Title: Particle Physics Lecture

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Collection: Particle Physics

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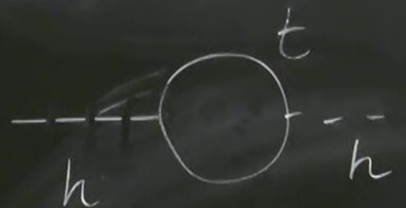
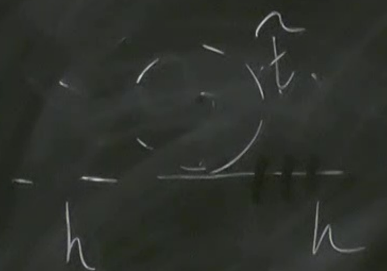
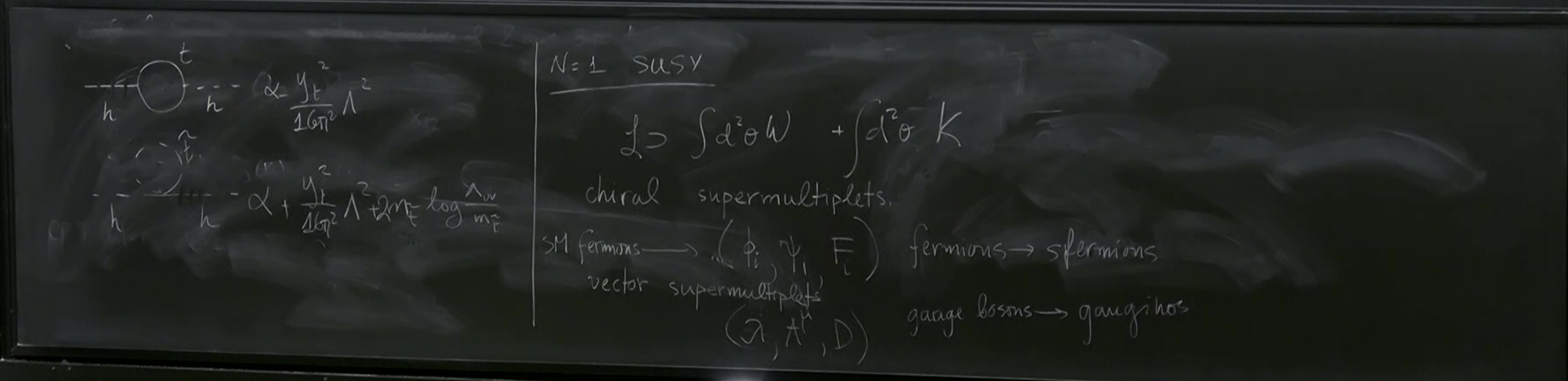


$$\propto -\frac{y_t^2}{16\pi^2}\Lambda^2$$



$$\propto +\frac{y_t^2}{16\pi^2}\Lambda^2 + 2m_{\tilde{t}}^2 \log\frac{\Lambda_{UV}}{m_{\tilde{t}}^2}$$


t
h h ∝ y_t^2/16π^2 Λ^2
t̃
h h ∝ y_t^2/16π^2 Λ^2 + 2m_t̃^2 log Λ_UV/m_t̃
N=1 SUSY
ℒ ⊃ ∫d^2θ W + ∫d^2θ K
chiral supermultiplets
SM fermions → (φ_i, ψ_i, F_i) fermions → sfermions
vector supermultiplets
(λ, A^μ, D) gauge bosons → gauginos

$d^2\theta\ K$

s.

fermions $\rightarrow$ sfermions

gauge bosons $\rightarrow$ gauginos

$$W = t_i \Phi^i + \frac{1}{2} M_{ij} \Phi_i \Phi_j + \frac{1}{6} y_{ijk} \Phi_i \Phi_j \Phi_k$$

$$\mathcal{L} \supset -\frac{1}{2} \sum_{i,j} \frac{\partial^2 W}{\partial \phi_i \partial \phi_j} \psi_i \psi_j - \sum_i \left| \frac{\partial W}{\partial \phi_i} \right|^2$$

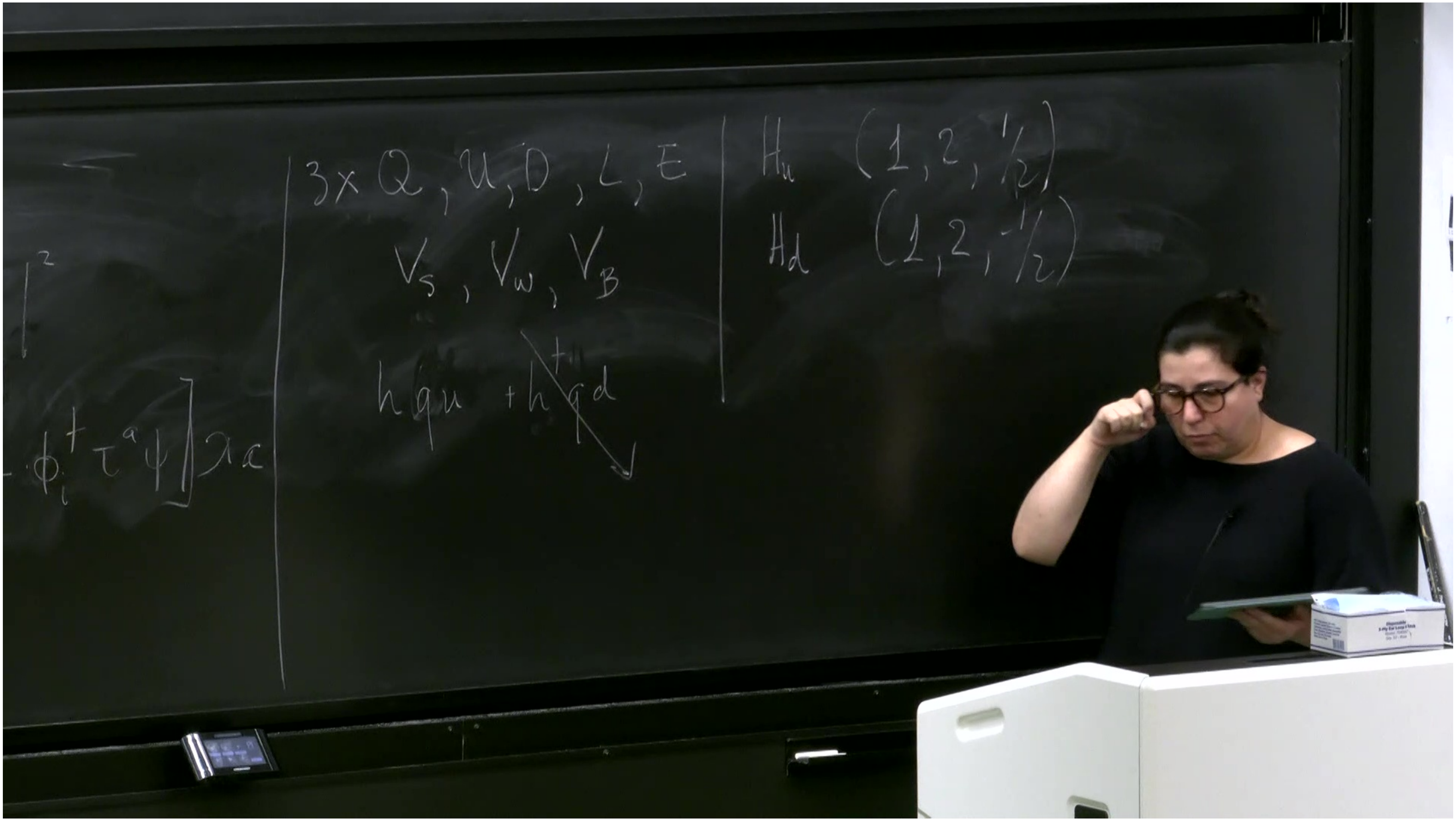
$$y_{ijk}\,\phi_k\,\psi_i\,\psi_j$$

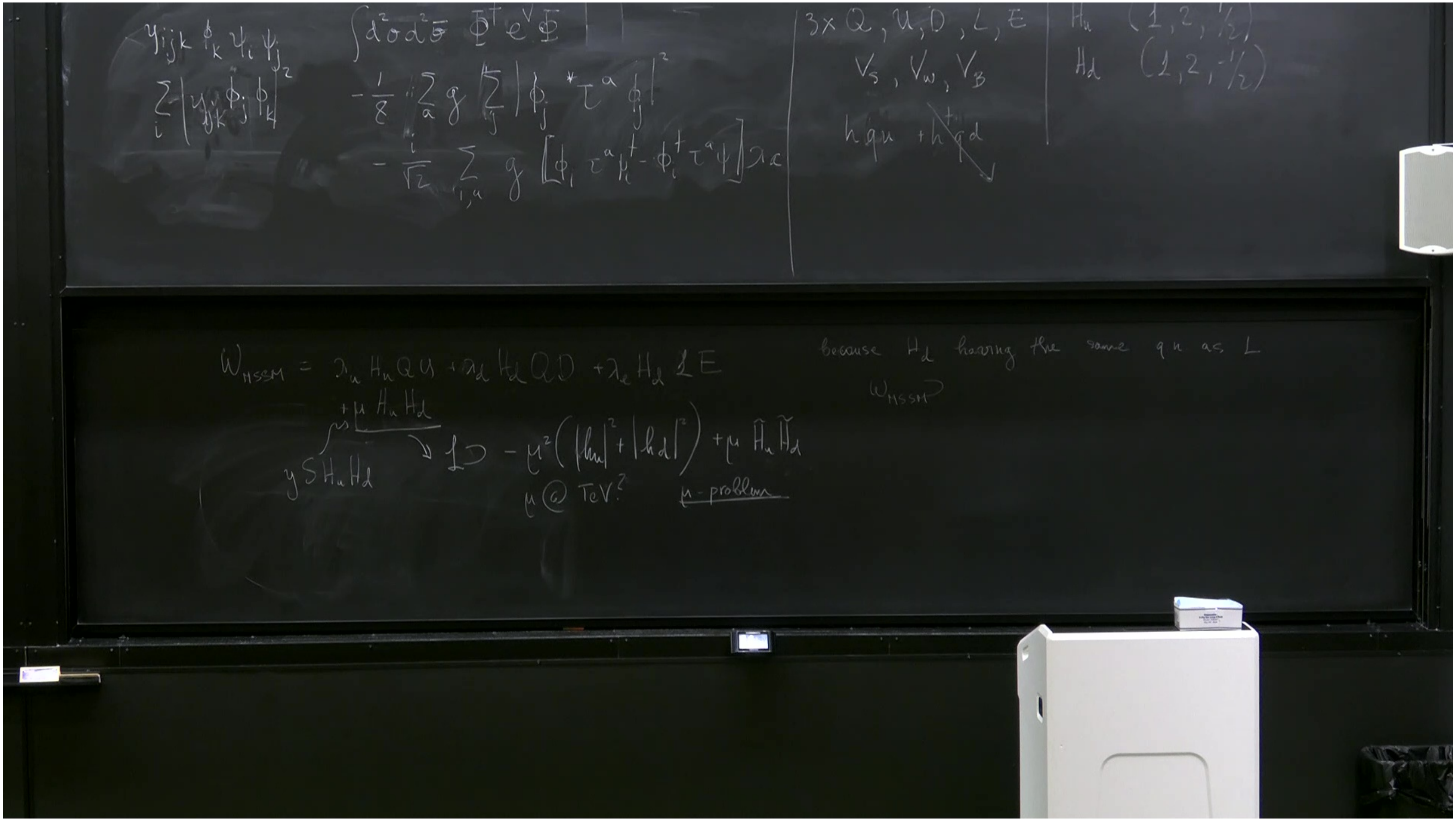
$$\sum_i \left| y_{ijk}\,\phi_j\,\phi_k \right|^2$$

$$\int d^2\theta\, d^2\bar{\theta}\;\Phi^\dagger e^V \Phi$$

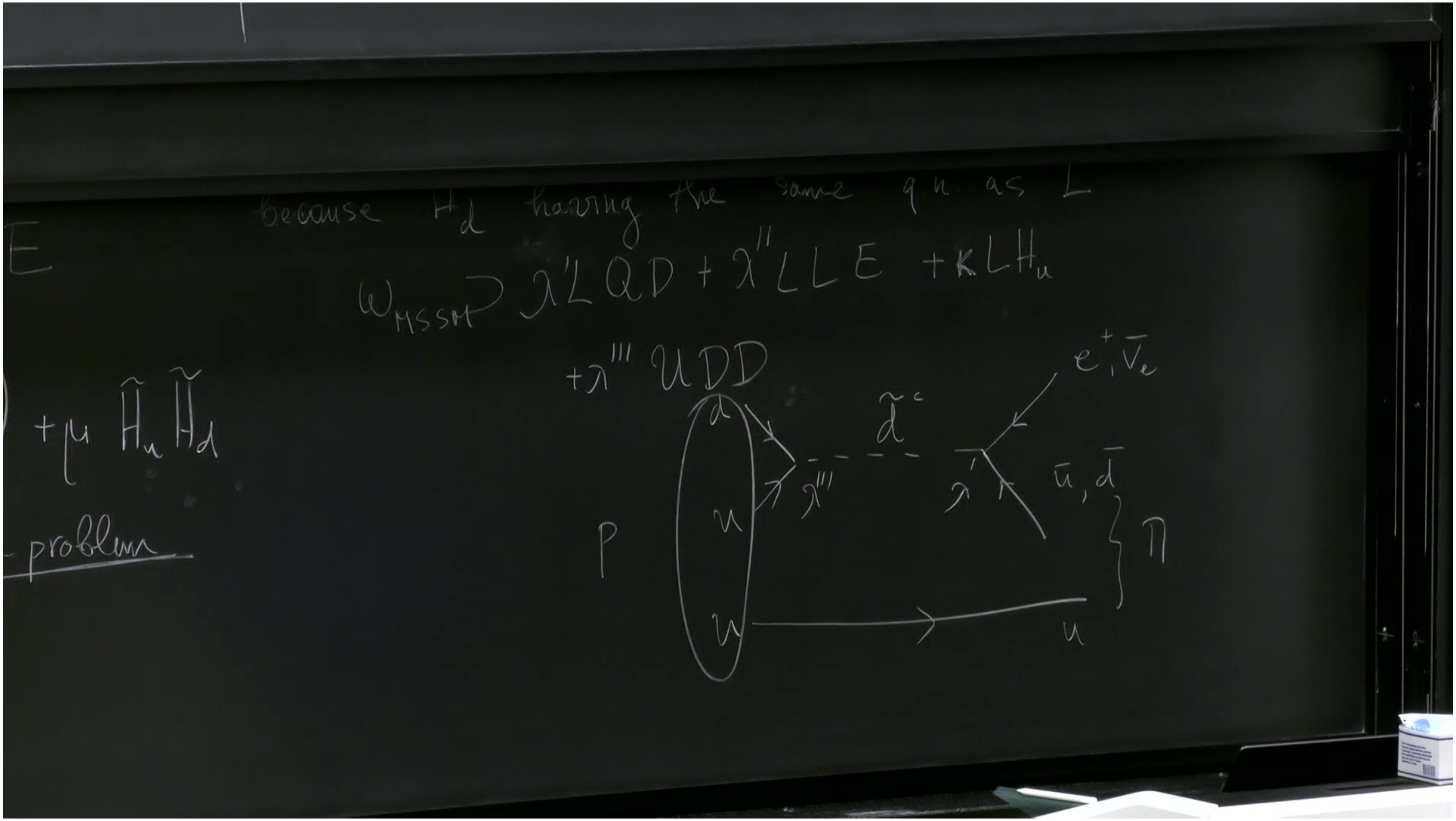
$$-\frac{1}{8}\sum_a g \left| \sum_j \phi_j^{*}\,\tau^a\,\phi_j \right|^2$$

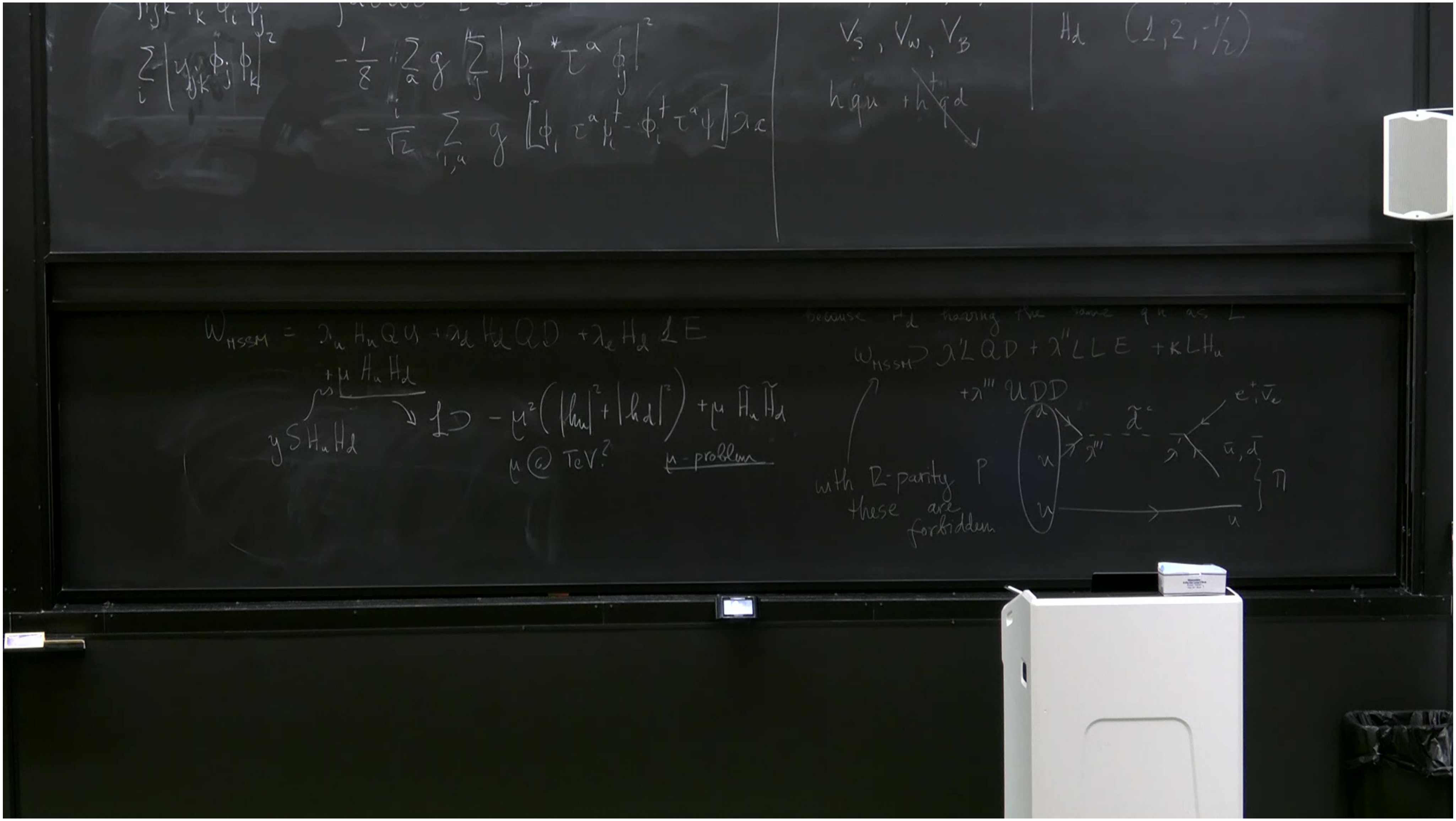
$$-\frac{i}{\sqrt{2}}\sum_{i,a} g\left[\phi_i\,\tau^a\,\psi_i^\dagger - \phi_i^\dagger\,\tau^a\,\psi\right]\lambda_a$$

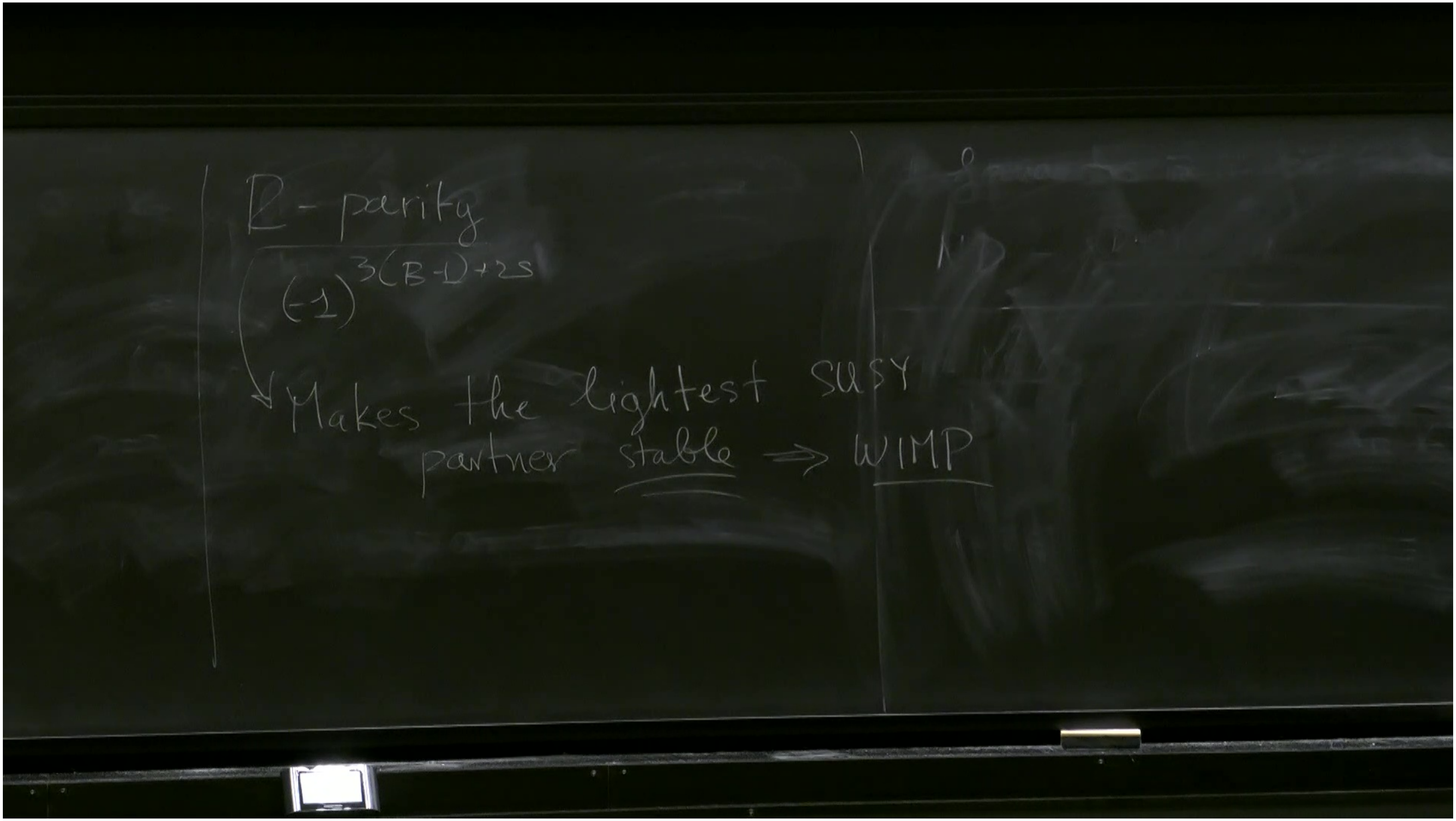

3x Q, U, D, L, E
Vs, Vw, VB
h q u + h q d
Hu (1, 2, 1/2)
Hd (1, 2, -1/2)


3× Q, U, D, L, E
Vs, Vw, VB
Hu (1, 2, 1/2)
Hd (1, 2, -1/2)
WMSSM = λu Hu Q U + λd Hd Q D + λe Hd L E
+ μ Hu Hd
y S Hu Hd
μ @ TeV?
μ-problem
because Hd having the same qn as L
WMSSM?

	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$
$Q \supset \tilde{q}, q, F_q$	3	2	$1/6$
$H_u \supset \tilde{H}_u, h_u, F_{h_u}$	1	2	$1/2$
$H_d \supset \tilde{H}_d, h_d, F_d$	1	2	$-1/2$

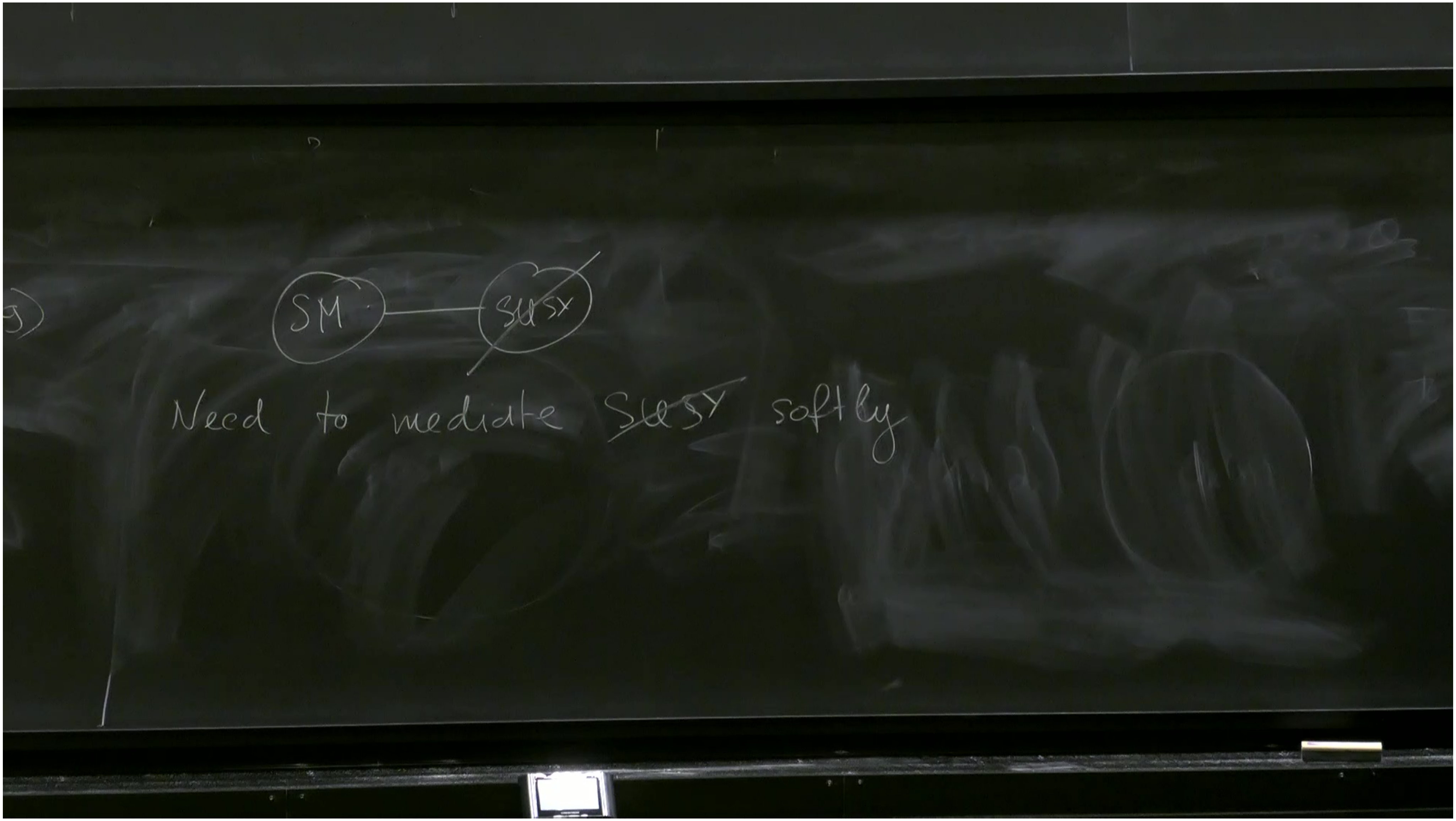

because H_d having the same q.n. as L
$W_{MSSM} \supset \lambda' LQD + \lambda'' LLE + \kappa L H_u$
$+ \lambda''' UDD$
$+ \mu \tilde{H}_u \tilde{H}_d$
problem
$\tilde{d}^c$
λ'''
λ'
$e^+, \bar{\nu}_e$
$\bar{u}, \bar{d}$
π
p
d
u
u
u


V_S , V_W , V_B
H_d (1, 2, -1/2)
W_MSSM = λ_u H_u Q U + λ_d H_d Q D + λ_e H_d L E
+ μ H_u H_d
y S H_u H_d
L ⊃ − μ²(|h_u|² + |h_d|²) + μ H̃_u H̃_d
μ @ TeV?
μ-problem
because H_d having the same q.n. as L
W_MSSM ⊃ λ' L Q D + λ'' L L E + κ L H_u
+ λ''' U D D
with R-parity P
these are
forbidden
e⁺, ν̄_e
ū, d̄
π


R - parity
$(-1)^{3(B-L)+2S}$
Makes the lightest SUSY partner stable ⇒ WIMP

How is SUSY broken?

Ferrara et. al (1979)


SM
SUSY
Need to mediate SUSY softly

$$\mathcal{L} \supset b_\mu h_u h_d + m^2_{\tilde q_{ij}} \tilde q_i^* \tilde q_j \ldots$$

$$+ m_\lambda (\lambda^a)^2 + A\, h_u \tilde q \tilde u \ldots$$

$$+ \tilde g\, |\tilde t|^2 |h_u|^2$$

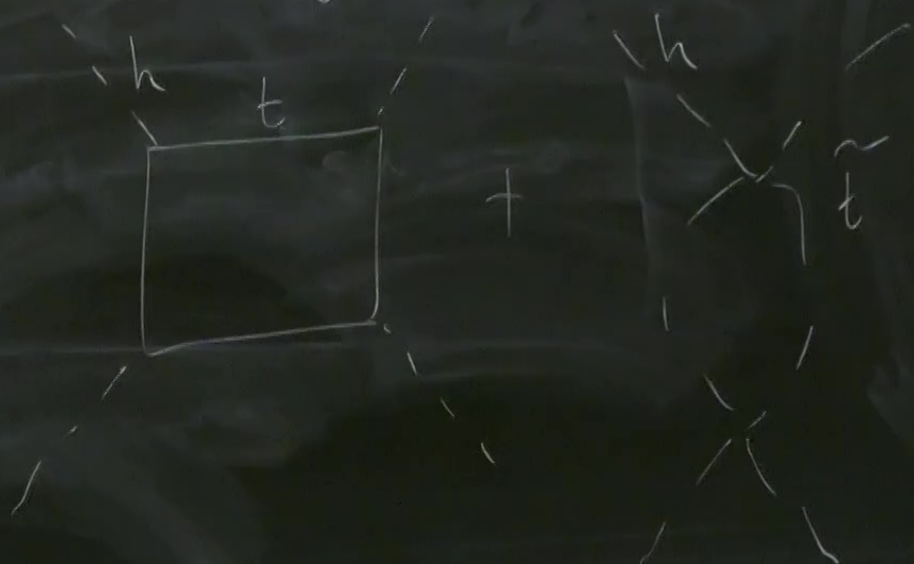
hard breaking of SUSY

~~SUSY~~ softly

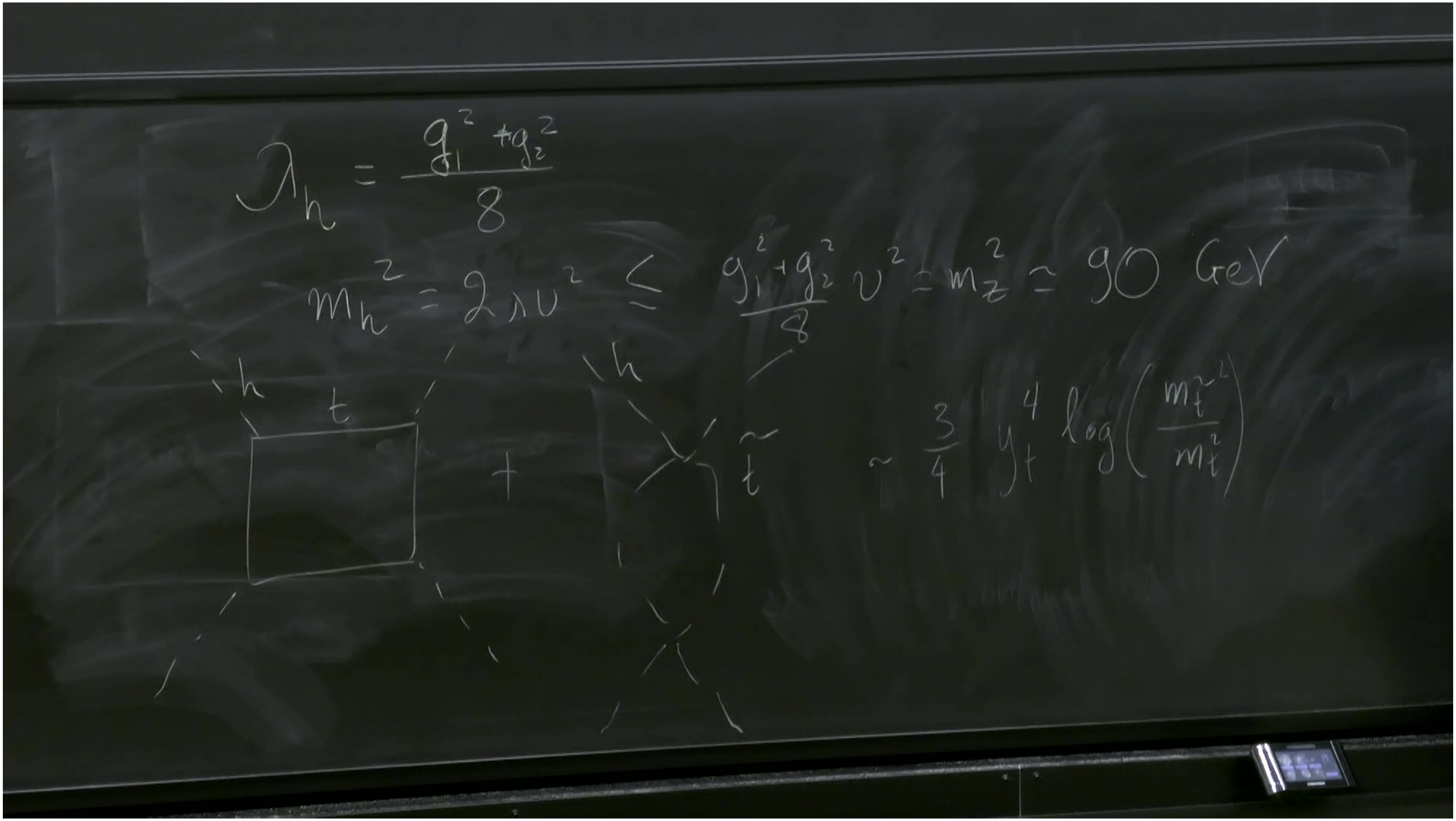
$$V_{eff}(h_u, h_d) = -|\mu|^2 \left(|h_u|^2 + |h_d|^2\right) + b_\mu h_u h_d + m^2_{h_u} |h_u|^2 + m^2_{h_d} |h_d|^2$$

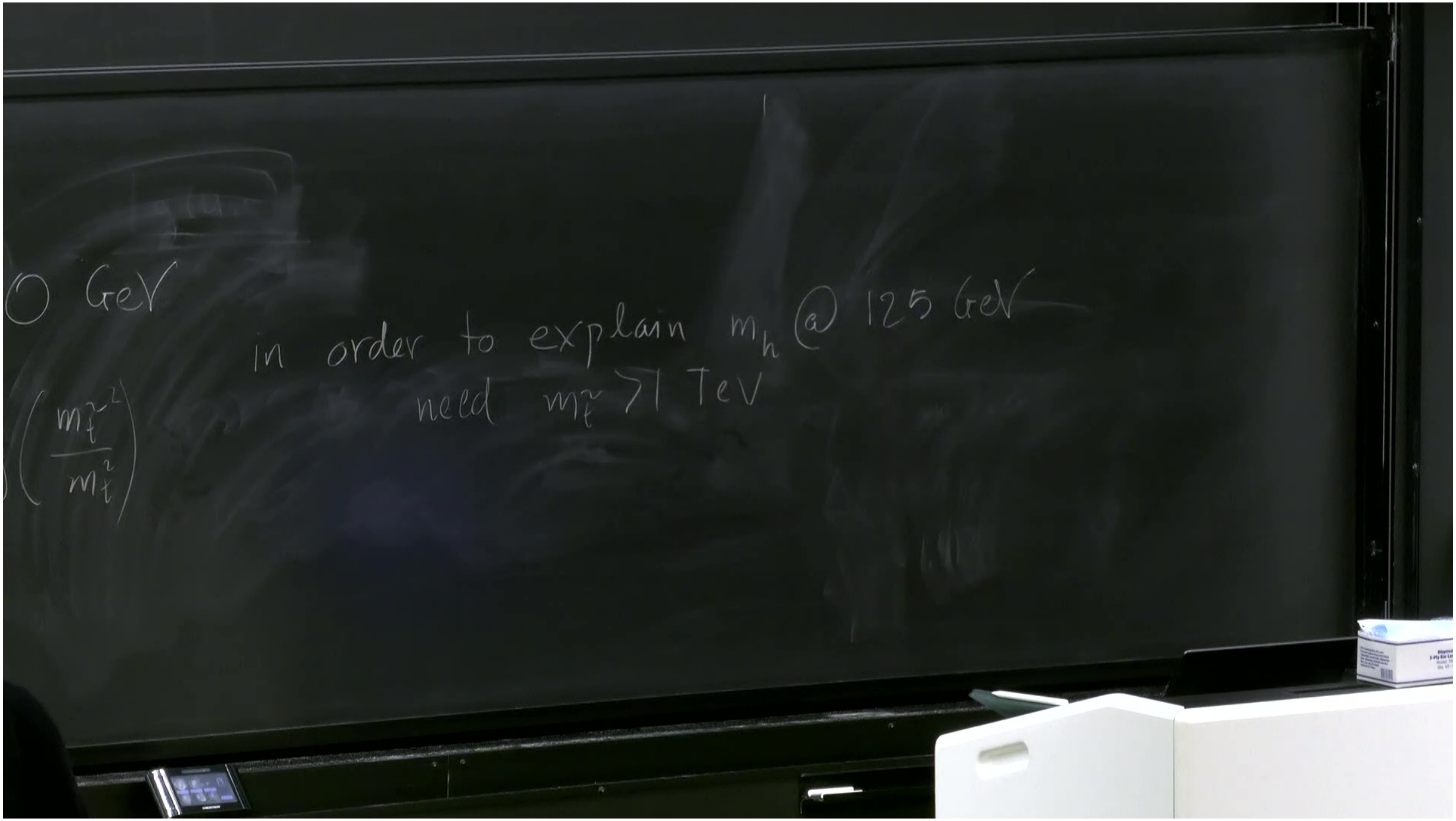
$$\lambda_h = \frac{g_1^2 + g_2^2}{8}$$

$$m_h^2 = 2\lambda v^2 \leq \frac{g_1^2 + g_2^2}{8} v^2 \simeq m_Z^2 \simeq 90 \text{ GeV}$$



$$\sim \frac{3}{4} y_t^4 \log\left(\frac{m_{\tilde{t}}^2}{m_t}\right)$$


$\lambda_h = \frac{g_1^2 + g_2^2}{8}$
$m_h^2 = 2\lambda v^2 \leq \frac{g_1^2 + g_2^2}{8} v^2 \simeq m_Z^2 \simeq 90$ GeV
h
t
+
h
$\tilde{t}$
$\sim \frac{3}{4} y_t^4 \log\left(\frac{m_{\tilde{t}}^2}{m_t^2}\right)$


GeV
in order to explain m_h @ 125 GeV
need $m_{\tilde{t}} > 1$ TeV
$\left(\frac{m_{\tilde{t}}^2}{m_t^2}\right)$