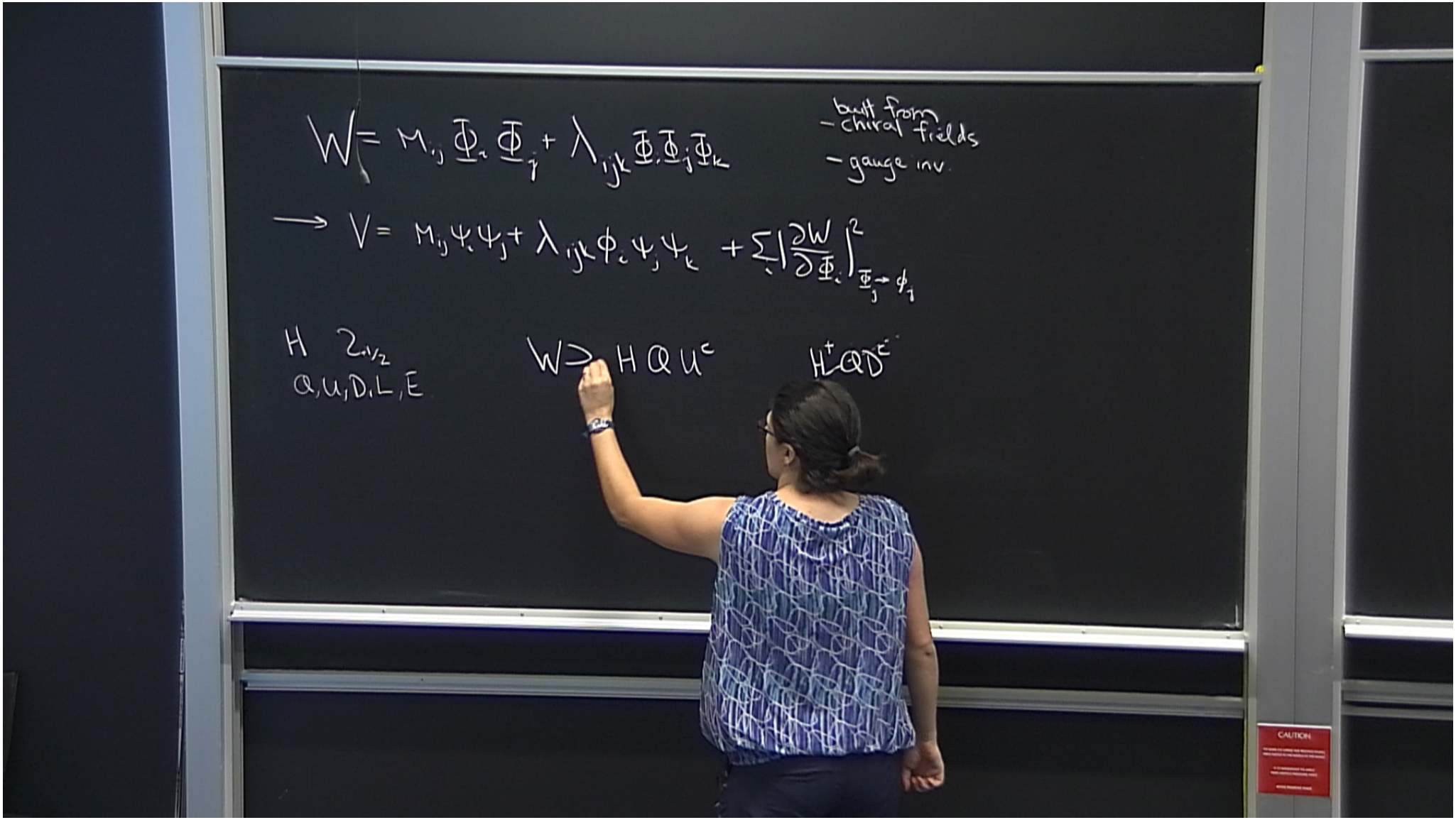
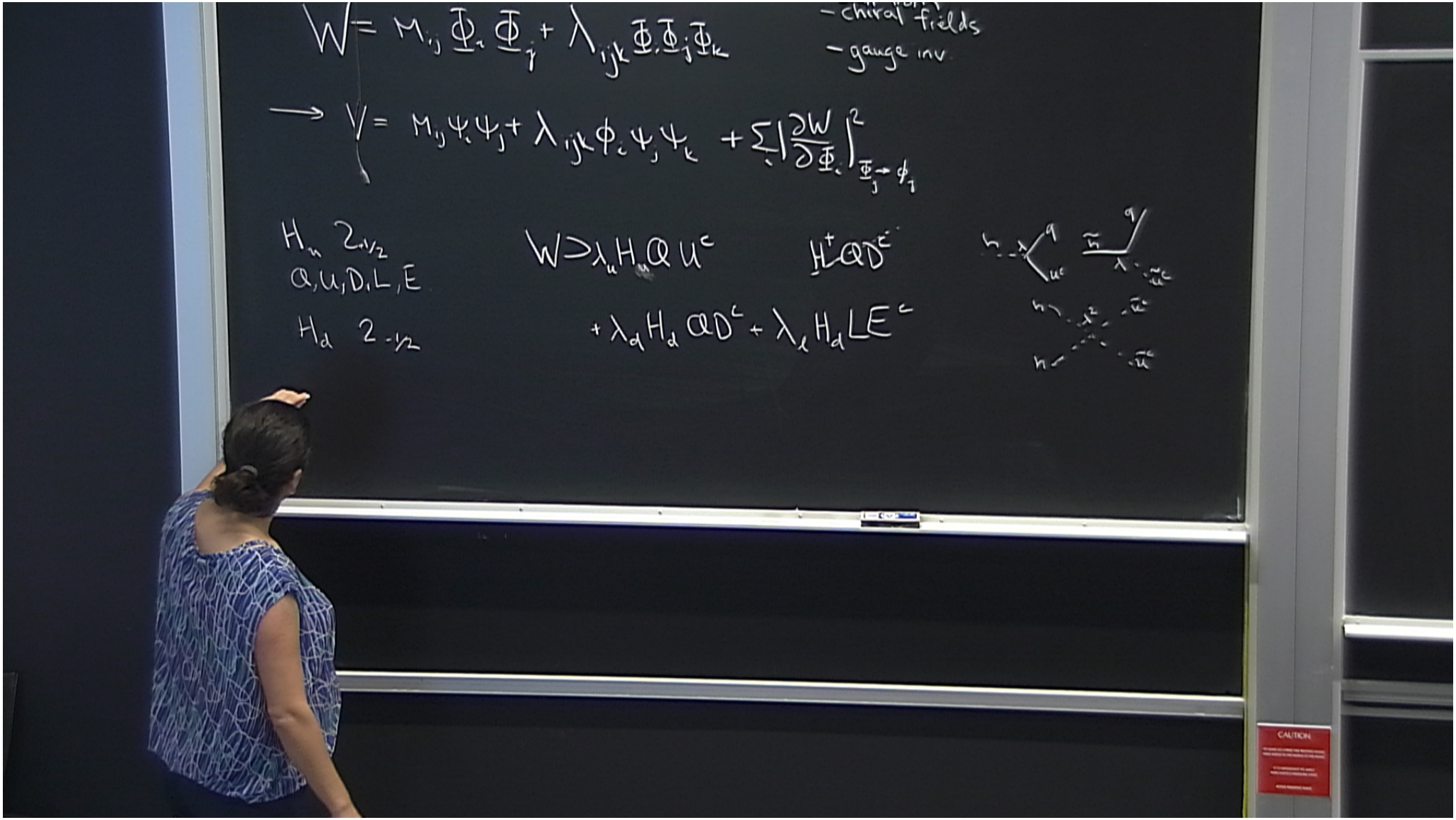
Title: Beyond the Standard Model â€“ Theory: BSM at high energy 2

Date: Jul 10, 2015 02:30 PM

URL: http://pirsa.org/15070034

Abstract:


$W = M_{ij}\Phi_i\Phi_j + \lambda_{ijk}\Phi_i\Phi_j\Phi_k$
built from chiral fields
gauge inv.
$\rightarrow V = M_{ij}\psi_i\psi_j + \lambda_{ijk}\phi_i\psi_j\psi_k + \sum_i \left|\frac{\partial W}{\partial \Phi_i}\right|^2_{\Phi_j \rightarrow \phi_j}$
H 2, 1/2
Q, U, D, L, E
$W \supset HQU^c$
H^+QD^c
CAUTION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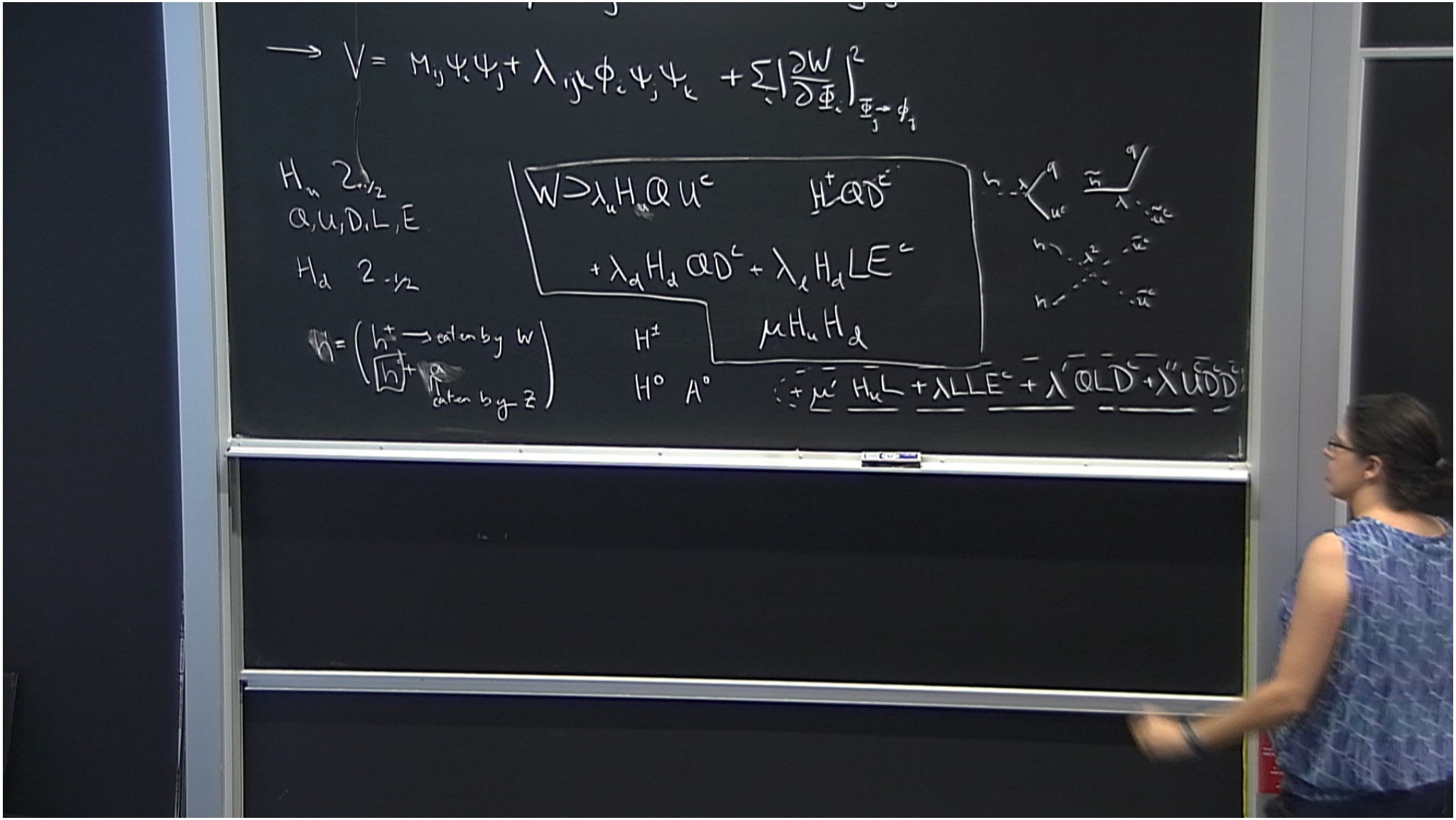
$\rightarrow V = M_{ij}\psi_i\psi_j + \lambda_{ijk}\phi_i\psi_j\psi_k + \sum_i \left|\frac{\partial W}{\partial \Phi_i}\right|^2_{\Phi_j \to \phi_j}$
H_u $2, +1/2$
Q, U, D, L, E
H_d $2, -1/2$
$W \supset \lambda_u H_u Q U^c$
$H_u^+ Q D^c$
$+ \lambda_d H_d Q D^c + \lambda_e H_d L E^c$
CAUTION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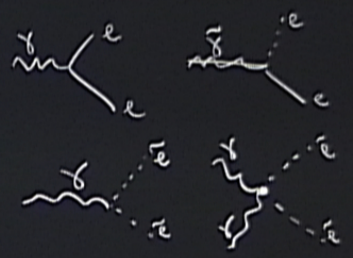
H_u 2, +1/2
Q, U, D, L, E
H_d 2, -1/2
$W \supset \lambda_u H_u Q U^c \quad H^+ L Q D^c$
$+ \lambda_d H_d Q D^c + \lambda_e H_d L E^c$
$H^\pm \quad \mu H_u H_d$
$H^0 \; A^0$
$+ \mu' H_u L + \lambda L L E^c + \lambda' Q L D^c + \lambda'' U D D^c$
$h = \begin{pmatrix} h^+ \to \text{eaten by } W \\ h^+ \quad \text{eaten by } Z \end{pmatrix}$

$h = \begin{pmatrix} h^+ \rightarrow \text{eaten by } W \\ h^0 + a \quad a \text{ eaten by } Z \end{pmatrix}$ $H^\pm$ H^0 A^0 $\mu H_u H_d$ $+\mu' H_u L + \lambda LLE^c + \lambda' QLD^c + \lambda'' UDD^c$ (R-parity)

- Gauge interactions
- Higgs potential (quartic!)



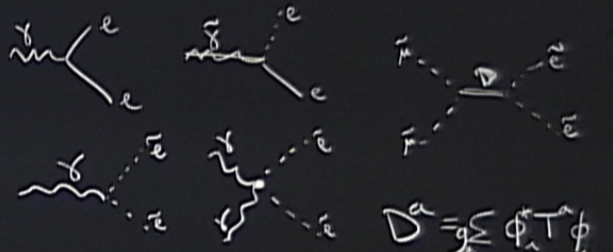
$h = \begin{pmatrix} h^+ \rightarrow \text{eaten by } W \\ h^0 + a \quad (a \uparrow \text{ eaten by } Z) \end{pmatrix}$ $H^\pm$ H^0 A^0

$\mu H_u H_d$

$+ \mu' H_u L + \lambda LLE^c + \lambda' QLD^c + \lambda'' UDD^c$

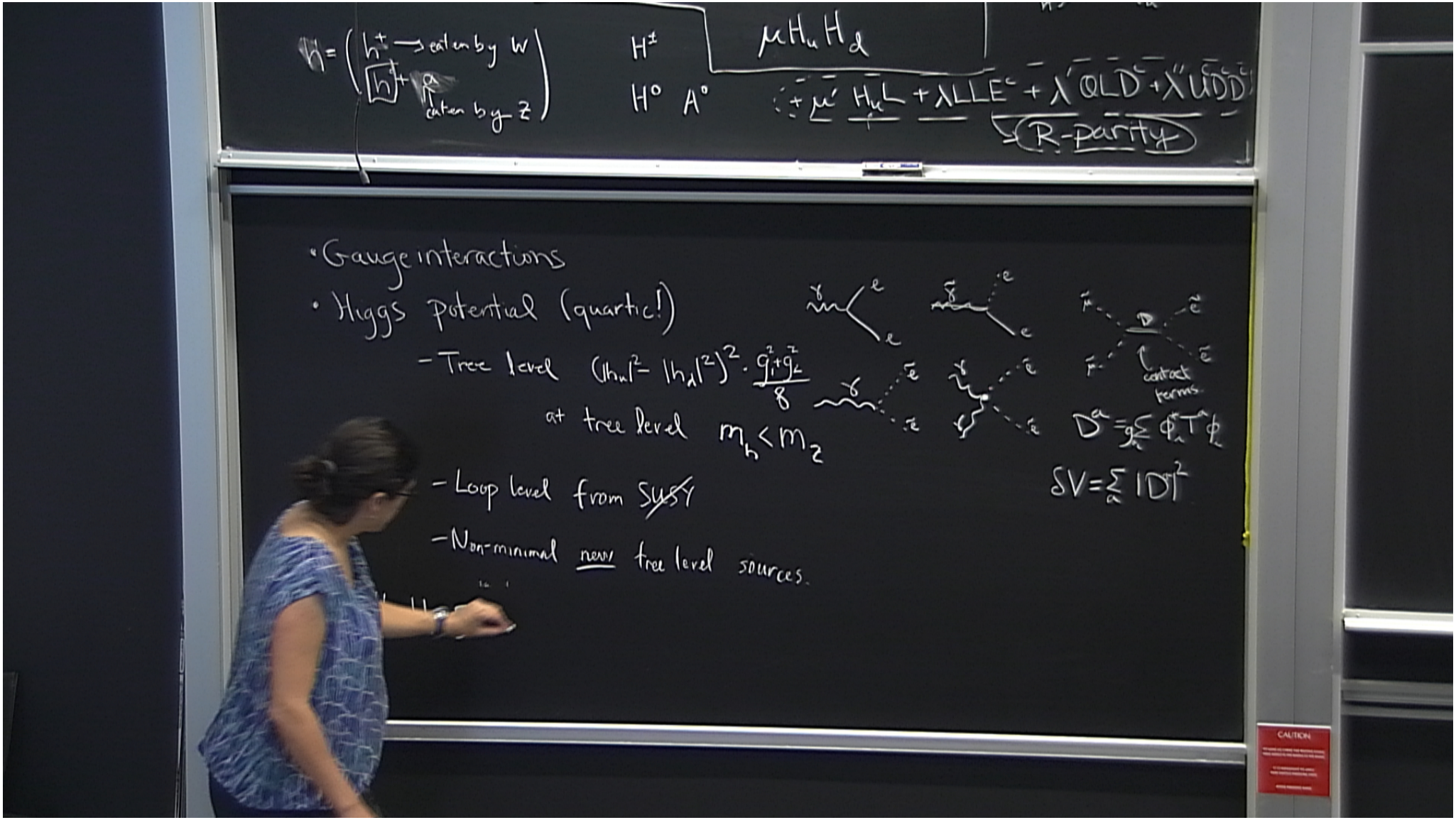
R-parity

- Gauge interactions
- Higgs potential (quartic!)



$D^a = g \sum_{i,j} \phi_i^* T^a \phi_j$

$\delta V = \sum_a |D|^2$


$h = \begin{pmatrix} h^+ \rightarrow \text{eaten by } W \\ h^{+\prime} \quad a \uparrow \text{eaten by } Z \end{pmatrix}$
$H^\pm$
H^0 A^0
$\mu H_u H_d$
$+\mu' H_u L + \lambda LLE^c + \lambda' QLD^c + \lambda'' UDD^c$
R-parity
• Gauge interactions
• Higgs potential (quartic!)
- Tree level $(|h_u|^2 - |h_d|^2)^2 \cdot \frac{g_1^2+g_2^2}{8}$
at tree level $m_h < m_Z$
- Loop level from SUSY
- Non-minimal new tree level sources
contact terms
$D^a = g \sum_i \phi_i^* T^a \phi_i$
$SV = \sum_i |D|^2$

$h = \begin{pmatrix} h^+ \rightarrow \text{eaten by } W \\ h^{+\prime} \quad a \rightarrow \text{eaten by } Z \end{pmatrix}$ $H^\pm$ H^0 A^0

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R-parity

- Gauge interactions
- Higgs potential (quartic!)
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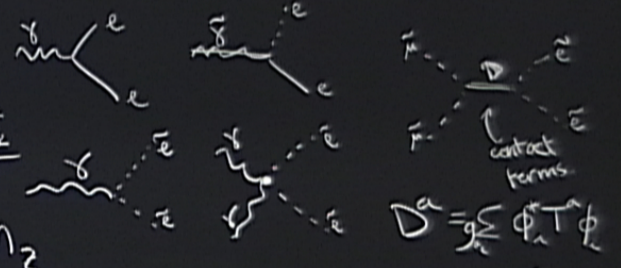
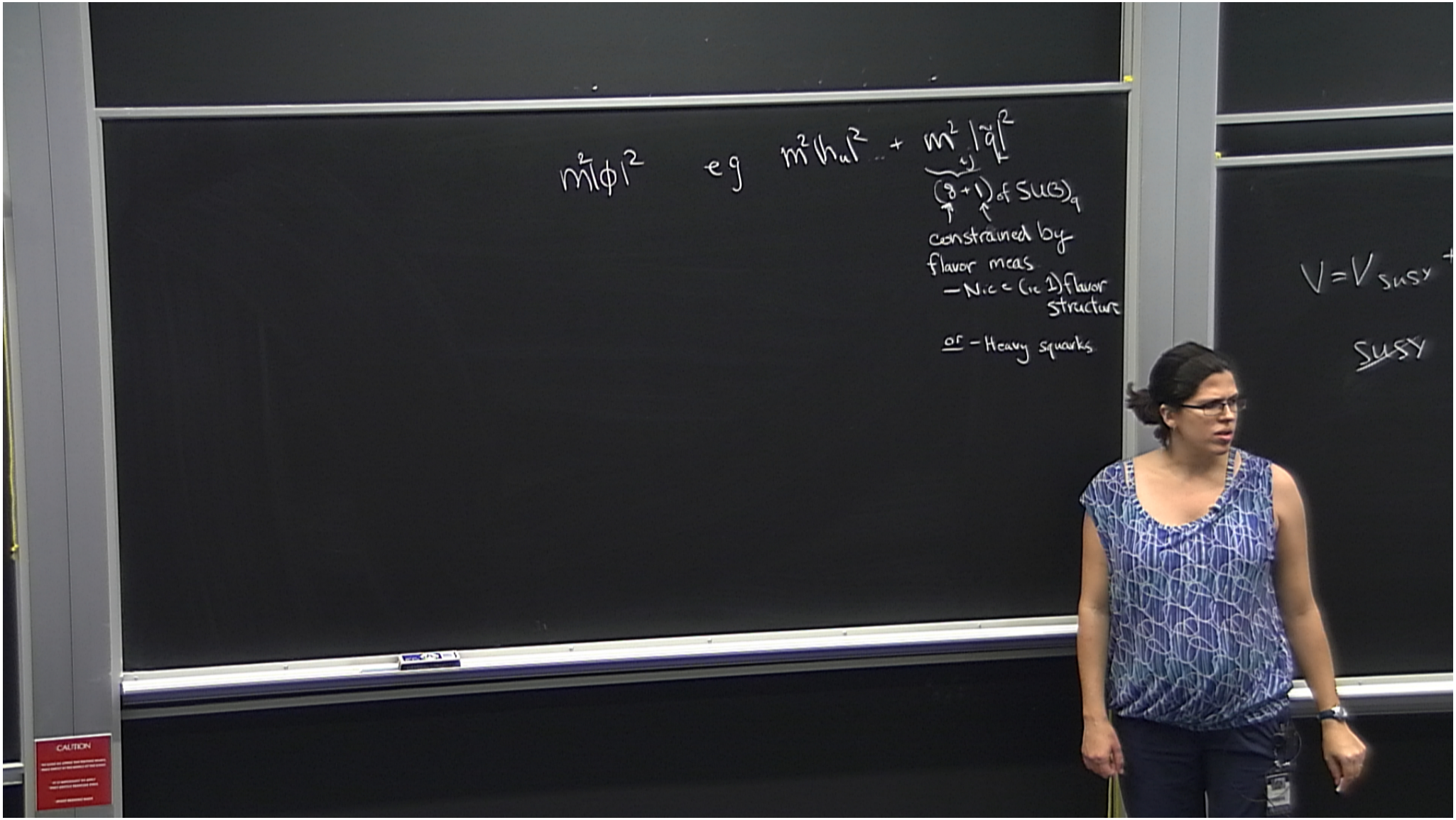
  - Non-minimal new tree level sources.

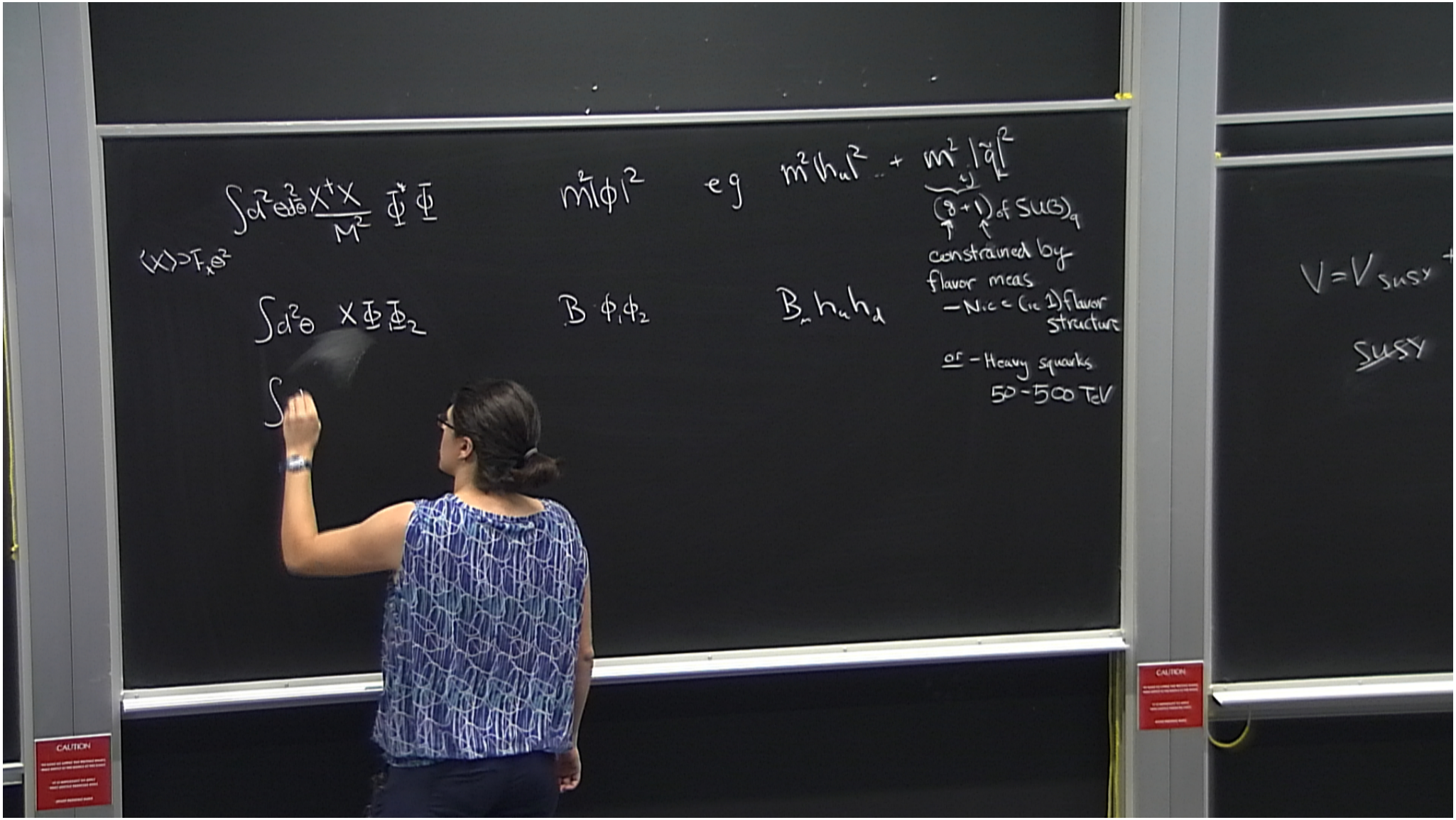
$\delta W = \lambda H_u H_d S \quad V \supset |h_u h_d|^2$ (NMSSM)

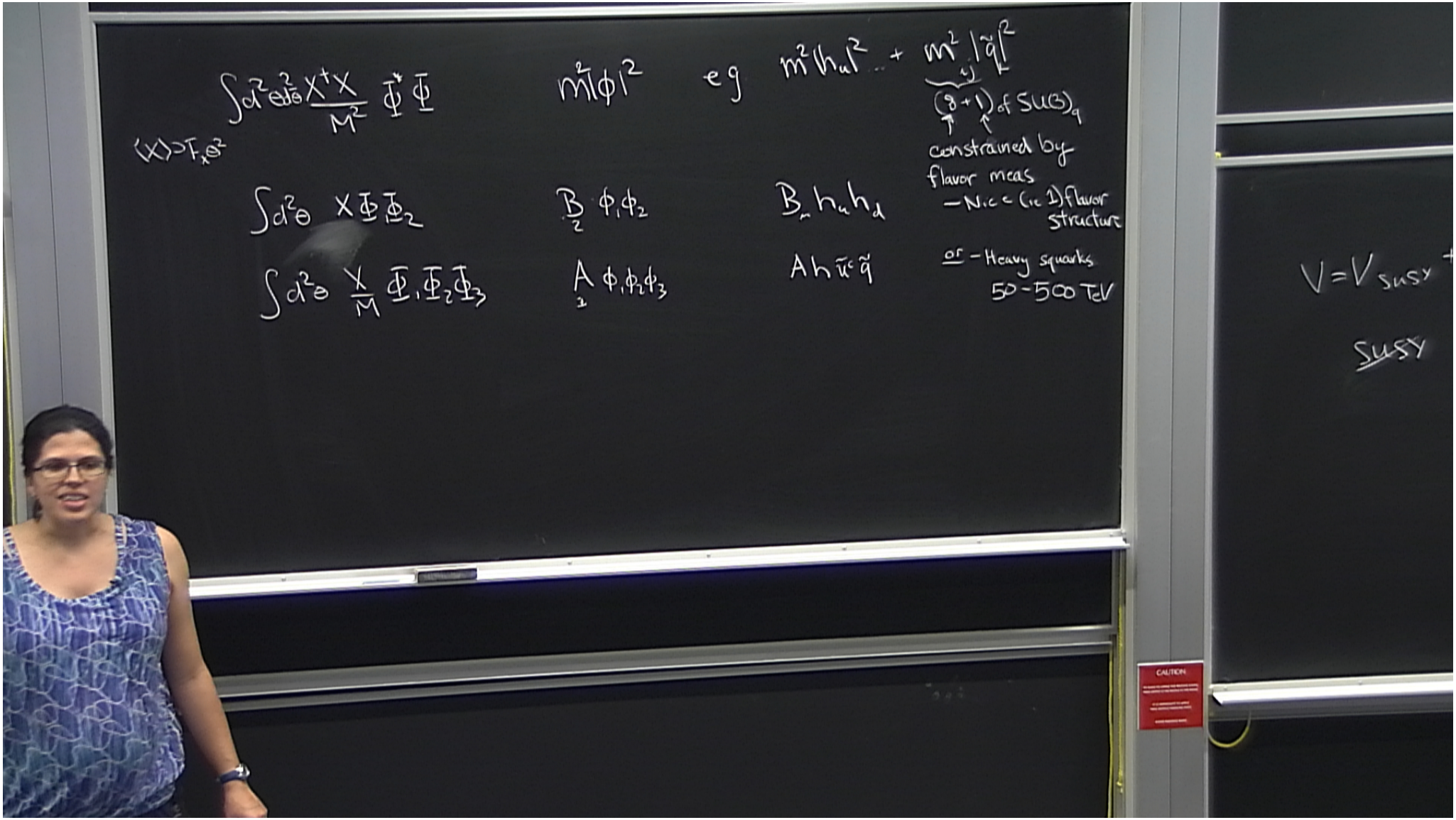


$D^a = g \sum_n \phi_n^* T^a \phi_n$

$\delta V = \sum_n |D|^2$


$m^2|\phi|^2$ eg $m^2|h_u|^2 + \underbrace{m^2}_{(9+1)} |\tilde{q}|^2$ of SU(3)$_q$
constrained by flavor meas
– Nice = (ie 1) flavor structure
or – Heavy squarks
$V = V_{susy}$ +
susy
CAUTION


$\int d^2\theta d^2\bar{\theta} \frac{X^\dagger X}{M^2} \Phi^\dagger \Phi$
$m^2|\phi|^2$
eg $m^2|h_u|^2 + \underbrace{m^2_{ij}}_{(8+1) \text{ of } SU(3)_q} |\tilde{q}|^2$
$\langle X \rangle = F_X \theta^2$
constrained by flavor meas
– N.c = (i.e. 1) flavor structure
or – Heavy squarks
50 – 500 TeV
$\int d^2\theta \; X \Phi_1 \Phi_2$
$B \phi_1 \phi_2$
$B_\mu h_u h_d$
$V = V_{SUSY}$
SUSY
CAUTION
CAUTION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constrained by flavor meas
– N.c = (i.e 1) flavor structure
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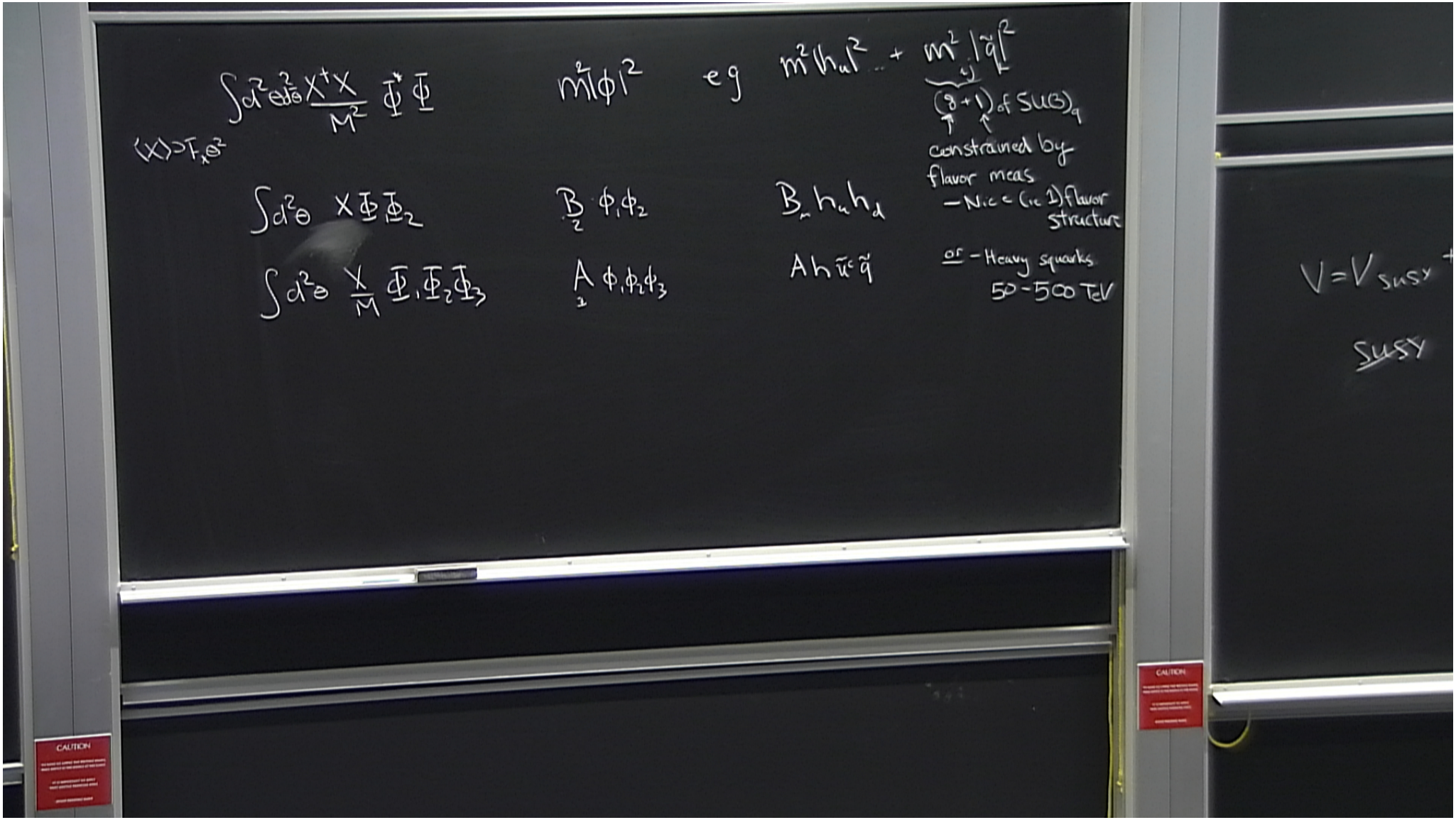
$\int d^2\theta \; X \Phi_1 \Phi_2$
$B_2 \phi_1 \phi_2$
$B_\mu h_u h_d$
$\int d^2\theta \frac{X}{M} \Phi_1 \Phi_2 \Phi_3$
$A_1 \phi_1 \phi_2 \phi_3$
$A h \tilde{u}^c \tilde{q}$
$V = V_{SUSY}$ +
SUSY
CAUTION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$A_1 \phi_1 \phi_2 \phi_3$
$A h \tilde{u}^c \tilde{q}$
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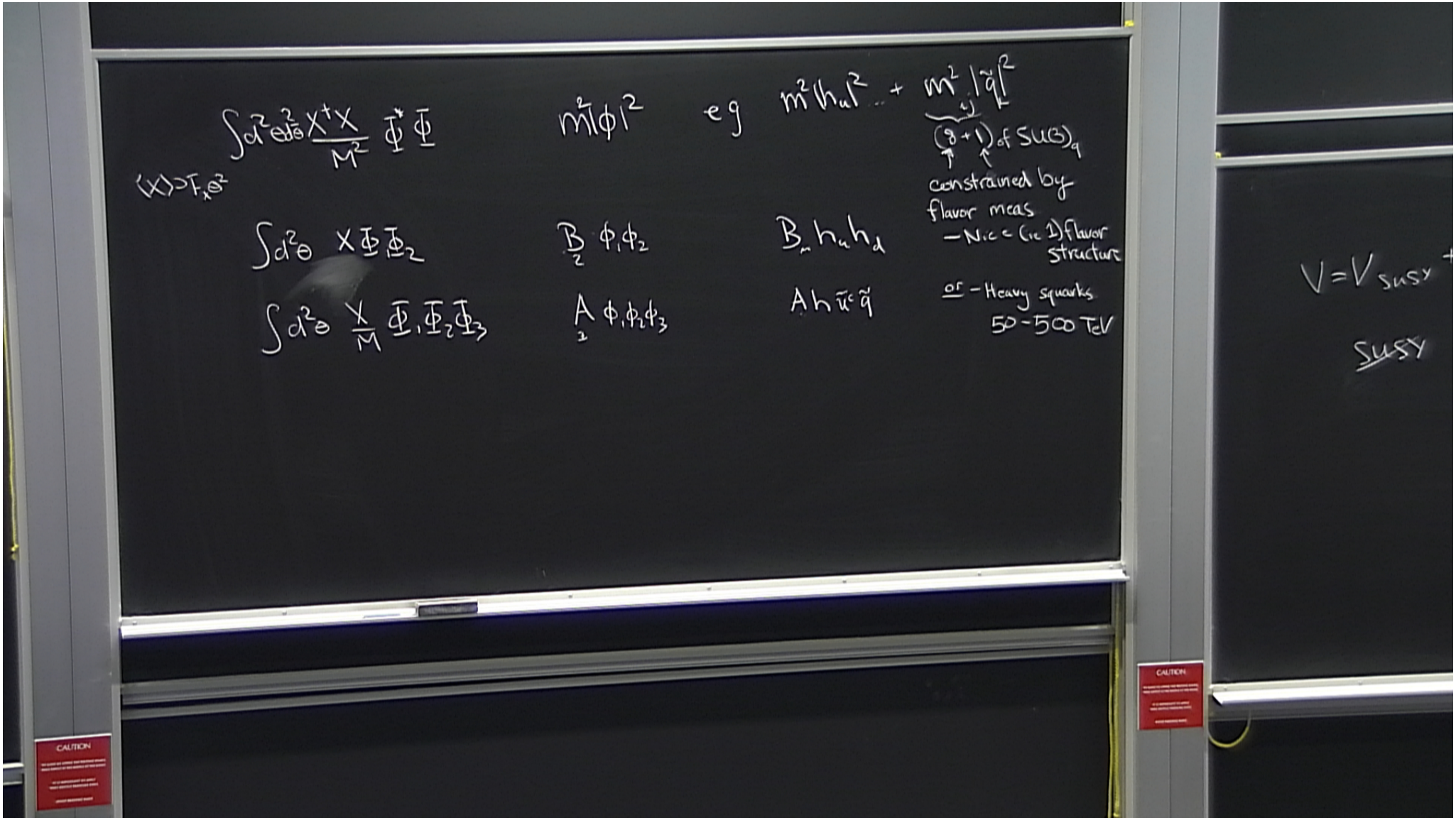
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$\frac{A}{3} \phi_1 \phi_2 \phi_3$
$A h \tilde{u}^c \tilde{q}$
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CAUTION
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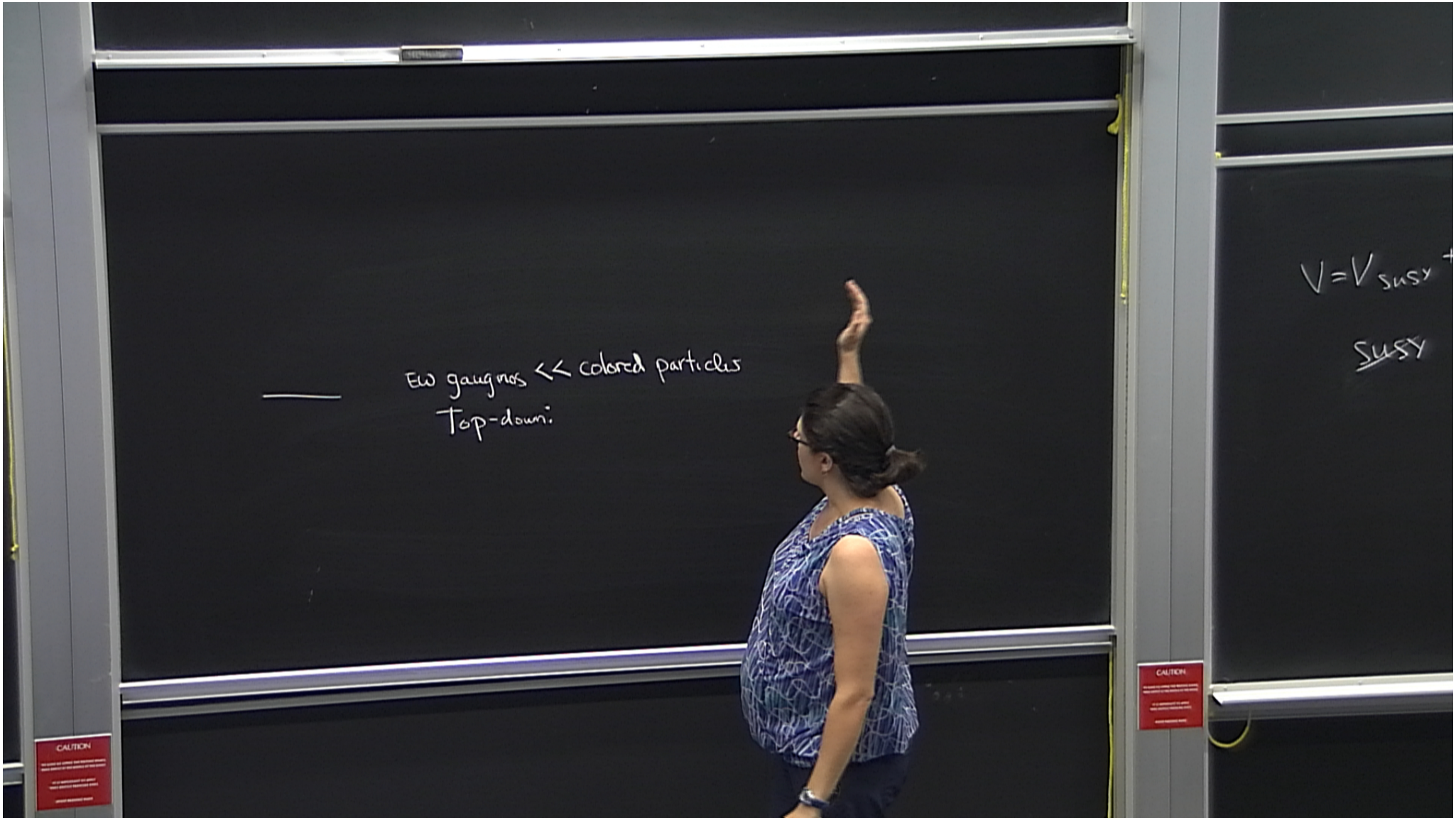
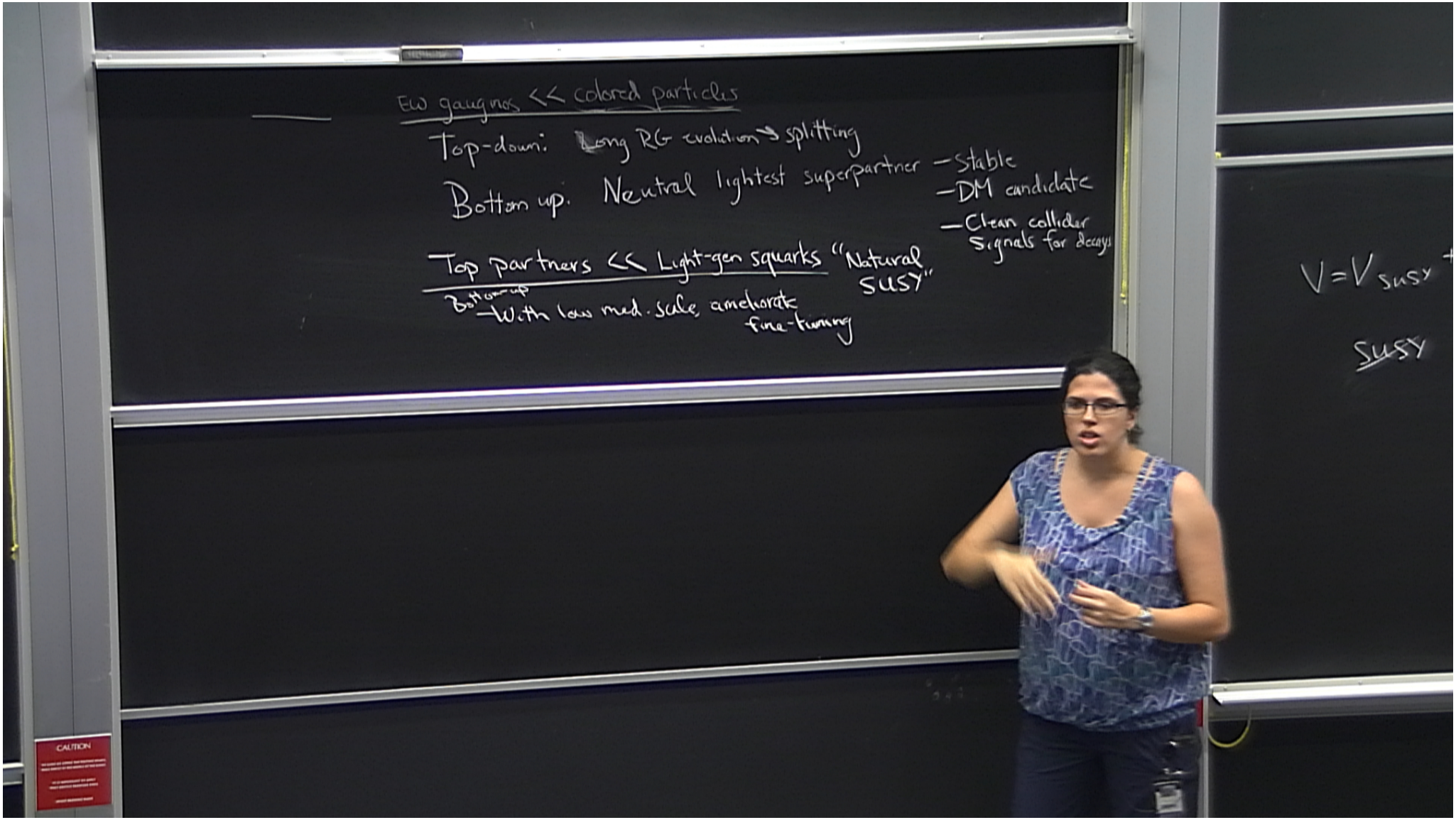

EW gauginos << colored particles
Top-down.
V=V susy
Susy
CAUTION
CAUTION


EW gauginos << colored particles
Top-down: Long RG evolution → splitting
Bottom up: Neutral lightest superpartner
-Stable
-DM candidate
-Clean collider signals for decays
Top partners << Light-gen squarks "Natural SUSY"
Bottom-up
-With low med. scale, ameliorate fine-tuning
V=V SUSY
SUSY
CAUTION

$h = \begin{pmatrix} h^+ \to \text{eaten by } W \\ h^0 \quad \text{eaten by } Z \end{pmatrix}$ $H^\pm$ H^0 A^0

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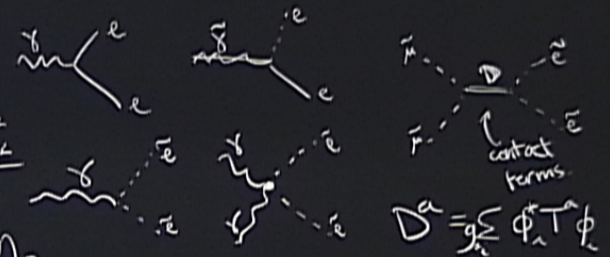

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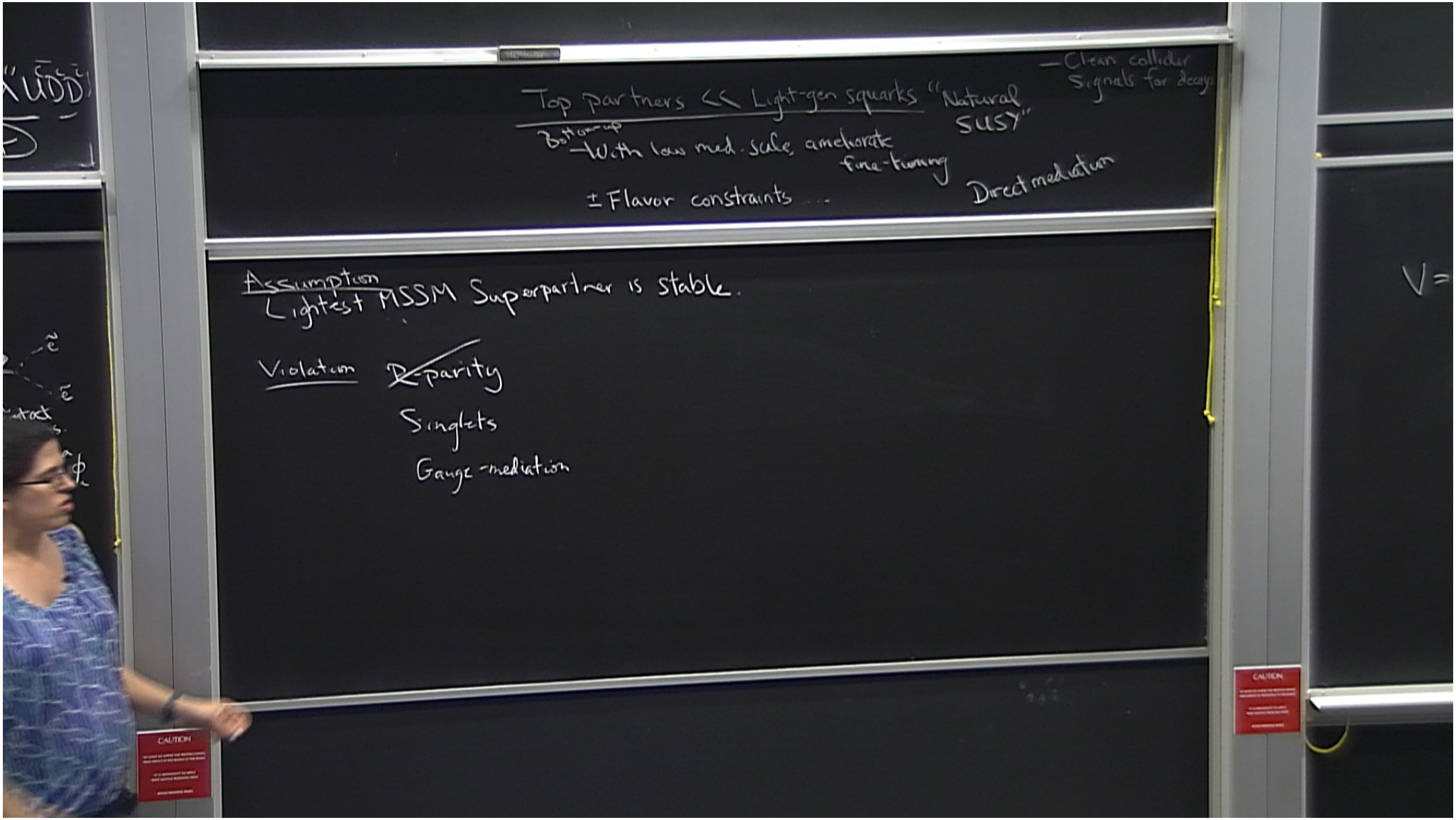
Top partners << Light-gen squarks "Natural SUSY"
Bottom-up
- With low med. scale, ameliorate fine-tuning
± Flavor constraints ...
- Clean collider signals for decays
Direct mediation
Assumption
Lightest MSSM Superpartner is stable.
Violation
R-parity
Singlets
Gauge-mediation
CAUTION
CAUTION

Top partners << Light-gen squarks "Natural SUSY"

Bottom-up

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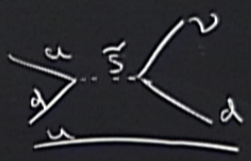

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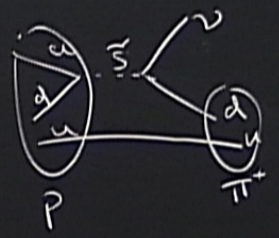


$\Gamma \sim \frac{m_p^5}{M_{susy}^4} \times$ couplings

Top partners << Light-gen squarks "Natural SUSY"

Bottom-up

- With low med. scale, ameliorate fine-tuning

± Flavor constraints ...

- Clean collider signals for decays

Direct mediation

Assumption

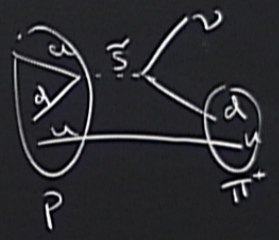
Lightest MSSM Superpartner is stable.

Violation ~~R-parity~~

Singlets

Gauge-mediation

$$R = (-1)^{J+L+3B}$$



$$\Gamma \sim \frac{m_p^5}{M_{susy}^4} \cdot \text{couplings}$$