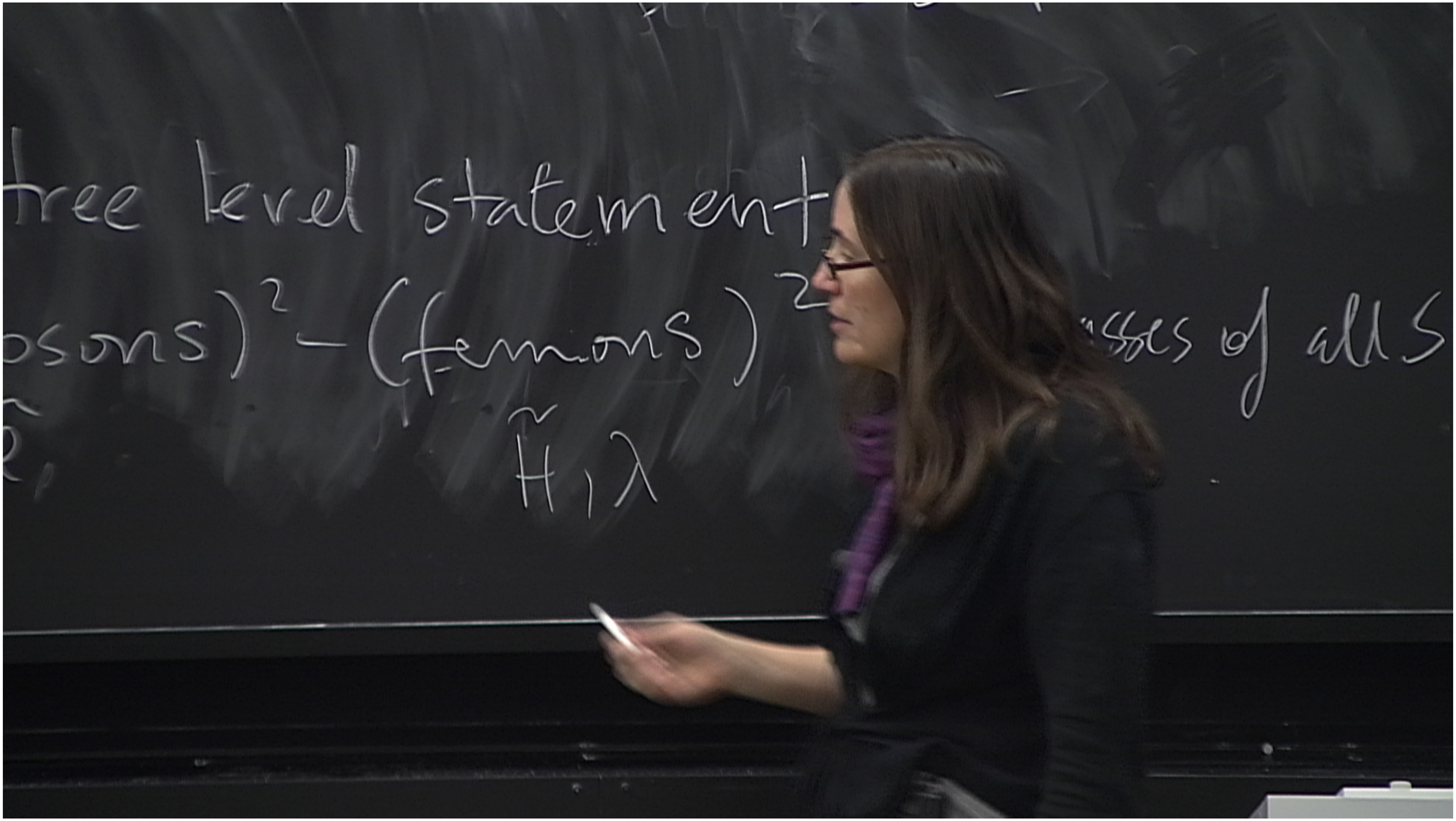
+ extra contrib

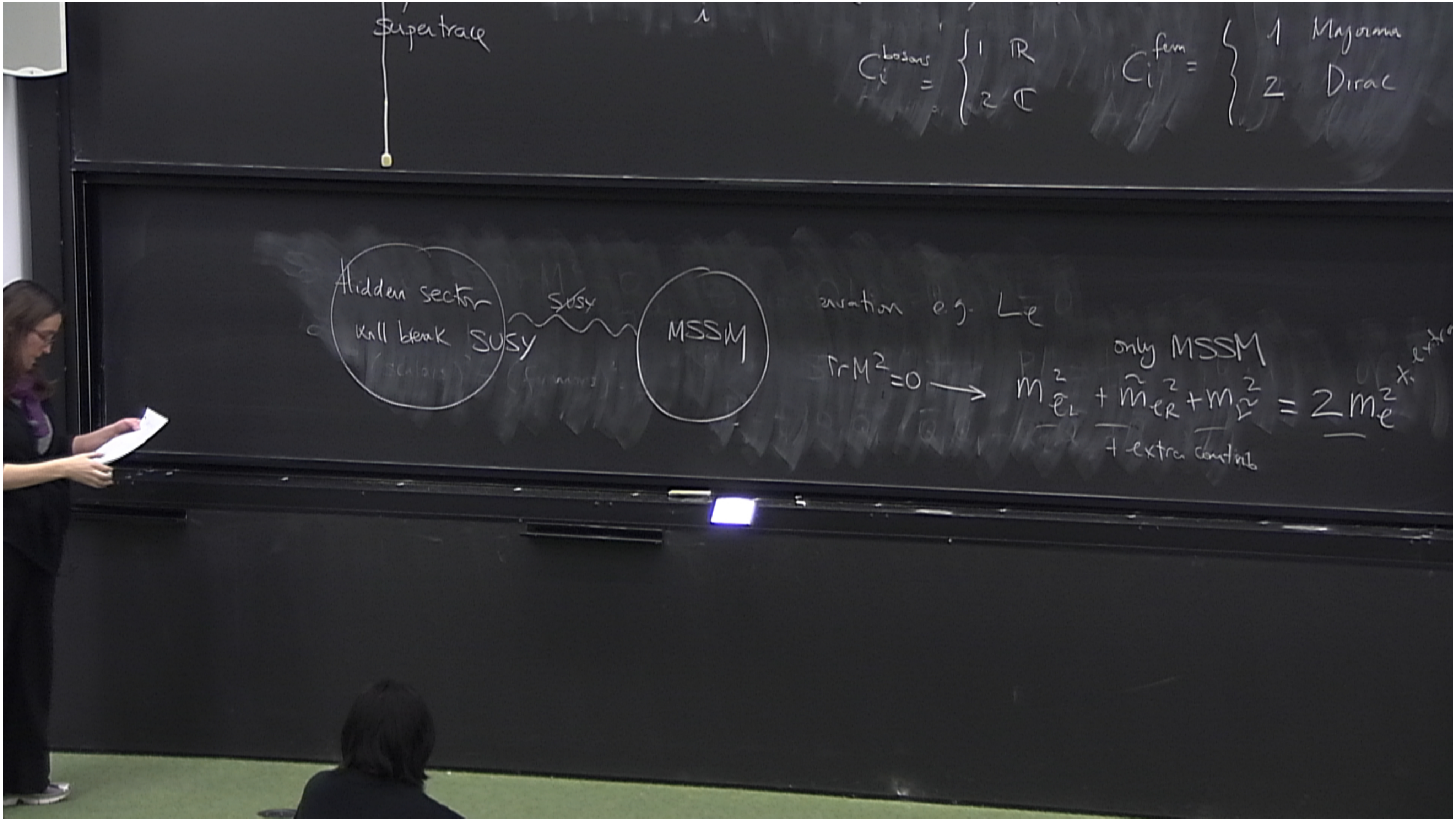

graviton
s=2
gravitino
if SUSY gauge (SUGRA) → goldstini eaten
add a new sector to the MSSM
① StrM² = tree level statement
② StrM²

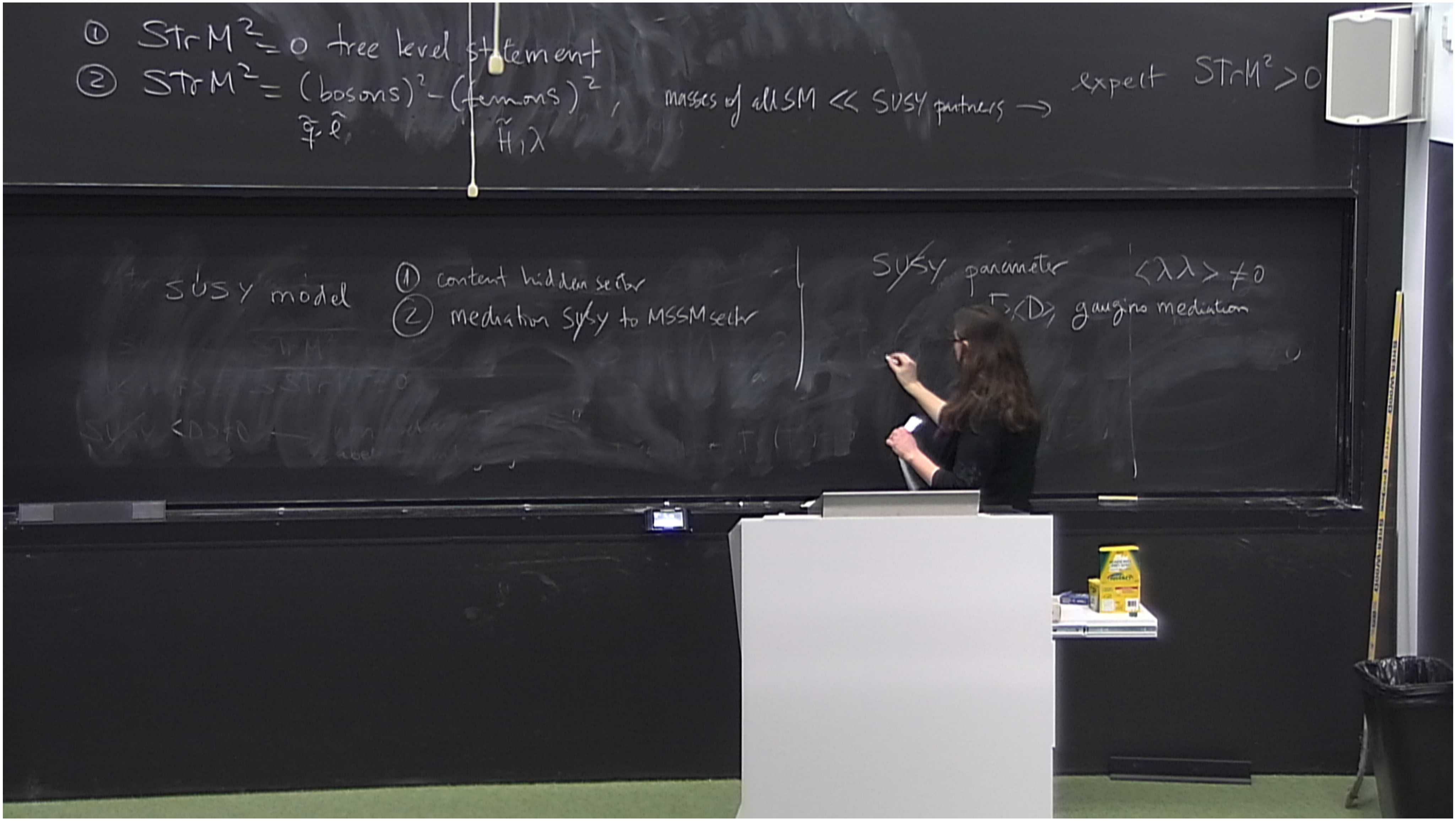

2GBs → would-be GB → eaten
if SUSY gauge (SUGRA) → goldstini eaten by gravitino
add a new sector to the MSSM
① StrM² = 0 tree level statement
② StrM² = (bosons)² − (fermions)²
masses of
SUSY

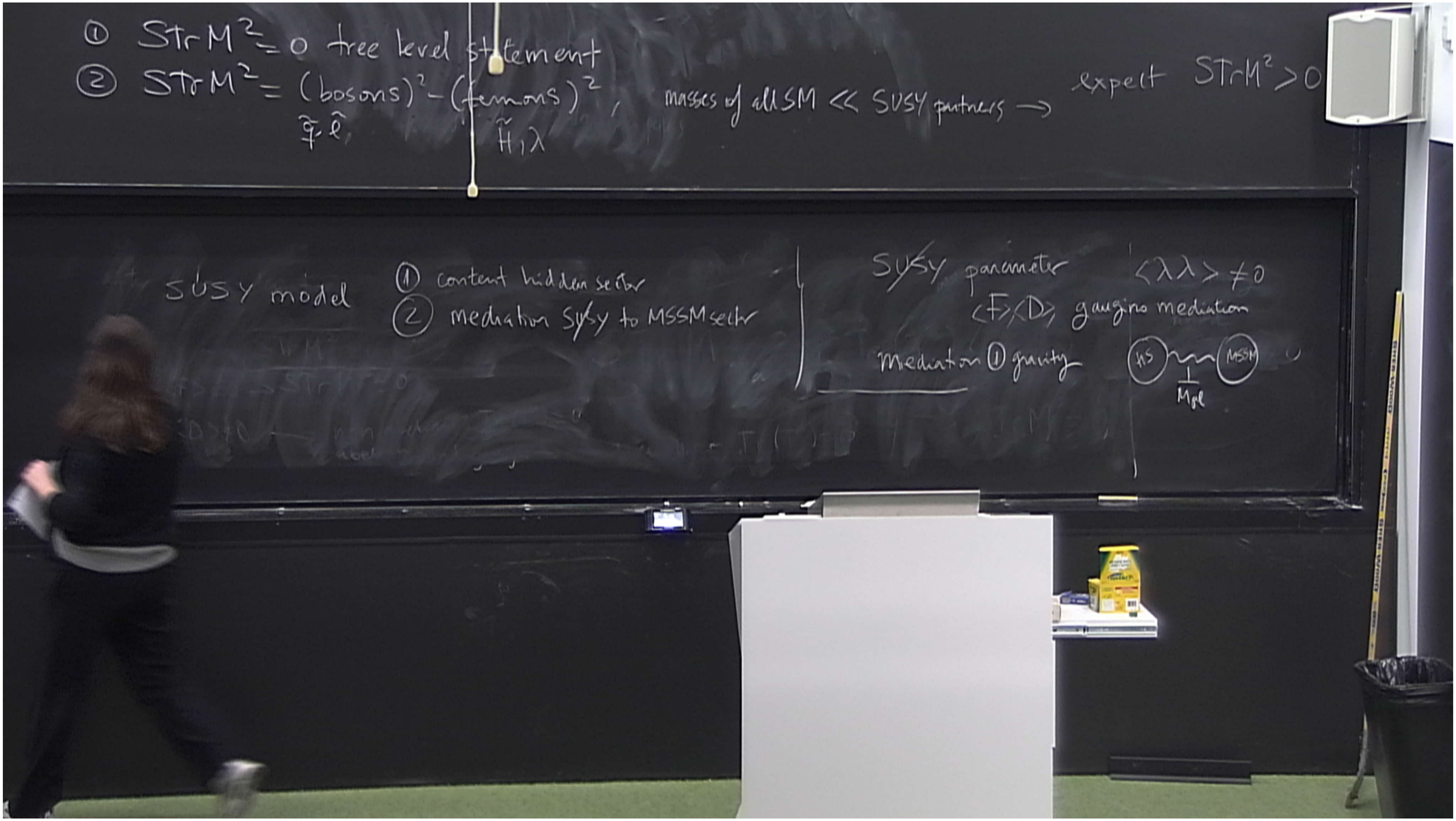

tree level statement
osons)² − (fermions)²
H̃, λ
alls

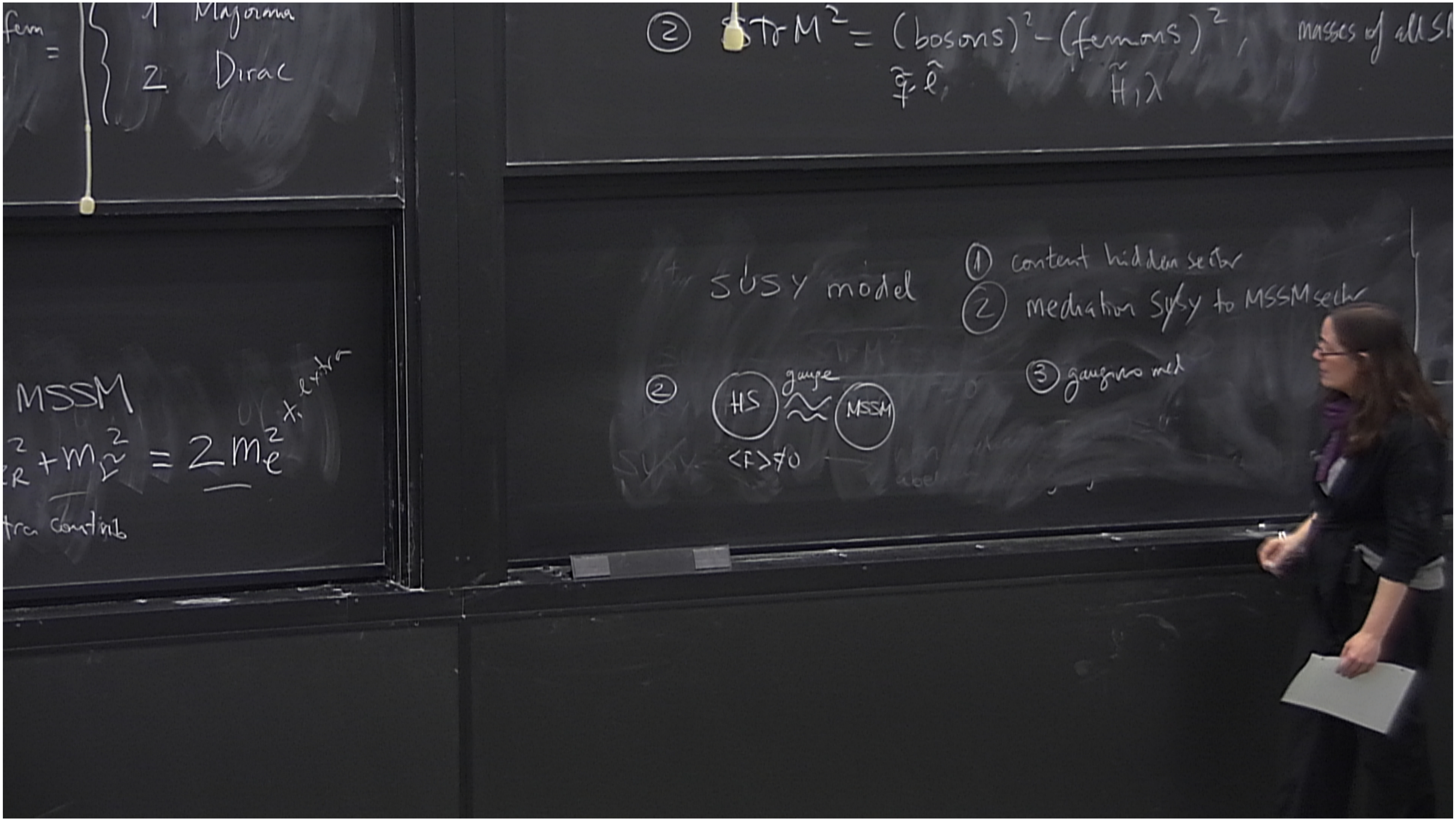

tree level statement
osons)² − (fermions)²
H̃, λ

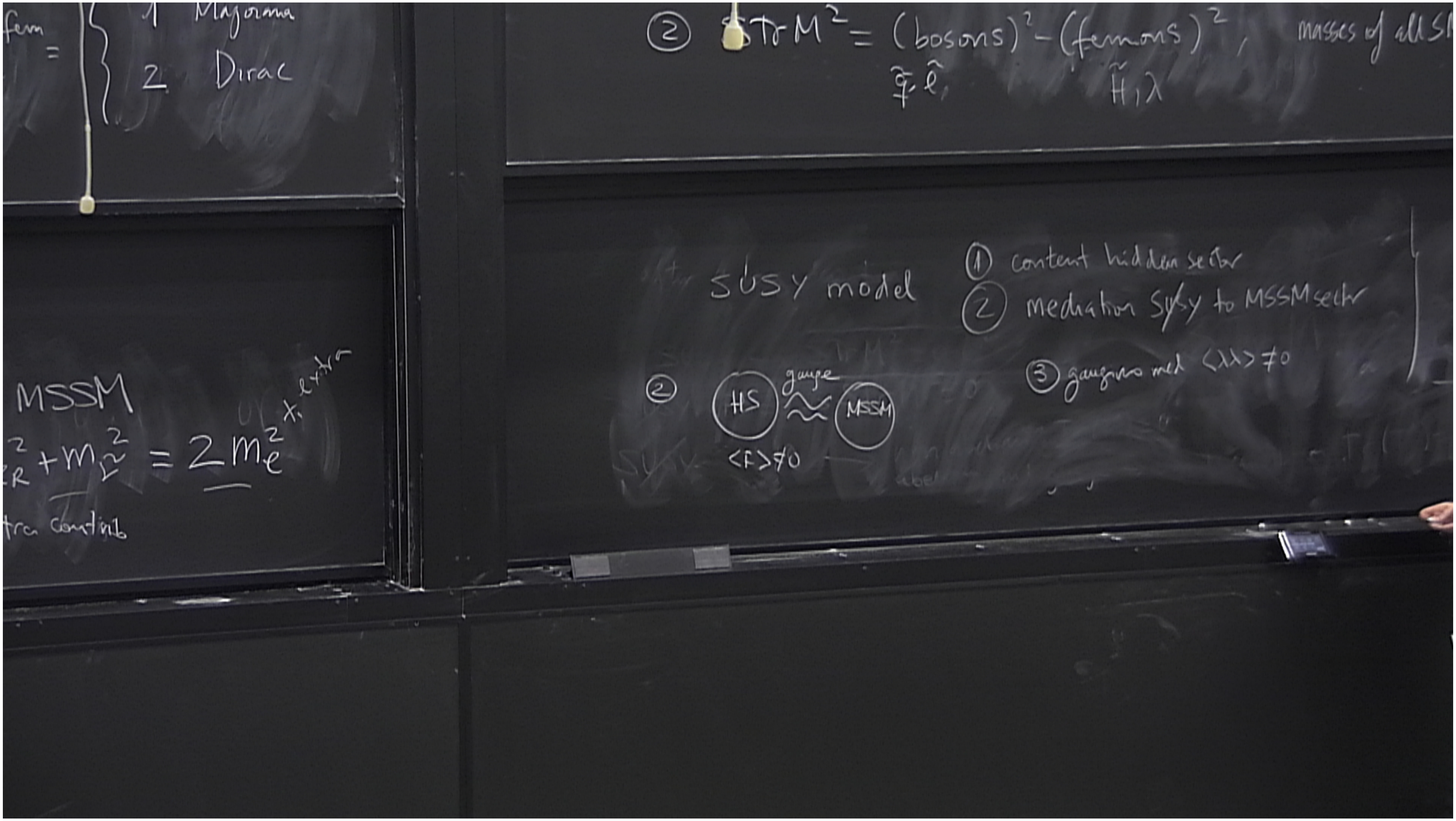

tree level statement
osons)² – (fermions)²
asses of all s
H̃, λ

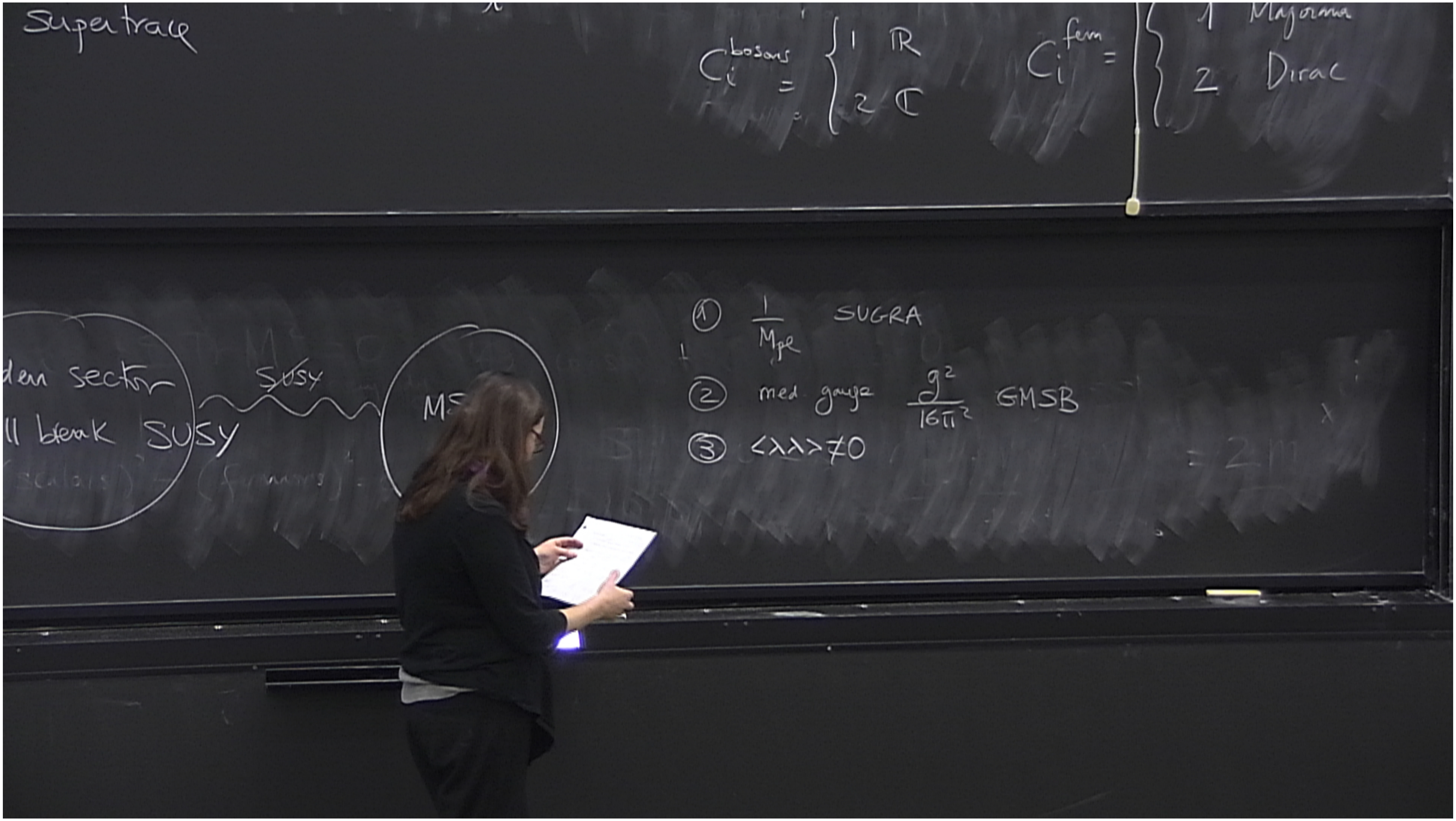

Supertrace
Ci bosons = 1 R, 2 C
Ci ferm = 1 Majorana, 2 Dirac
Hidden sector
will break SUSY
SUSY
MSSM
e.g. Le
only MSSM
+ extra contrib

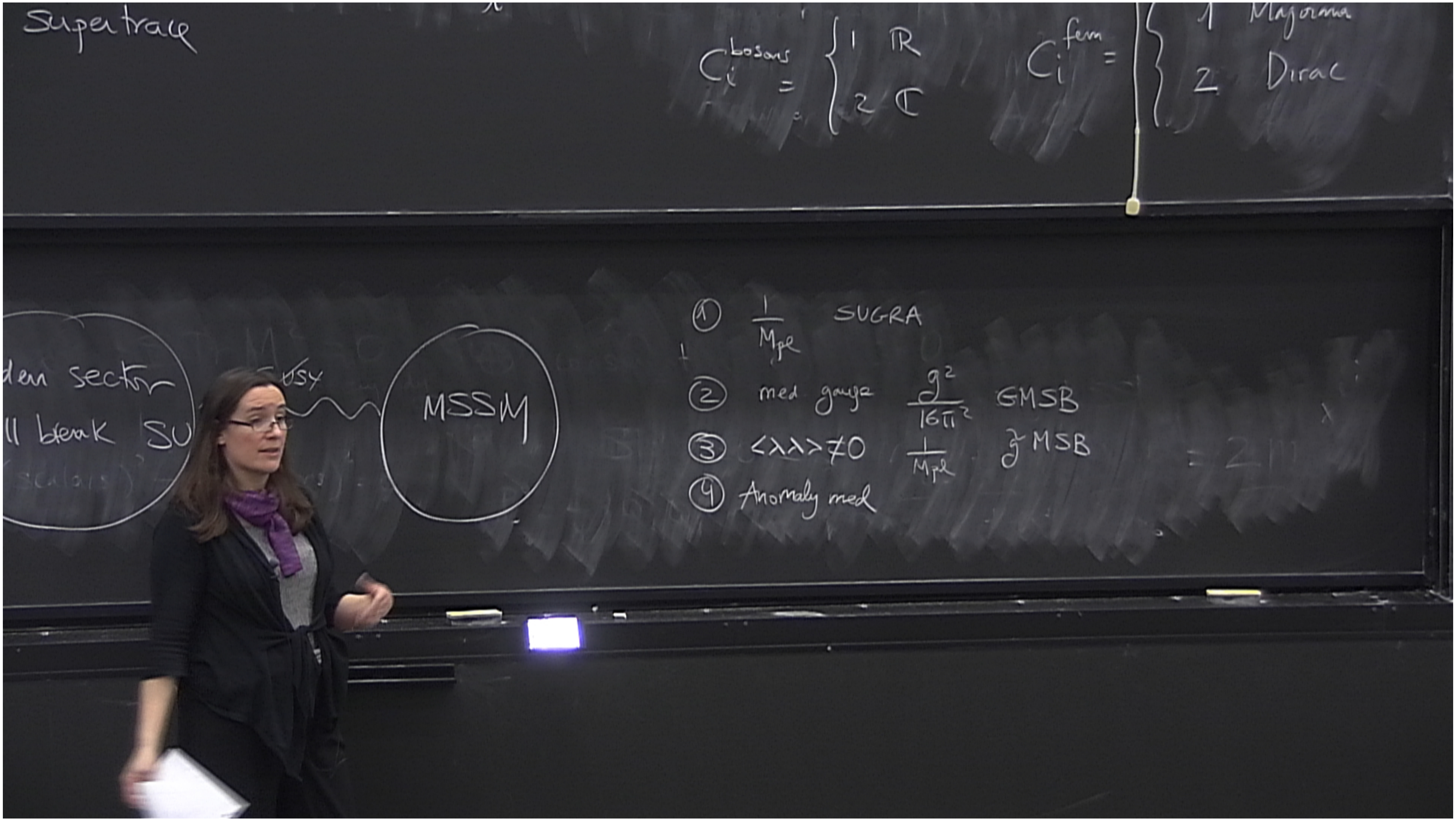

① StrM² = 0 tree level statement
② StrM² = (bosons)² − (fermions)²
masses of all SM << SUSY partners → expect StrM² > 0
SUSY model
① content hidden sector
② mediation SUSY to MSSM sector
SUSY parameter
⟨λλ⟩ ≠ 0
gaugino mediation

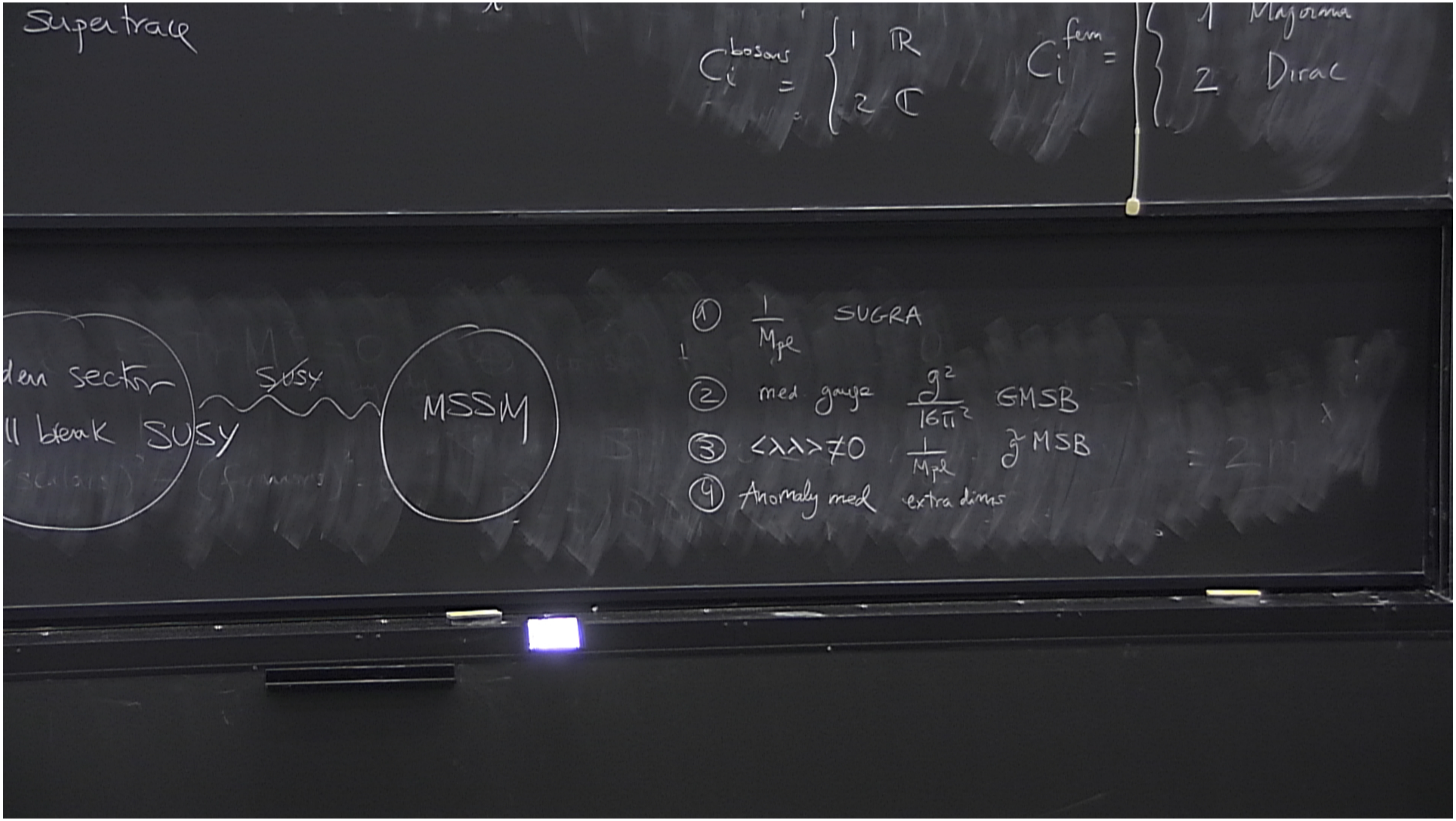

① StrM² = 0 tree level statement
② StrM² = (bosons)² − (fermions)²
q̃, ẽ
H̃, λ
masses of all SM ≪ SUSY partners →
expect StrM² > 0
SUSY model
① content hidden sector
② mediation SUSY to MSSM sector
SUSY parameter
⟨λλ⟩ ≠ 0
⟨F⟩ ⟨D⟩ gaugino mediation
Mediation ① gravity
HS
MSSM
1/Mpl

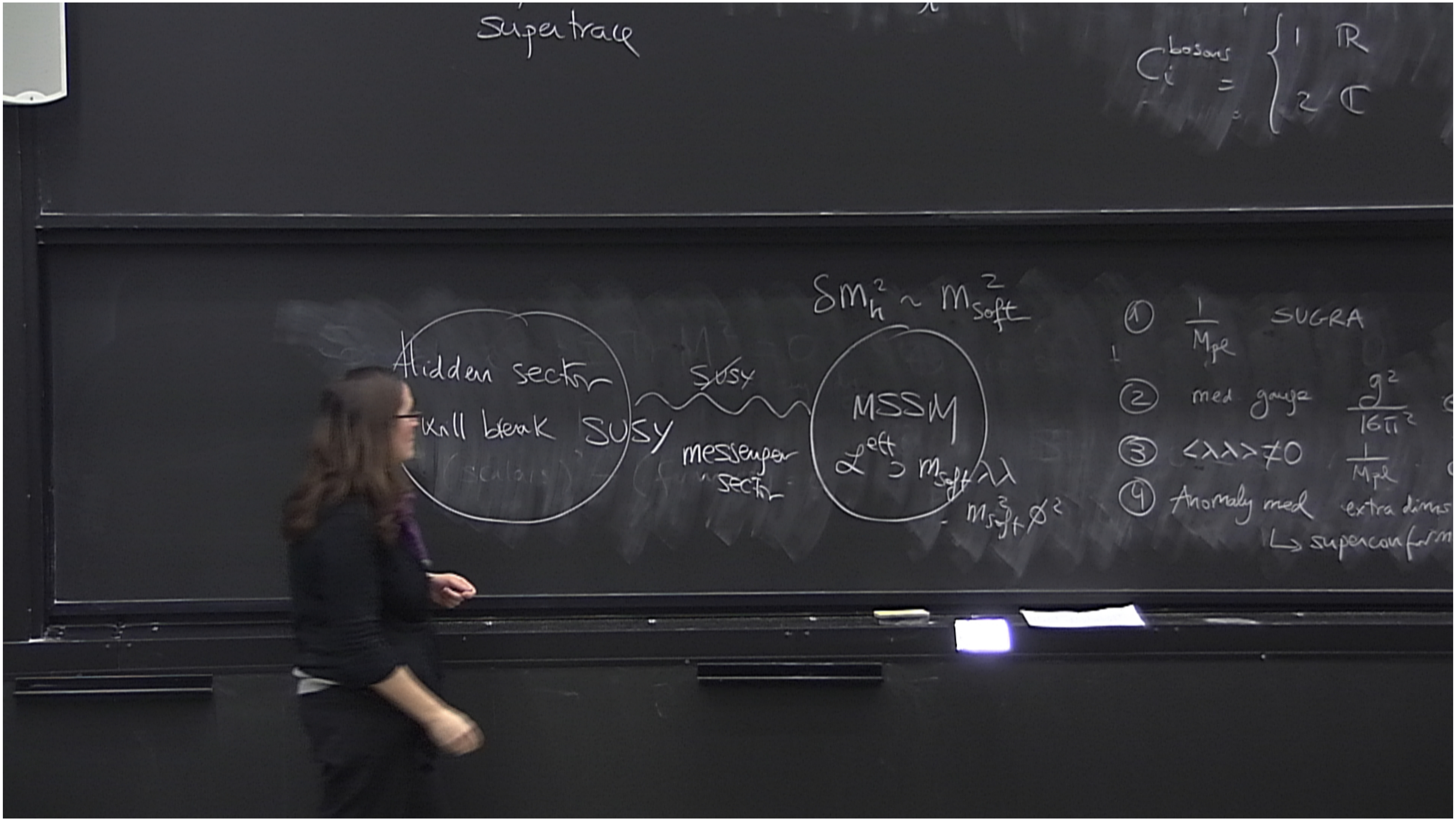

1 Majorana
2 Dirac
MSSM
extra contrib
② STr M² = (bosons)² − (fermions)²
masses of all SM
susy model
① content hidden sector
② mediation susy to MSSM sector
③ gaugino med
HS
gauge
MSSM
<F>≠0


ferm =
1 Majorana
2 Dirac
② STr M² = (bosons)² − (fermions)²,
masses of all S
MSSM
= 2 mẽ²
extra contrib
SUSY model
① content hidden sector
② mediation SUSY to MSSM sector
③ gaugino med ⟨λλ⟩ ≠ 0
②
HS
gauge
MSSM
⟨F⟩≠0


Supertrace
bosons
1 R
2 C
fem
1 Majorana
2 Dirac
SUSY
① 1/Mpl SUGRA
② med gauge g²/16π² GMSB
③ ⟨λλ⟩≠0


Supertrace
bosons
1 R
2 C
fem
1 Majorana
2 Dirac
SUGRA
med gauge
GMSB
Anomaly med
MSSM
hidden sector
will break SUSY


Supertrace
C_i^bosons = 1 R, 2 C
C_i^ferm = 1 Majorana, 2 Dirac
den sector
ll break SUSY
SUSY
MSSM
① 1/Mpl SUGRA
② med gauge g²/16π² GMSB
③ <λλ>≠0 1/Mpl ǧMSB
④ Anomaly med extra dims


supertrace
bosons
1 R
2 C
δm_h^2 ~ m_soft^2
Hidden sector
will break SUSY
SUSY
messenger sector
MSSM
L^eff ⊃ m_soft λλ
m_soft^2 φ^2
① 1/M_pl SUGRA
② med gauge g^2/16π^2
③ <λλ> ≠ 0 1/M_pl
④ Anomaly med extra dims
↳ superconform