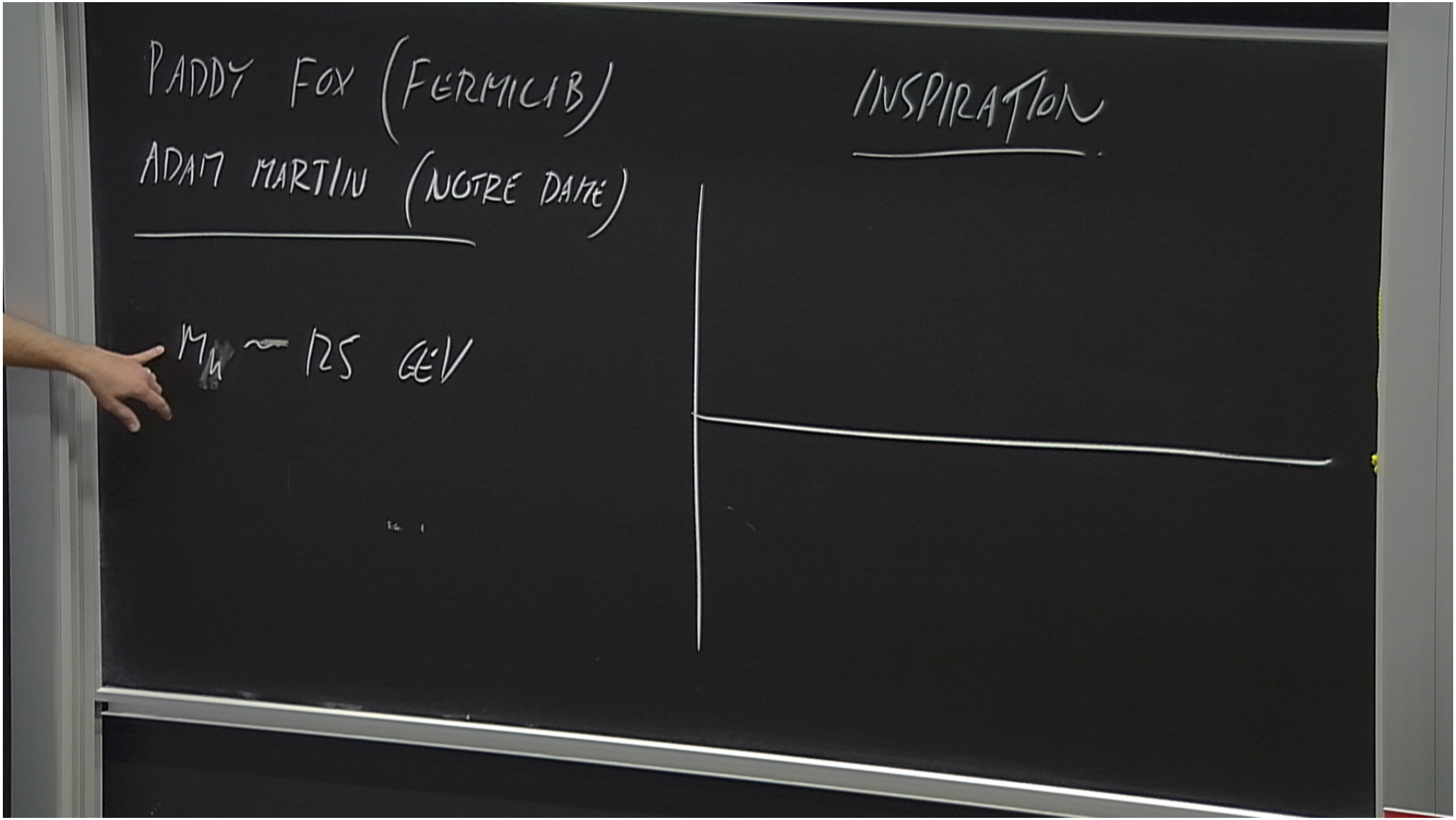
Title: Split Dirac Supersymmetry and a Higgsino LSP

Date: Nov 01, 2013 01:00 PM

URL: http://pirsa.org/13110052

Abstract: TBA


PADDY FOX (FERMILAB)
ADAM MARTIN (NOTRE DAME)
INSPIRATION
$M_H \sim 125$ GeV

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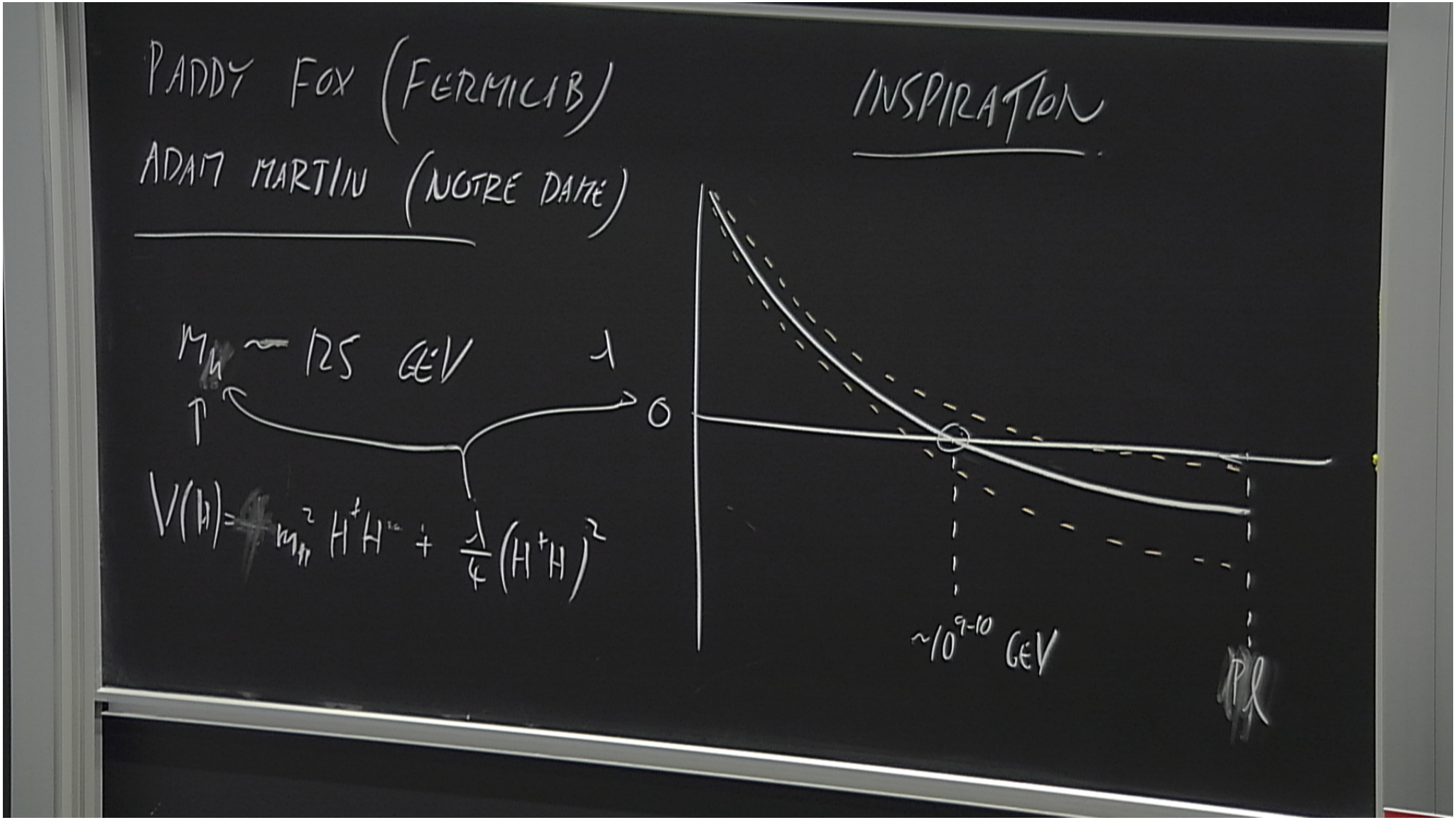
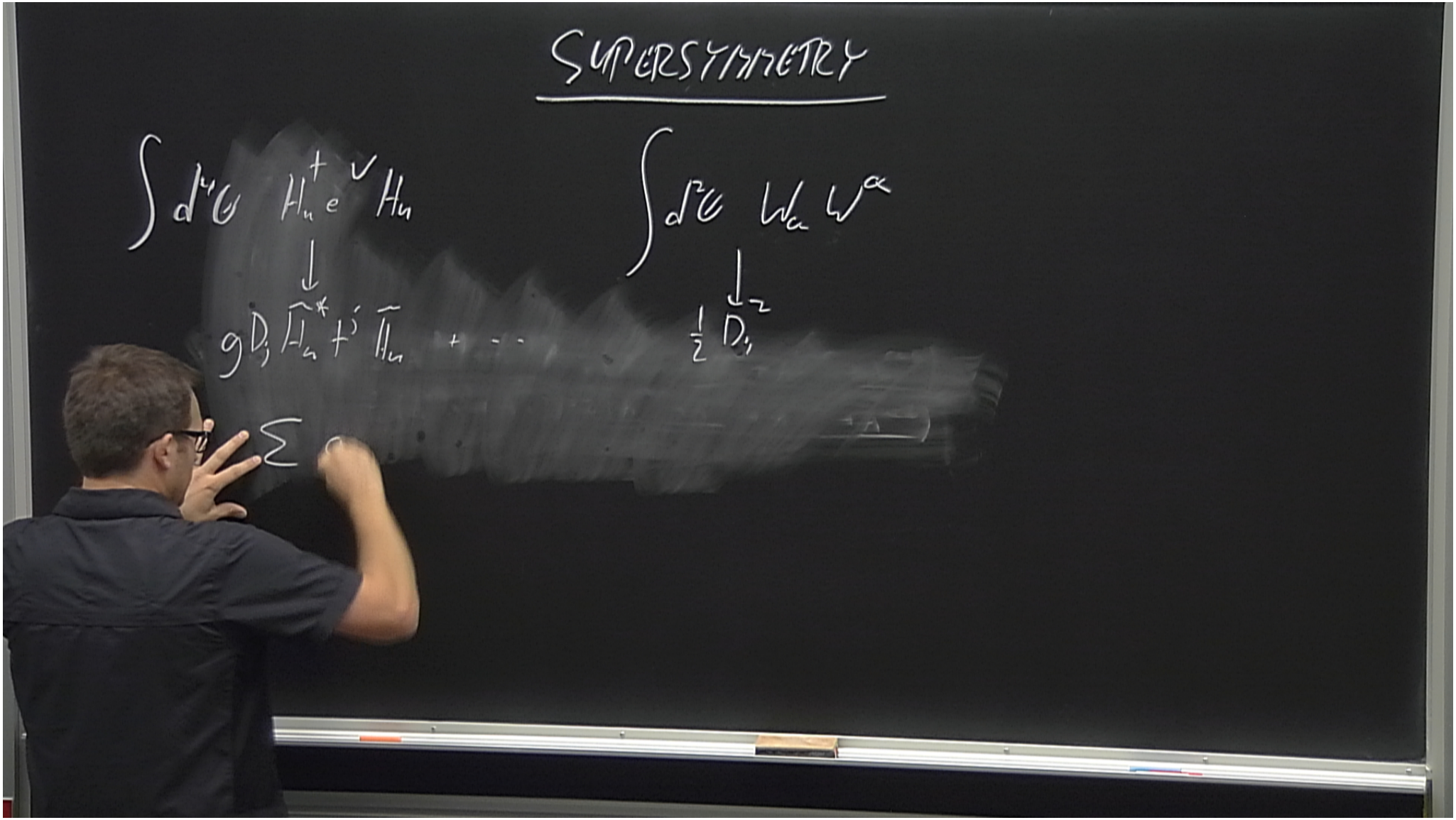
ADAM MARTIN (NOTRE DAME)

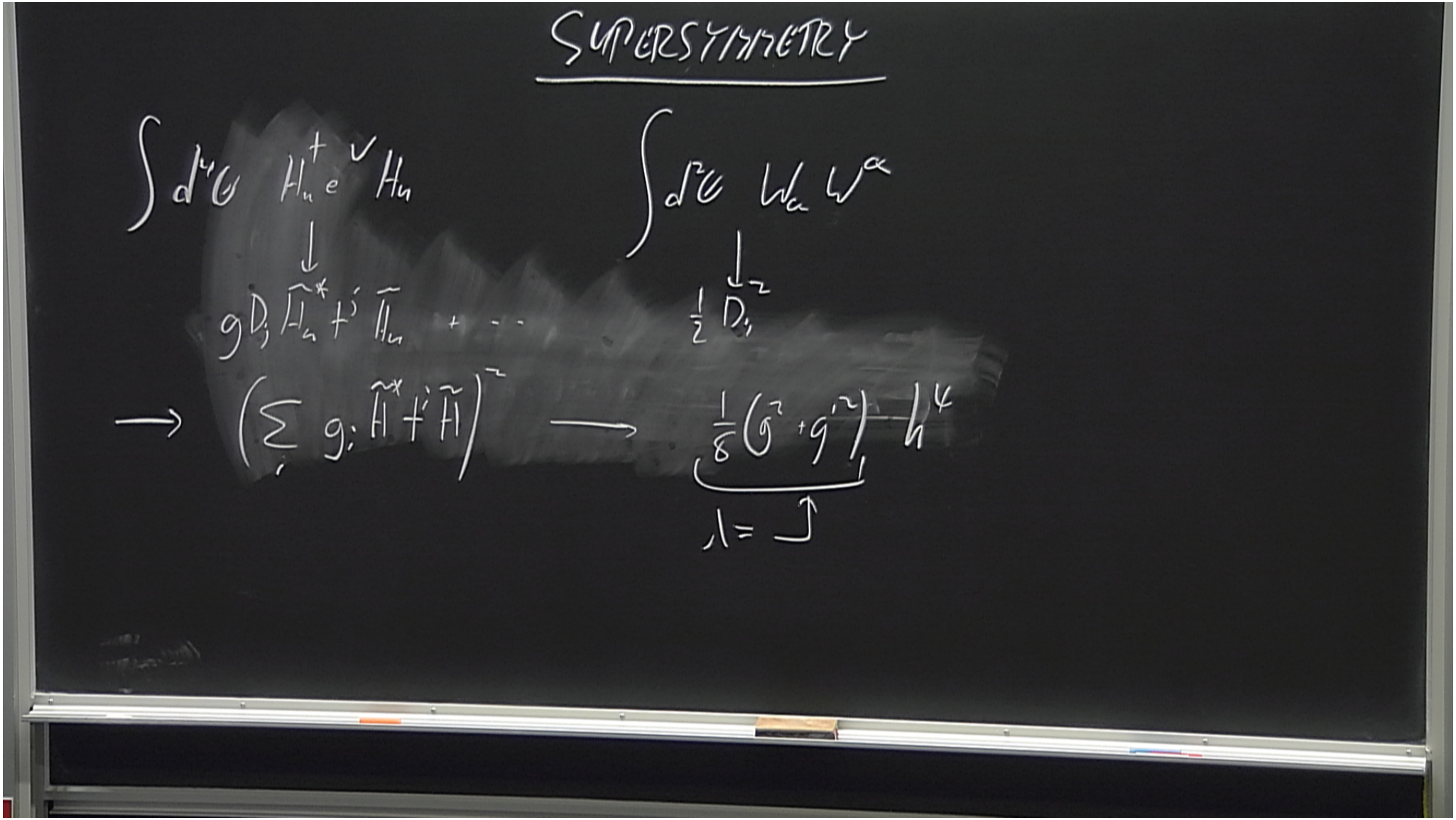
INSPIRATION

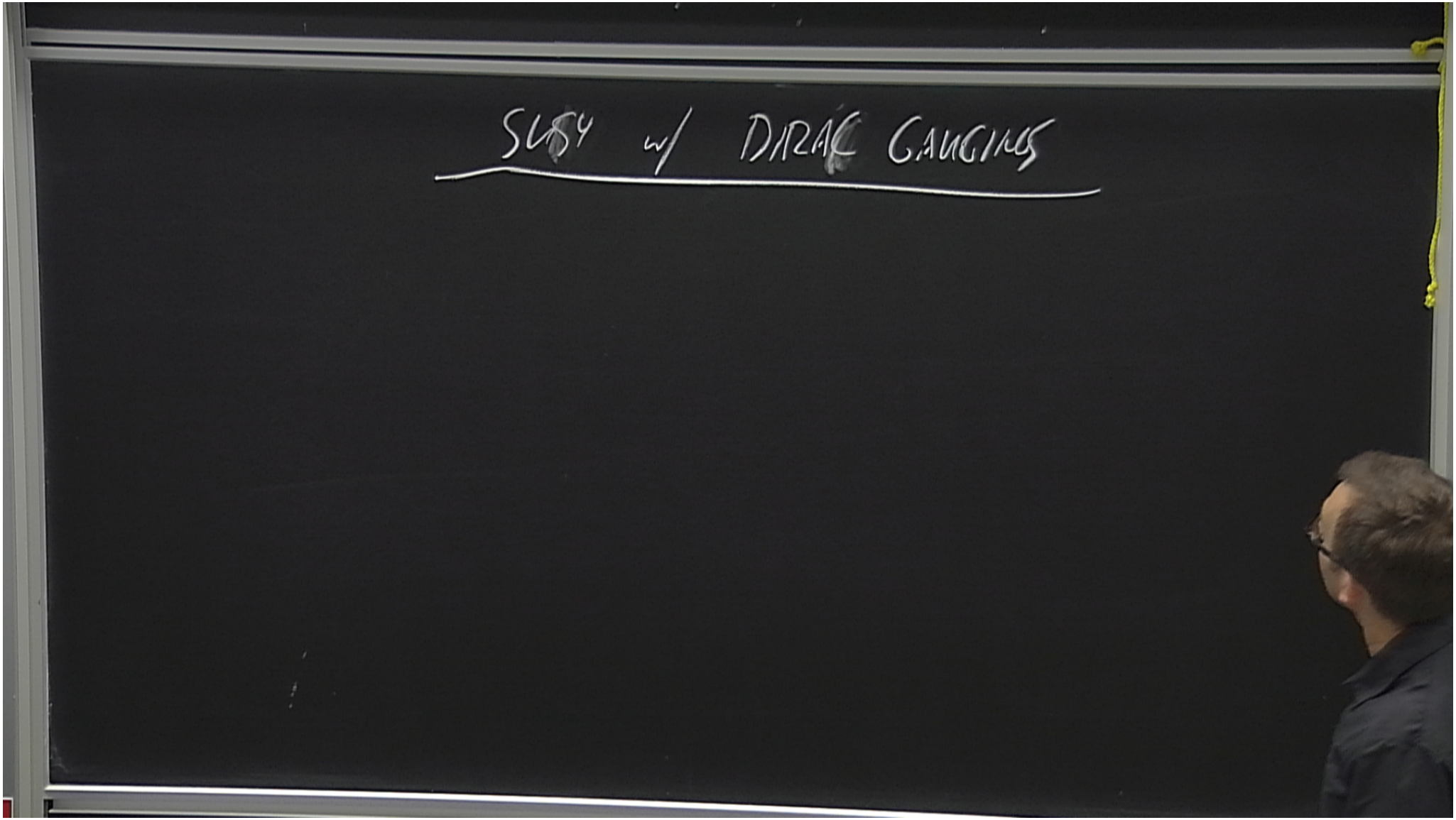
$M_H \sim 125$ GeV

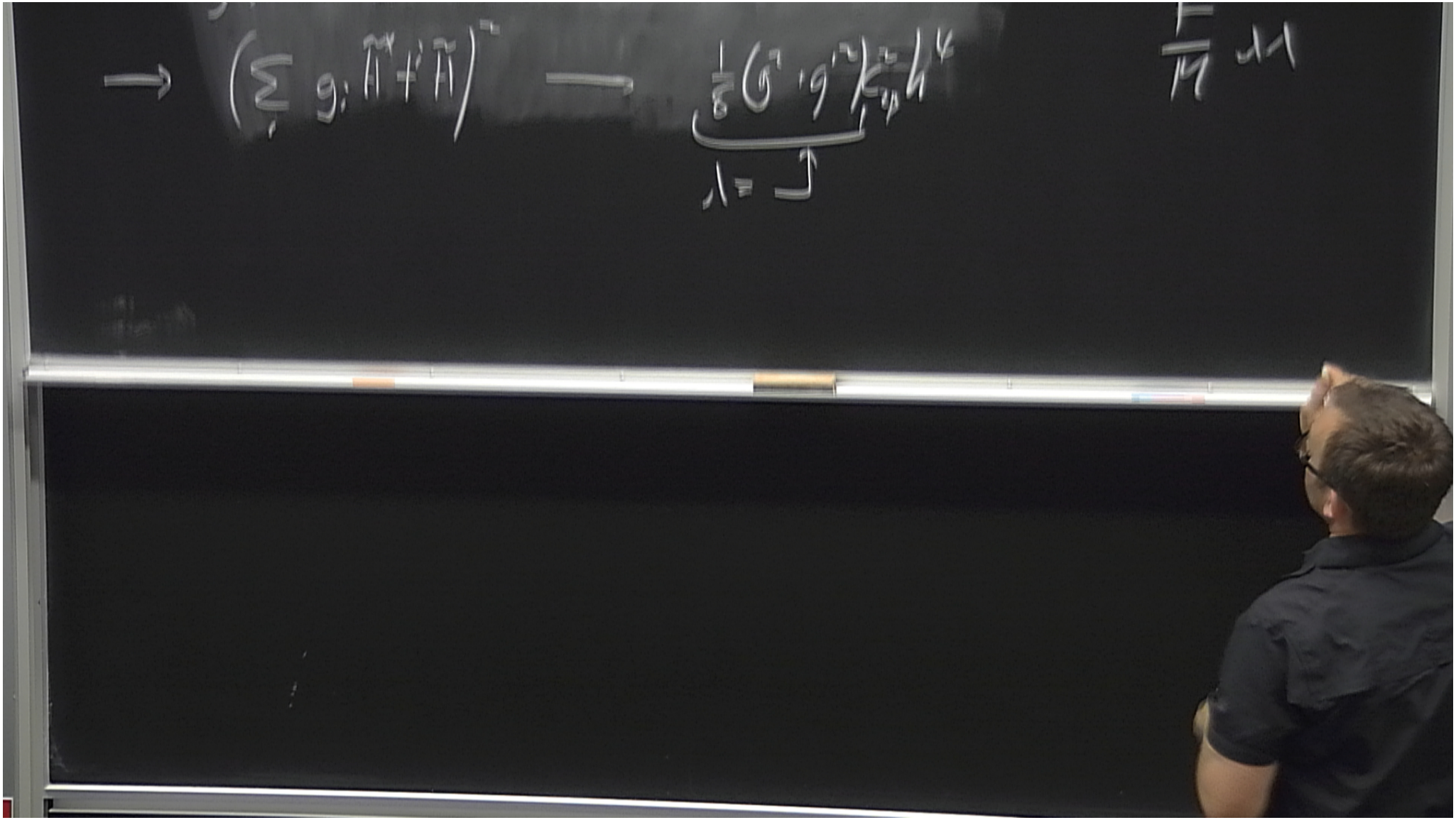
T

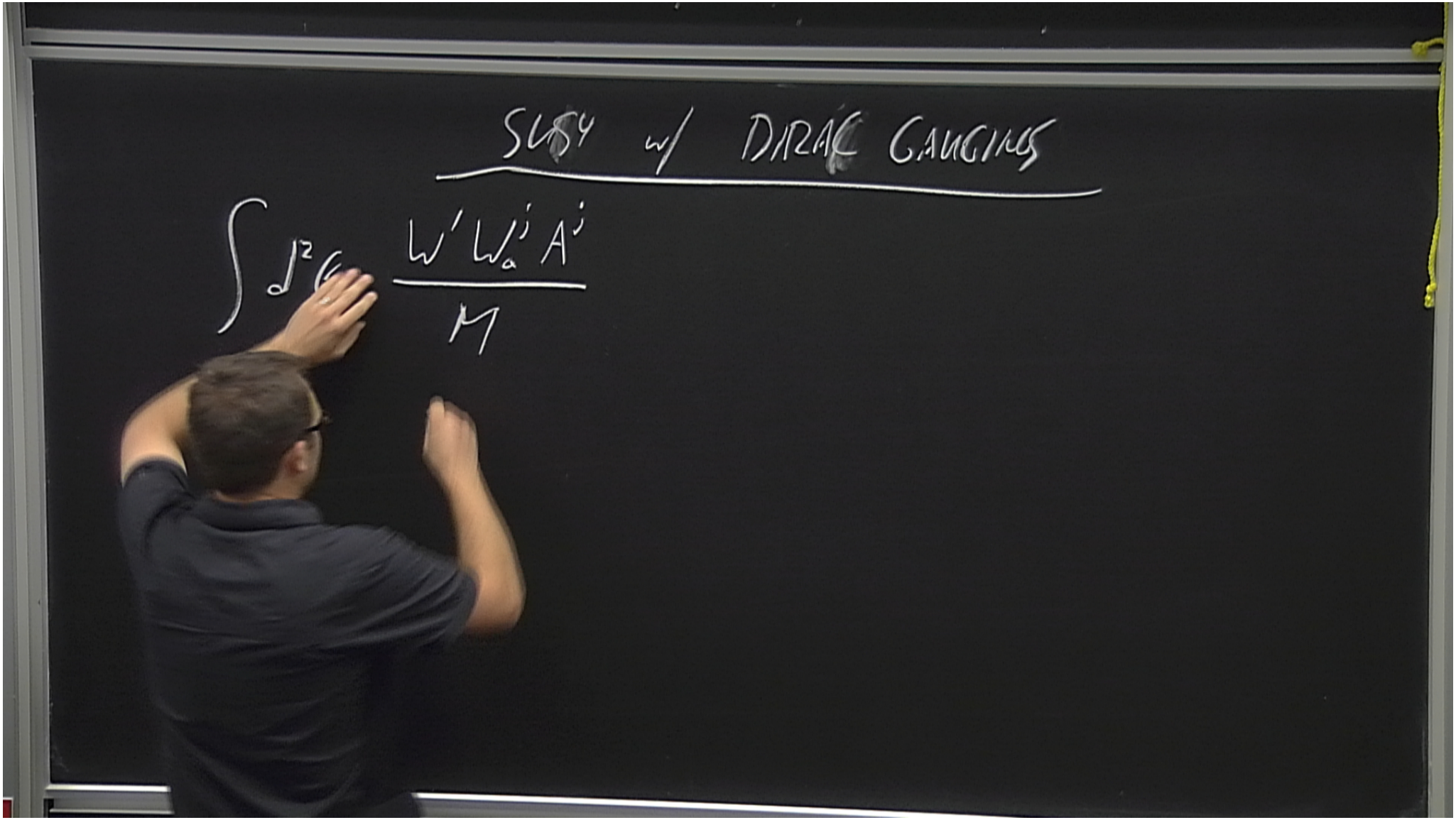

PADDY FOX (FERMILAB)
ADAM MARTIN (NOTRE DAME)
INSPIRATION
$M_H \sim 125$ GeV
λ
T
0
$V(H) = m_H^2 H^\dagger H + \frac{\lambda}{4}(H^\dagger H)^2$
$\sim 10^{9\text{-}10}$ GeV
PL


SUPERSYMMETRY
$\int d^4\theta\ H_u^\dagger e^V H_u$
$\int d^2\theta\ W_\alpha W^\alpha$
$g D_j \tilde{H}_u^* t^j \tilde{H}_u + \cdots$
$\frac{1}{2} D_i^2$
Σ


SUPERSYMMETRY
$\int d^4\theta\ H_u^\dagger e^V H_u$
$\int d^2\theta\ W_a W^a$
$g D_j \tilde{H}_u^* t^j \tilde{H}_u + \cdots$
$\frac{1}{2} D_i^2$
$\rightarrow \left(\sum_j g_j \tilde{H}^* t^j \tilde{H}\right)^2 \rightarrow \frac{1}{8}(g^2 + g'^2)\ h^4$
$\lambda = 1$


SUSY w/ DIRAC GAUGINOS




SUSY w/ DIRAC GAUGINOS
$\int d^2\theta \frac{W' W_\alpha^i A^i}{M}$

SUSY w/ DIRAC GAUGINOS

$$\int d^2\theta \, \frac{W' W_\alpha^i A^i}{M} \qquad W' = \theta D$$

$$\frac{D}{M} \lambda^4$$

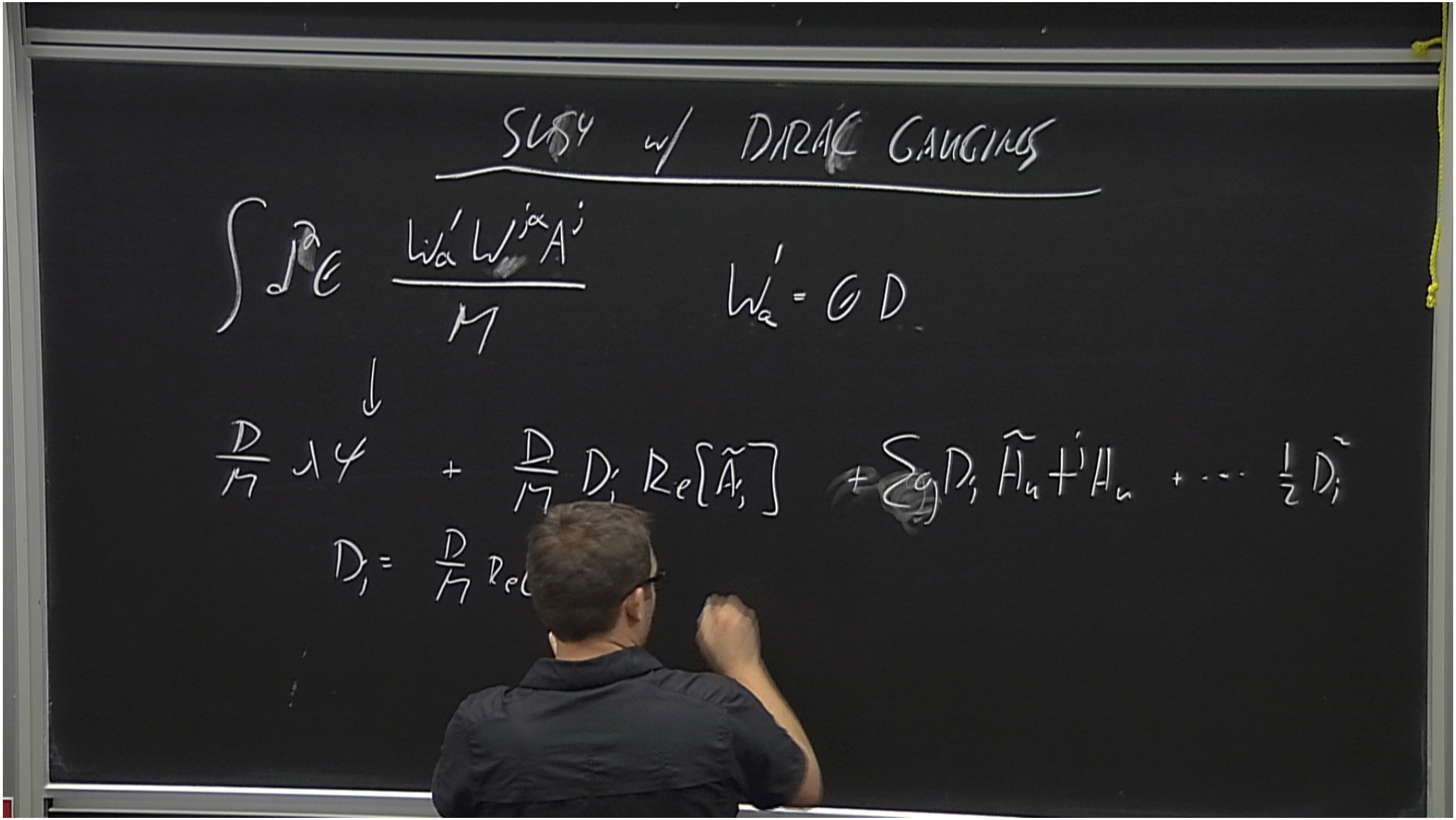
SUSY w/ DIRAC GAUGINOS

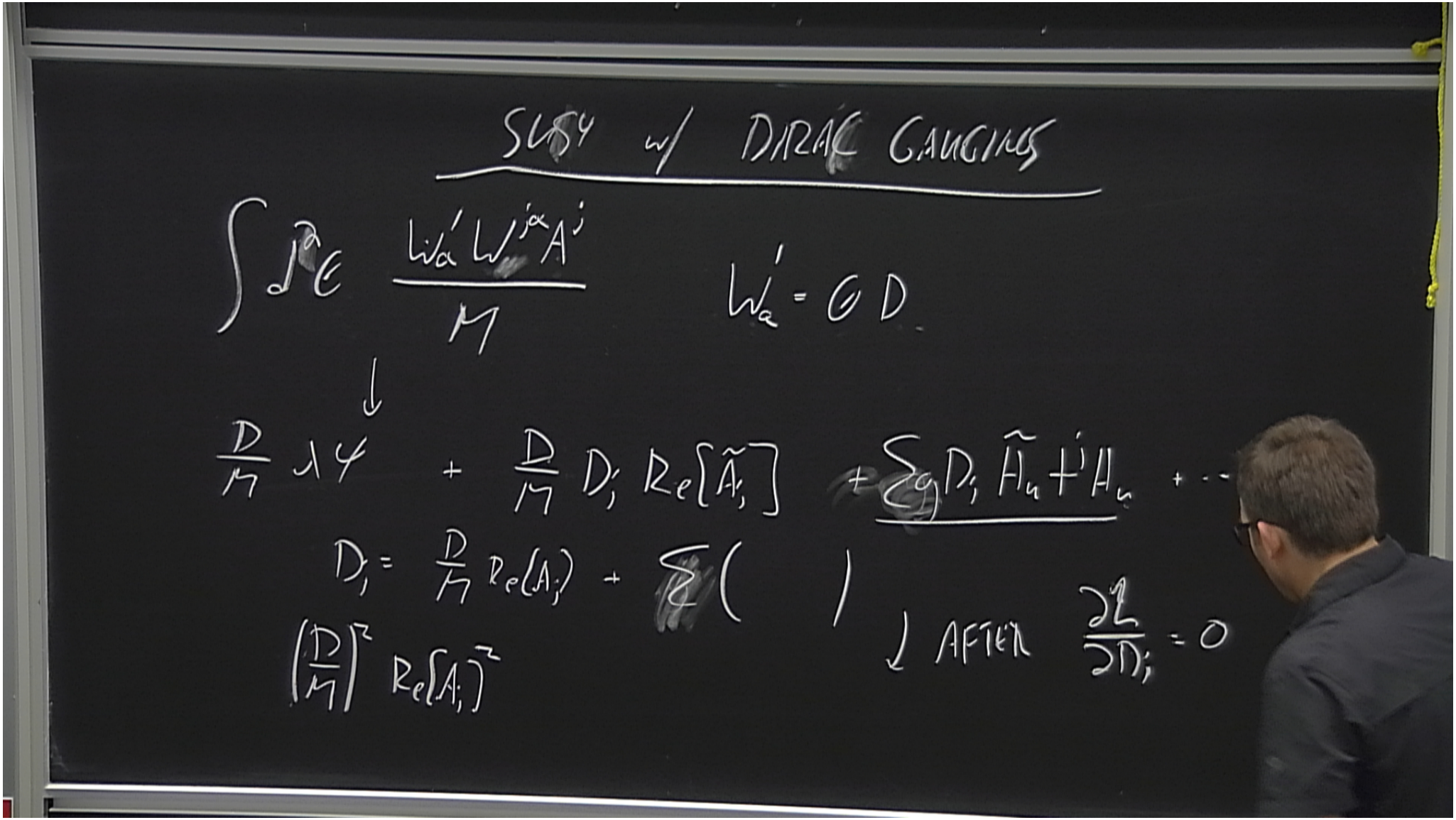
$$\int d^2\theta \, \frac{W' W_\alpha^i A^i}{M} \qquad W' = \theta D$$

$$\downarrow$$

$$\frac{D}{M}\lambda\psi + \frac{D}{M} D_i \, \mathrm{Re}[\tilde{A}_i] + \sum_q D_i \tilde{A}_u + i H_u + \cdots \frac{1}{2} D_i$$

$$D_i = \frac{D}{M} \mathrm{Re}(A_i) +$$


SUSY w/ DIRAC GAUGINOS
$\int d^2\theta \frac{W_\alpha' W'^{\alpha} A'}{M}$
$W_\alpha' = \theta D$
$\frac{D}{M}\lambda\psi + \frac{D}{M} D_i \mathrm{Re}[\tilde{A}_i] + \Sigma_q D_i \tilde{A}_u + \ldots \frac{1}{2} D_i$
$D_i = \frac{D}{M}$ Re


SUSY w/ DIRAC GAUGINOS
$\int d^2\theta \frac{W_\alpha' W'^\alpha A'}{M}$
$W_\alpha' = \theta D$
$\frac{D}{M} \lambda\psi + \frac{D}{M} D_i \mathrm{Re}[\tilde{A}_i] + \sum_q D_i \tilde{A}_u + i H_u + \cdots$
$D_i = \frac{D}{M} \mathrm{Re}(A_i) + \sum_q (\quad)$
$\left(\frac{D}{M}\right)^2 \mathrm{Re}[A_i]^2$
AFTER $\frac{\partial \mathcal{L}}{\partial D_i} = 0$

SUSY w/ DIRAC GAUGINOS

$$\int d^2\theta \; \frac{W_\alpha' W'^{\alpha} A^i}{M} \qquad W_\alpha' = \theta D$$

$$\downarrow$$

$$\frac{D}{M}\lambda\psi + \frac{D}{M} D_i \, \mathrm{Re}[\tilde{A}_i] + \sum_q D_i \tilde{A}_u + i H_u + \cdots \frac{1}{2} D_i$$

$$D_i = \frac{D}{M}\mathrm{Re}(A_i) + \Sigma(\quad)$$

$$\left(\frac{D}{M}\right)^2 \mathrm{Re}[A_i]^2 + \frac{D}{M}\Sigma(\quad) + \cdots \Sigma(\quad)^2$$

↓ AFTER $\frac{\partial \mathcal{L}}{\partial D_i} = 0$

SUSY w/ DIRAC GAUGINOS

$$\int d^2\theta \, \frac{W_\alpha' W'^{\alpha} A^i}{M} \qquad W_\alpha' = \theta D$$

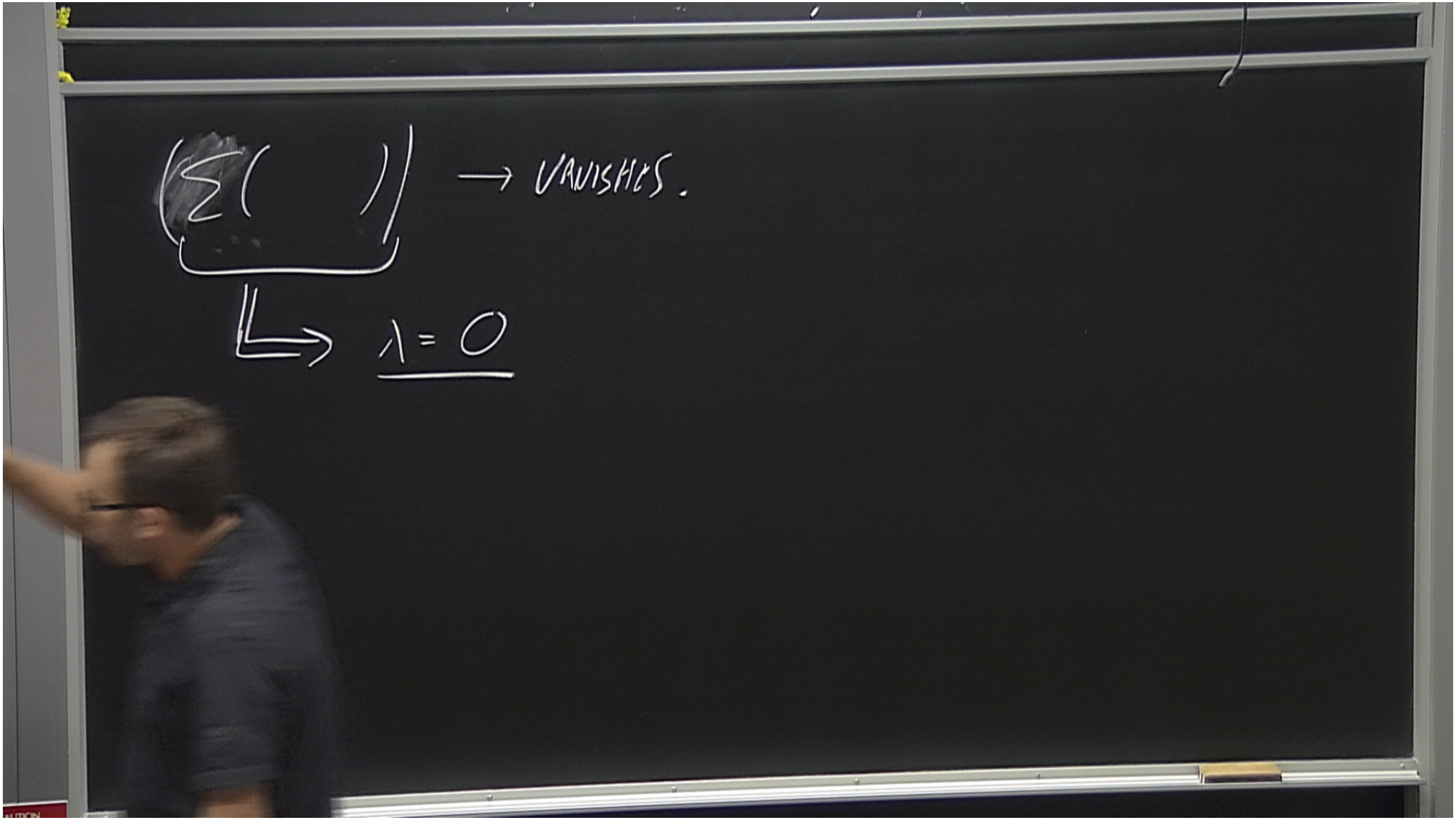
$$\downarrow$$

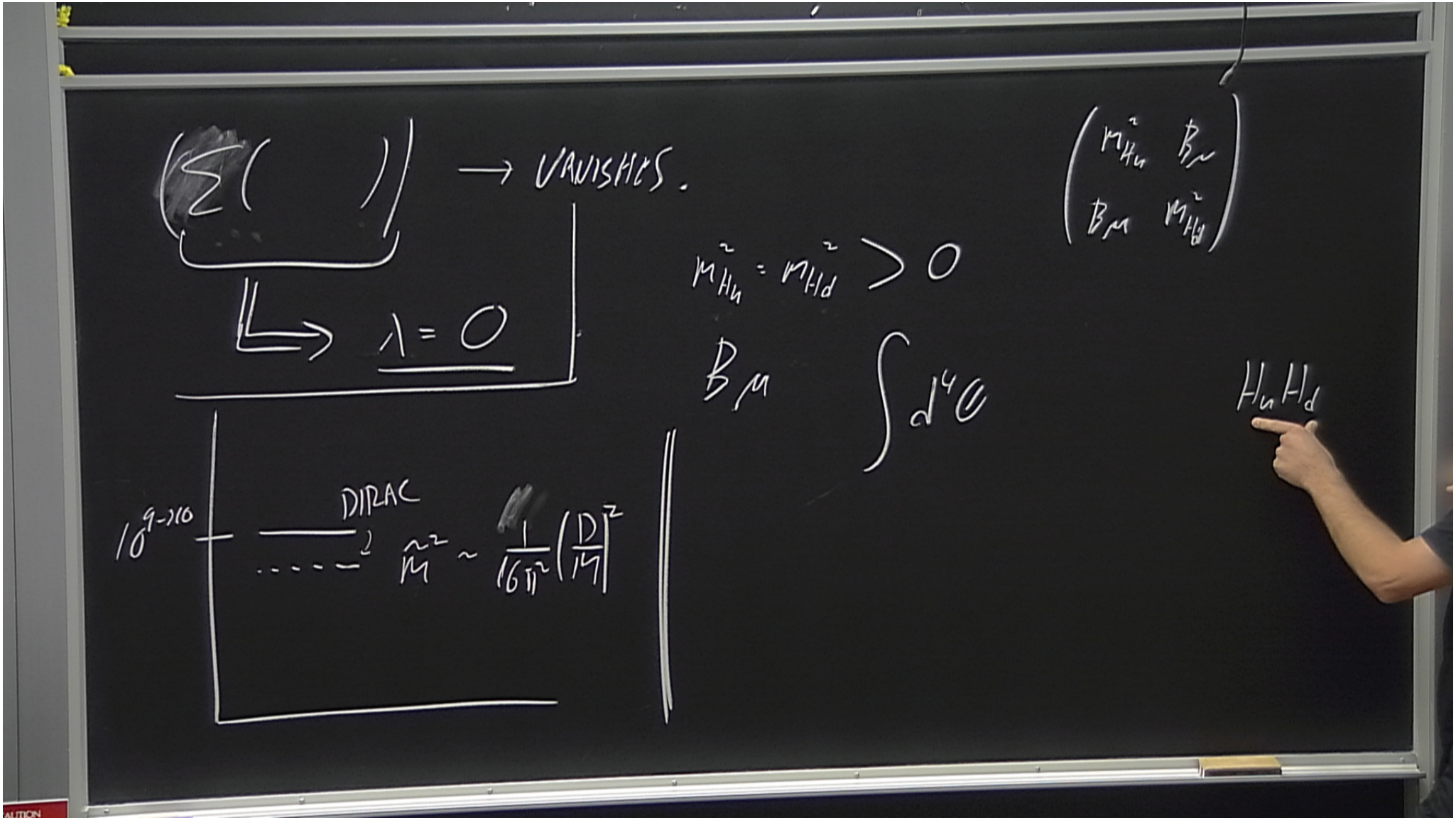
$$\frac{D}{M}\lambda\psi + \frac{D}{M} D_i \, \mathrm{Re}[\tilde{A}_i] + \sum_q D_i \tilde{A}_u + i H_u + \cdots \frac{1}{2} D_i$$

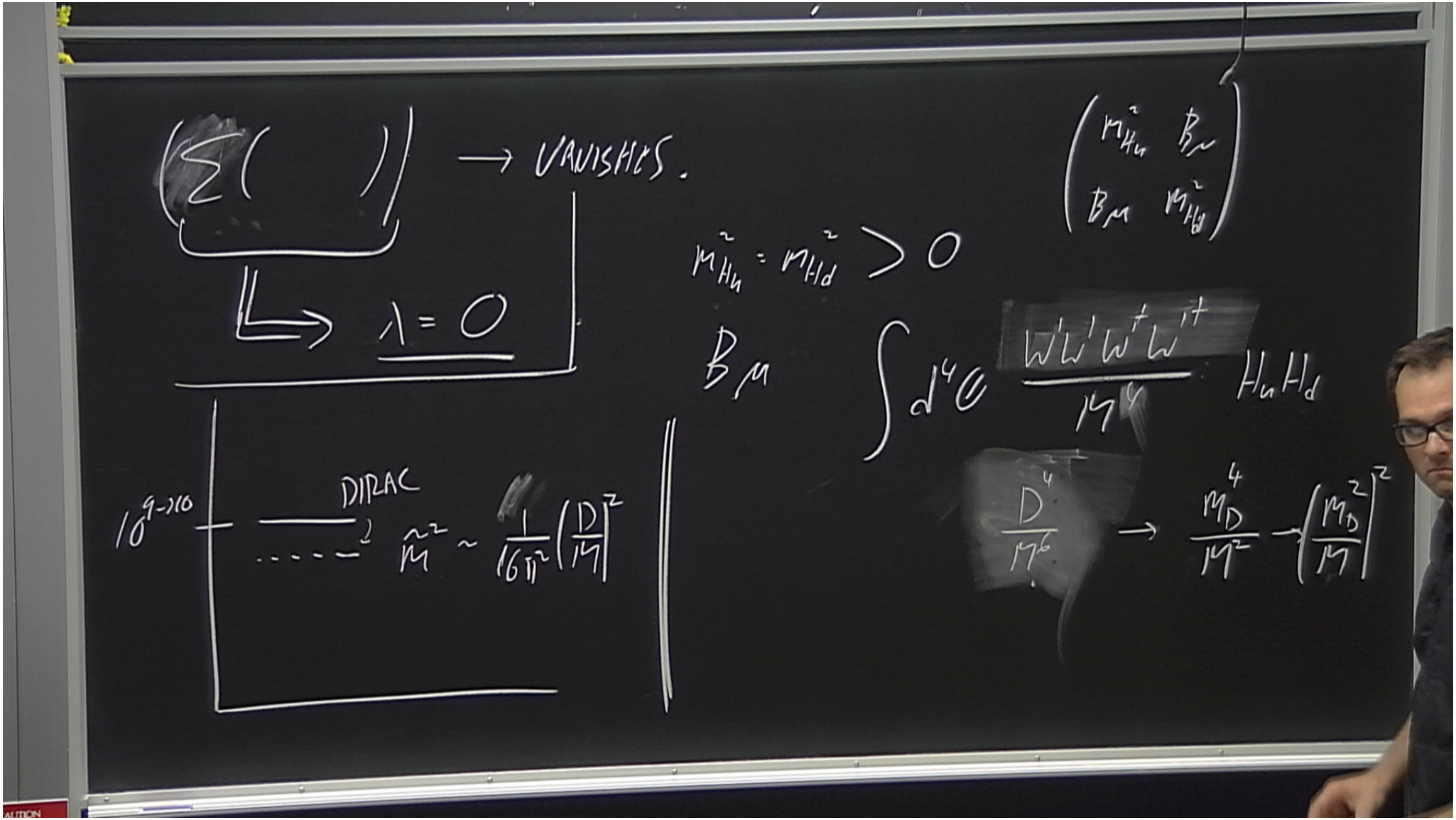
$$D_i = \frac{D}{M}\mathrm{Re}(A_i) + \Sigma(\quad)$$

$$\left(\frac{D}{M}\right)^2 \mathrm{Re}[A_i]^2 + \frac{D}{M}\Sigma(\quad) + \cdots \Sigma \, \Gamma^2$$

$$\downarrow \text{AFTER } \frac{\partial \mathcal{L}}{\partial D_i} = 0$$


$\Sigma(\quad)$ → VANISHES.
↳ $\lambda = 0$


$\Sigma(\ \ ) \to$ VANISHES.
$\hookrightarrow \lambda = 0$
$m_{H_u}^2 = m_{H_d}^2 > 0$
$\begin{pmatrix} m_{H_u}^2 & B_\mu \\ B_\mu & m_{H_d}^2 \end{pmatrix}$
$B_\mu \int d^4\theta$
$H_u H_d$
10^{9-16}
DIRAC
$\tilde{m}^2 \sim \frac{1}{16\pi^2}\left(\frac{D}{M}\right)^2$


$\Sigma(\quad) \to$ VANISHES.
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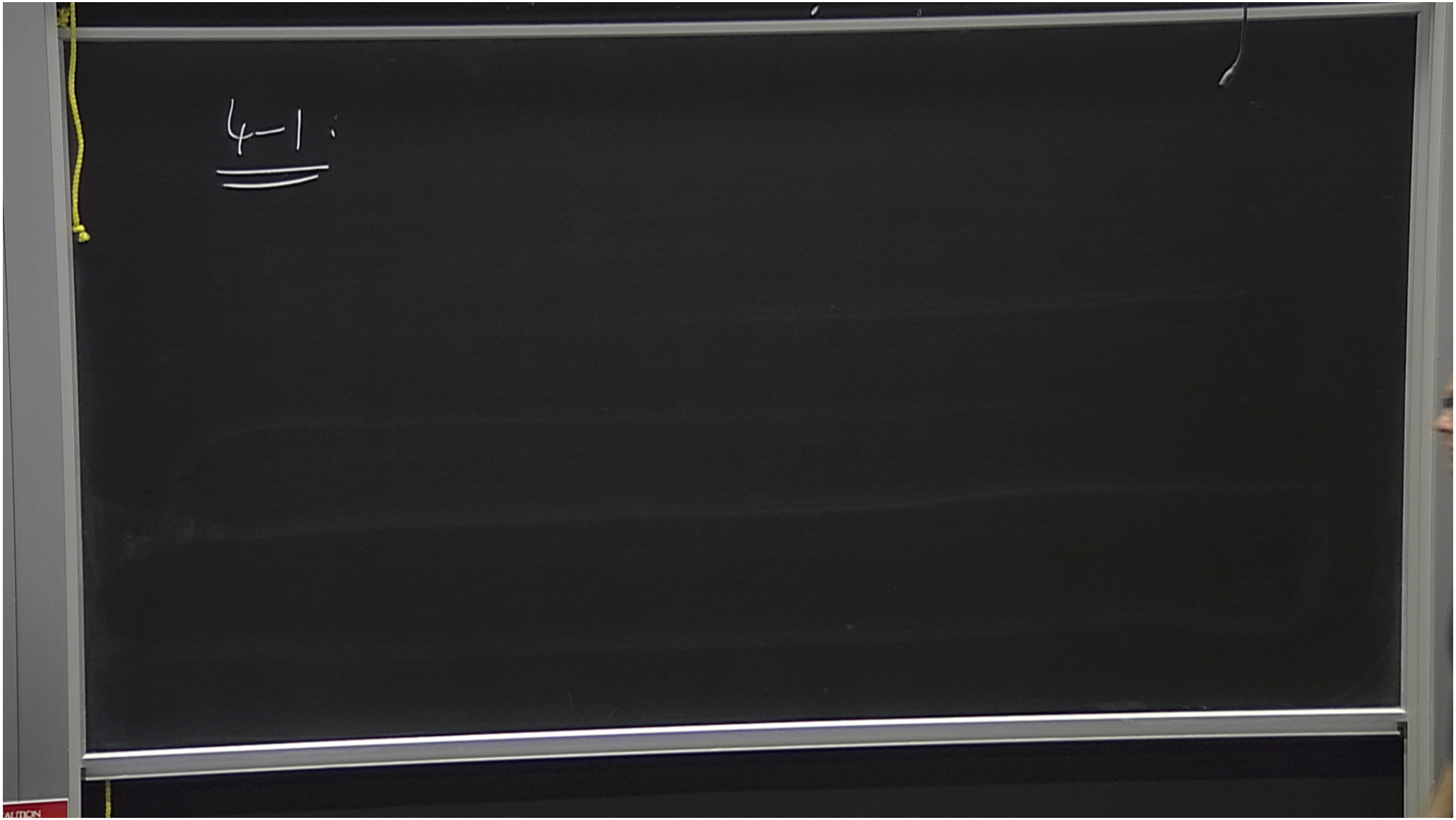
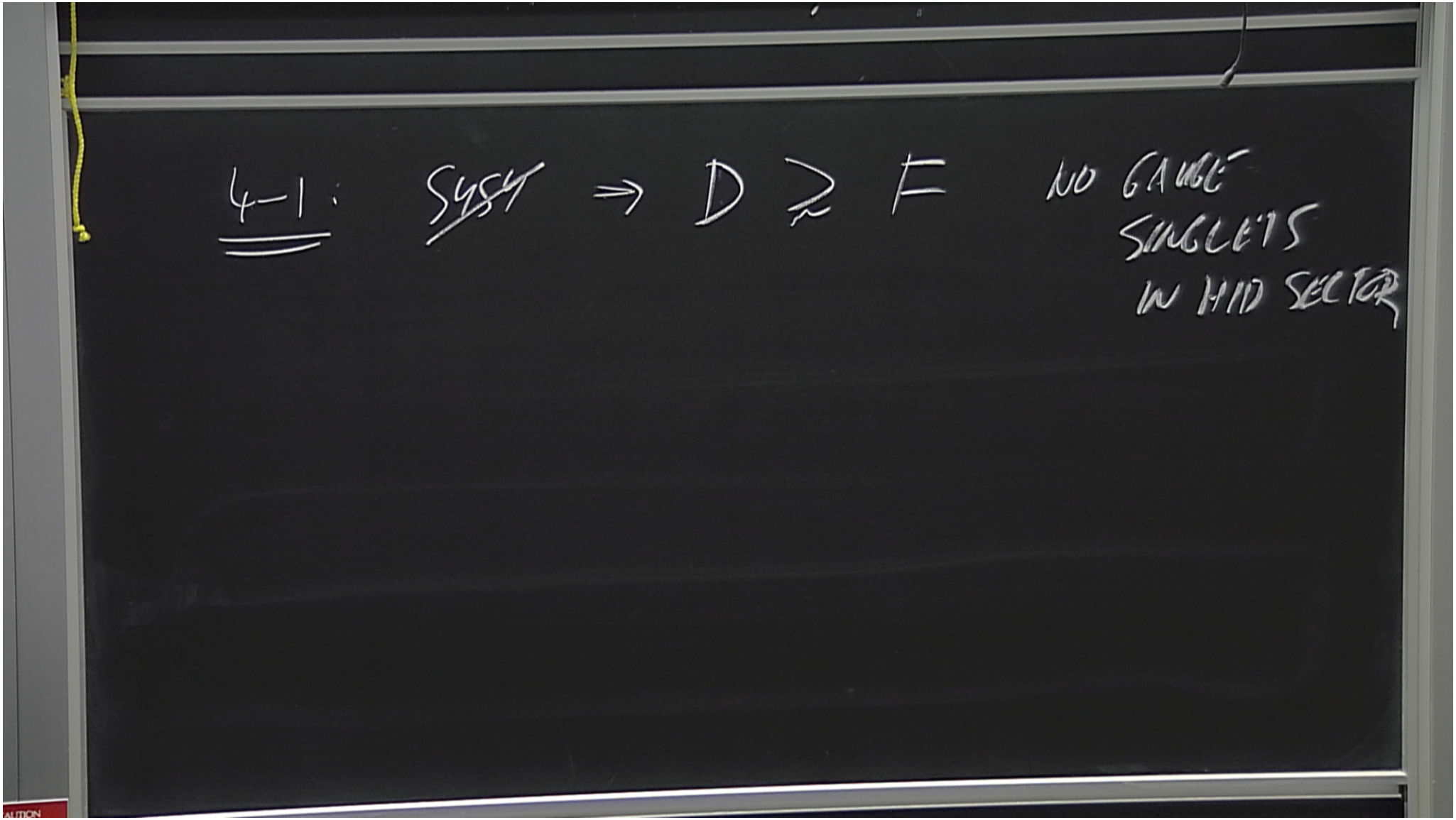
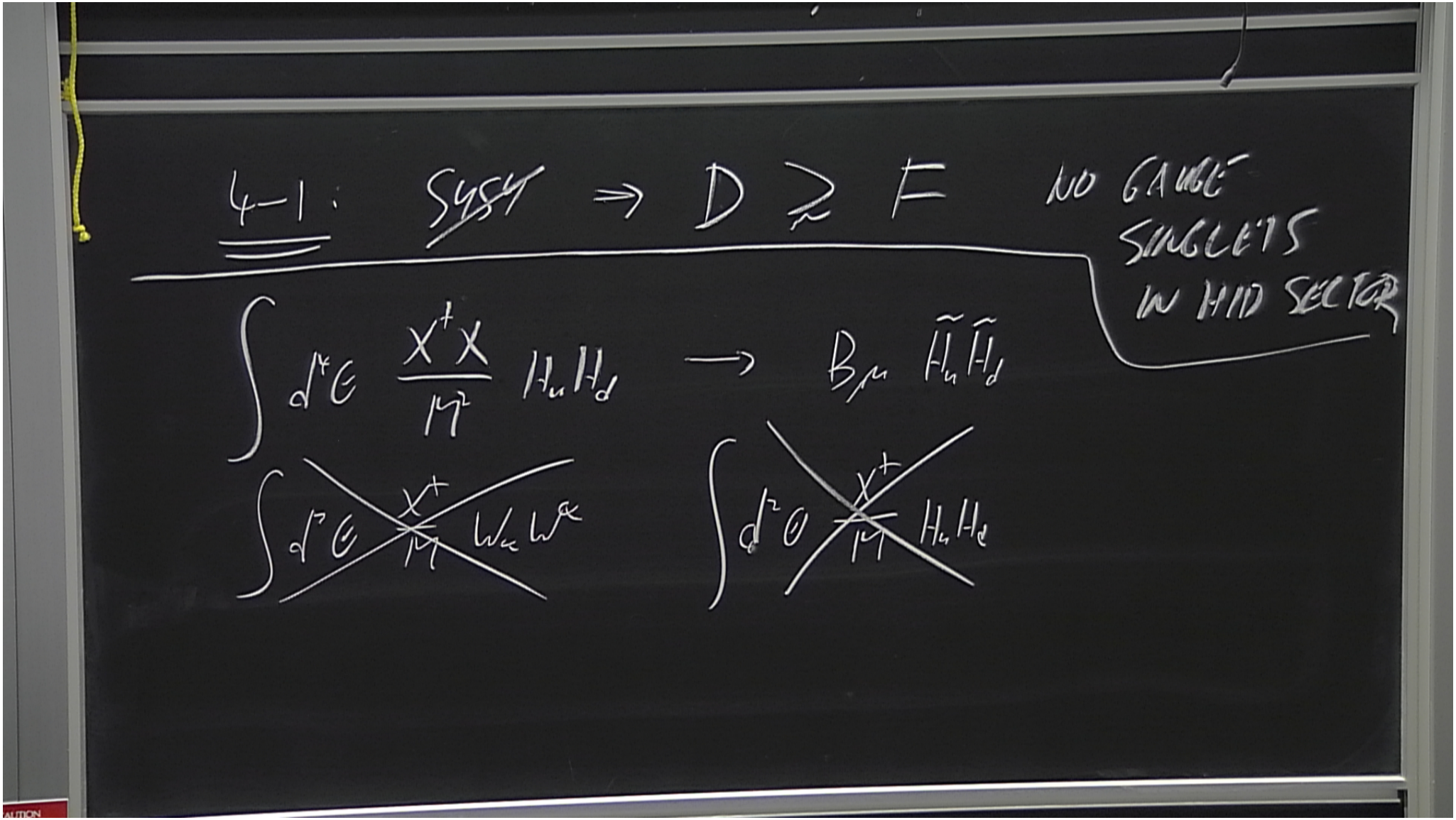
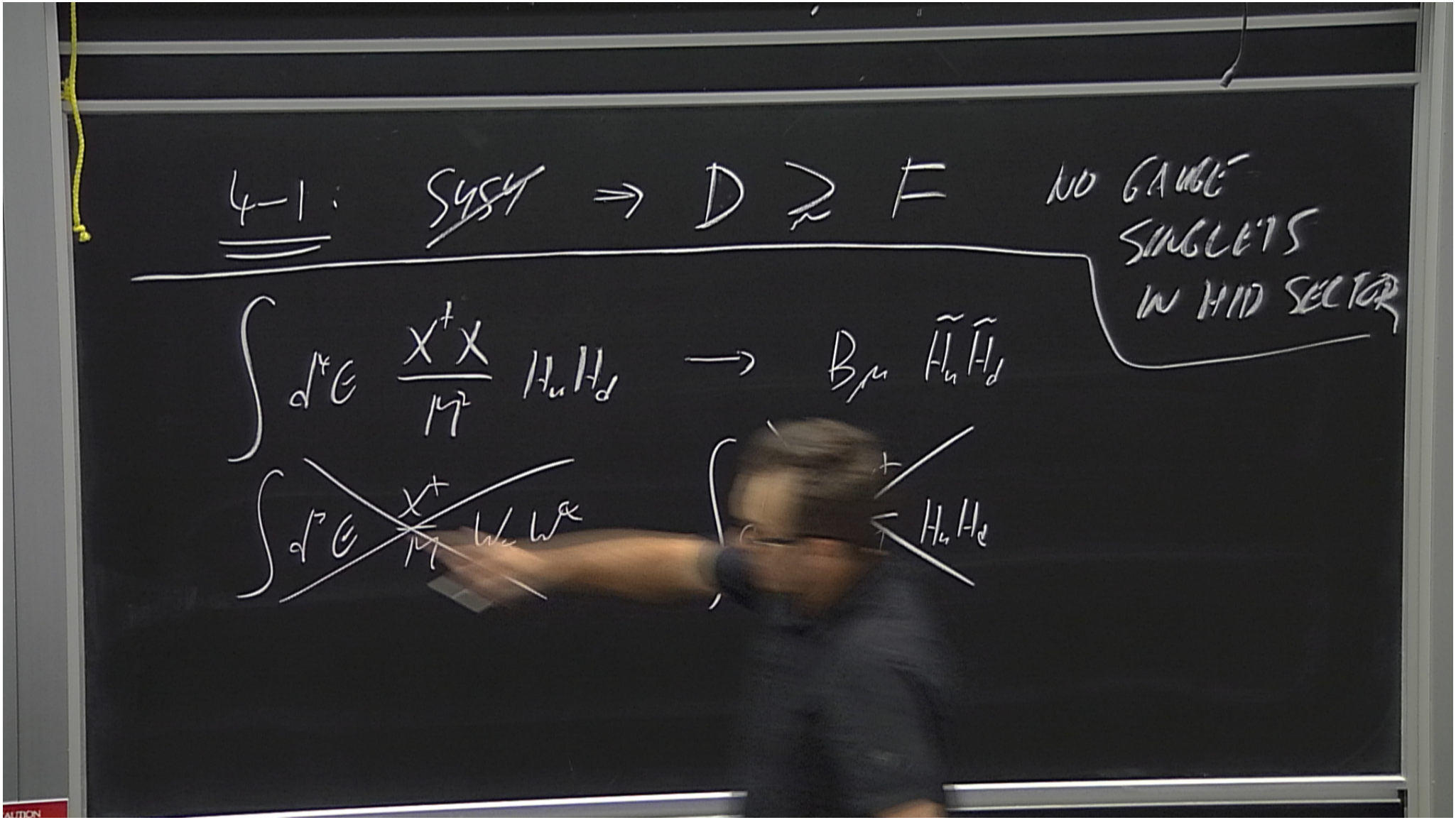
$m_{H_u}^2 = m_{H_d}^2 > 0$
$\begin{pmatrix} m_{H_u}^2 & B_\mu \\ B_\mu & m_{H_d}^2 \end{pmatrix}$
$B_\mu \int d^4\theta \frac{W_\alpha W^\alpha W^\dagger W^\dagger}{\Lambda^6} H_u H_d$
10^{9-16} + DIRAC $\hat{m}^2 \sim \frac{1}{16\pi^2}\left(\frac{D}{\Lambda}\right)^2$
$\frac{D^4}{\Lambda^6} \to \frac{m_D^4}{\Lambda^2} \to \left(\frac{m_D^2}{\Lambda}\right)^2$


4-1:


4-1: SUSY ⇒ D ≥ F
NO GAUGE SINGLETS IN HID SECTOR


4-1: SUSY ⇒ D ≳ F
NO GAUGE SINGLETS IN HID SECTOR
$\int d^4\theta \frac{X^\dagger X}{M^2} H_u H_d \rightarrow B_\mu \tilde{H}_u \tilde{H}_d$
$\int d^2\theta \frac{X}{M} W_\alpha W^\alpha$
$\int d^2\theta \frac{X}{M} H_u H_d$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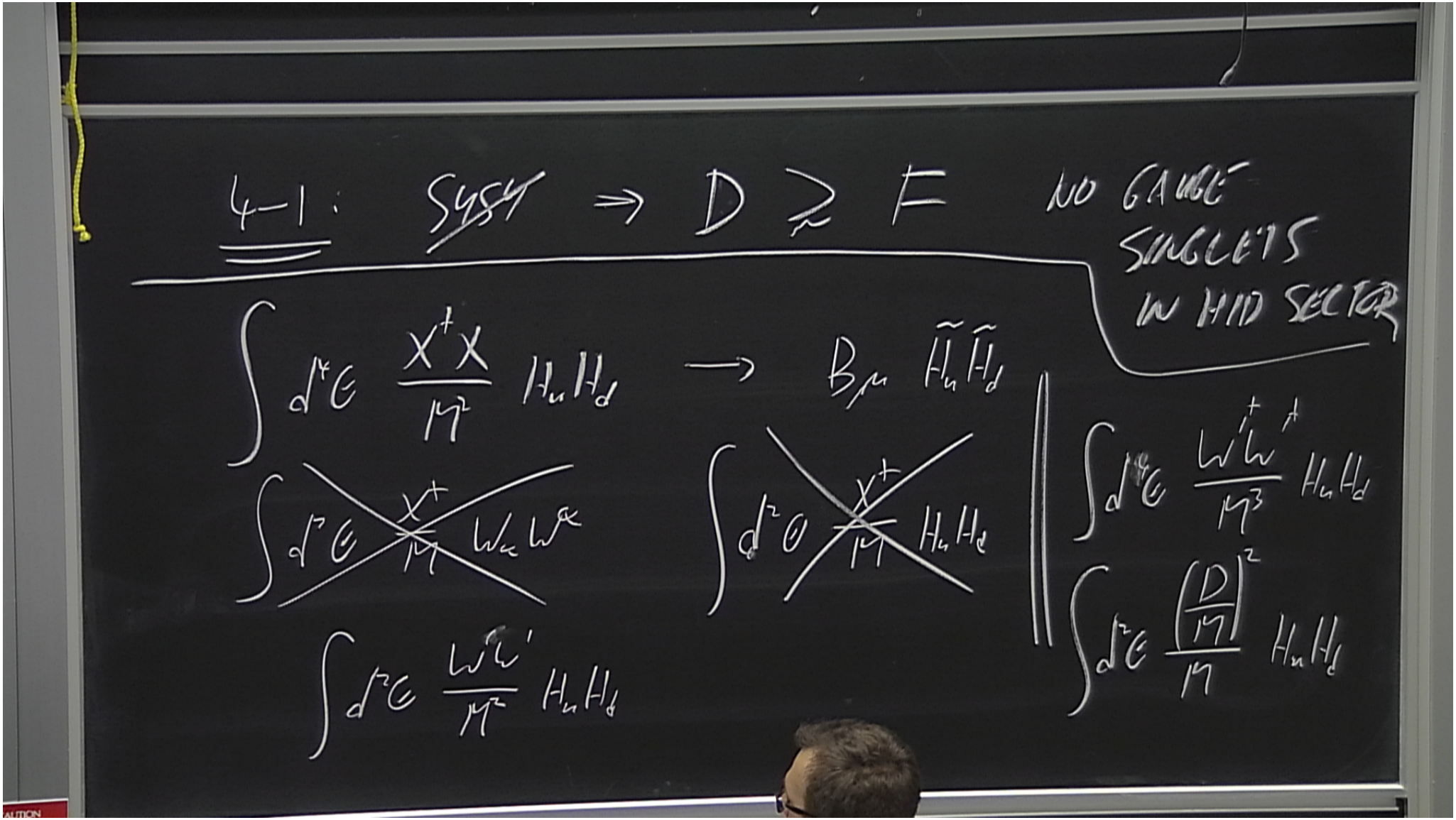
$\int d^4\theta \frac{X^\dagger X}{M^2} H_u H_d \rightarrow B_\mu \tilde{H}_u \tilde{H}_d$
$\int d^2\theta \frac{X}{M} W_\alpha W^\alpha$
$\int H_u H_d$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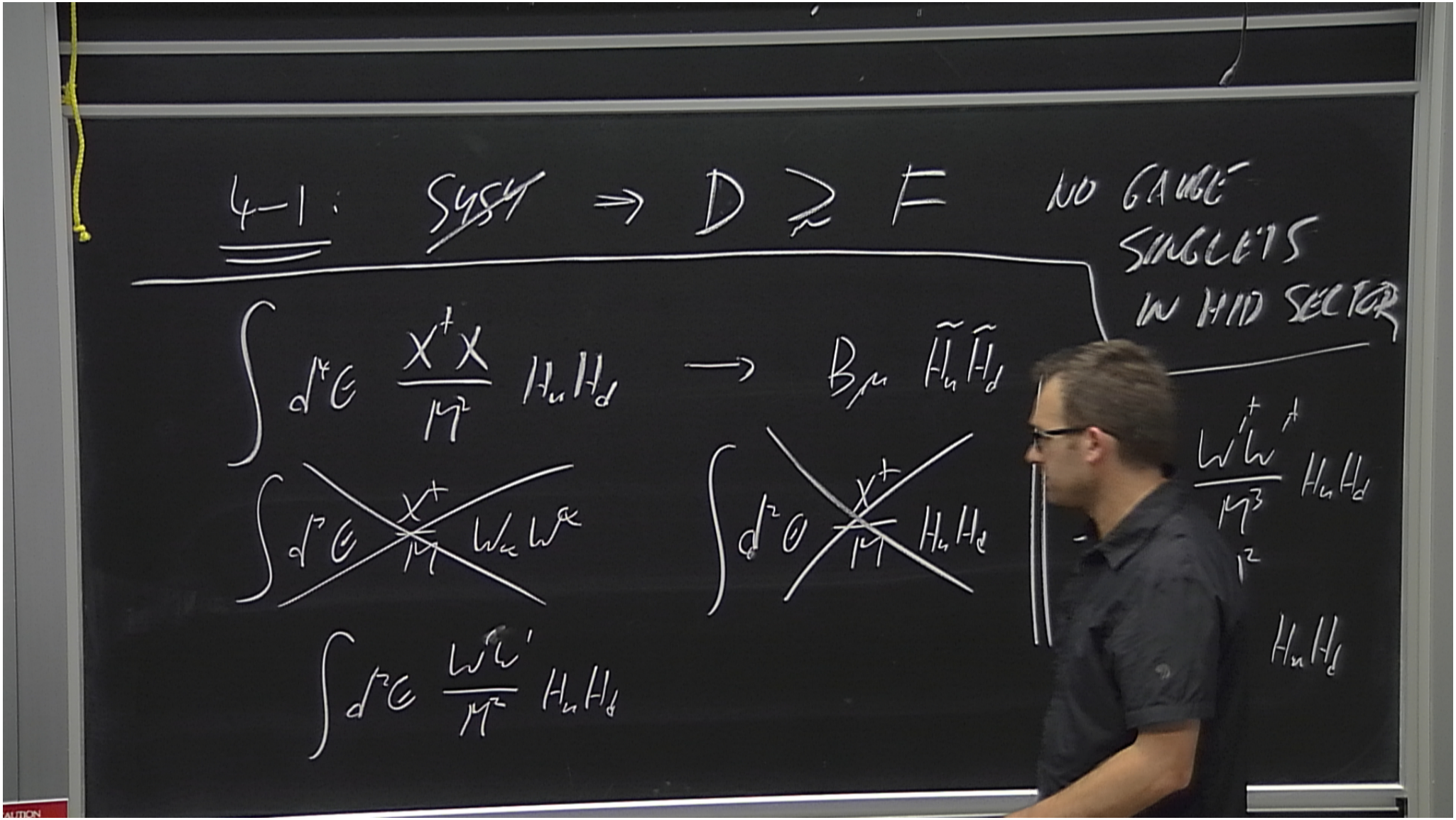
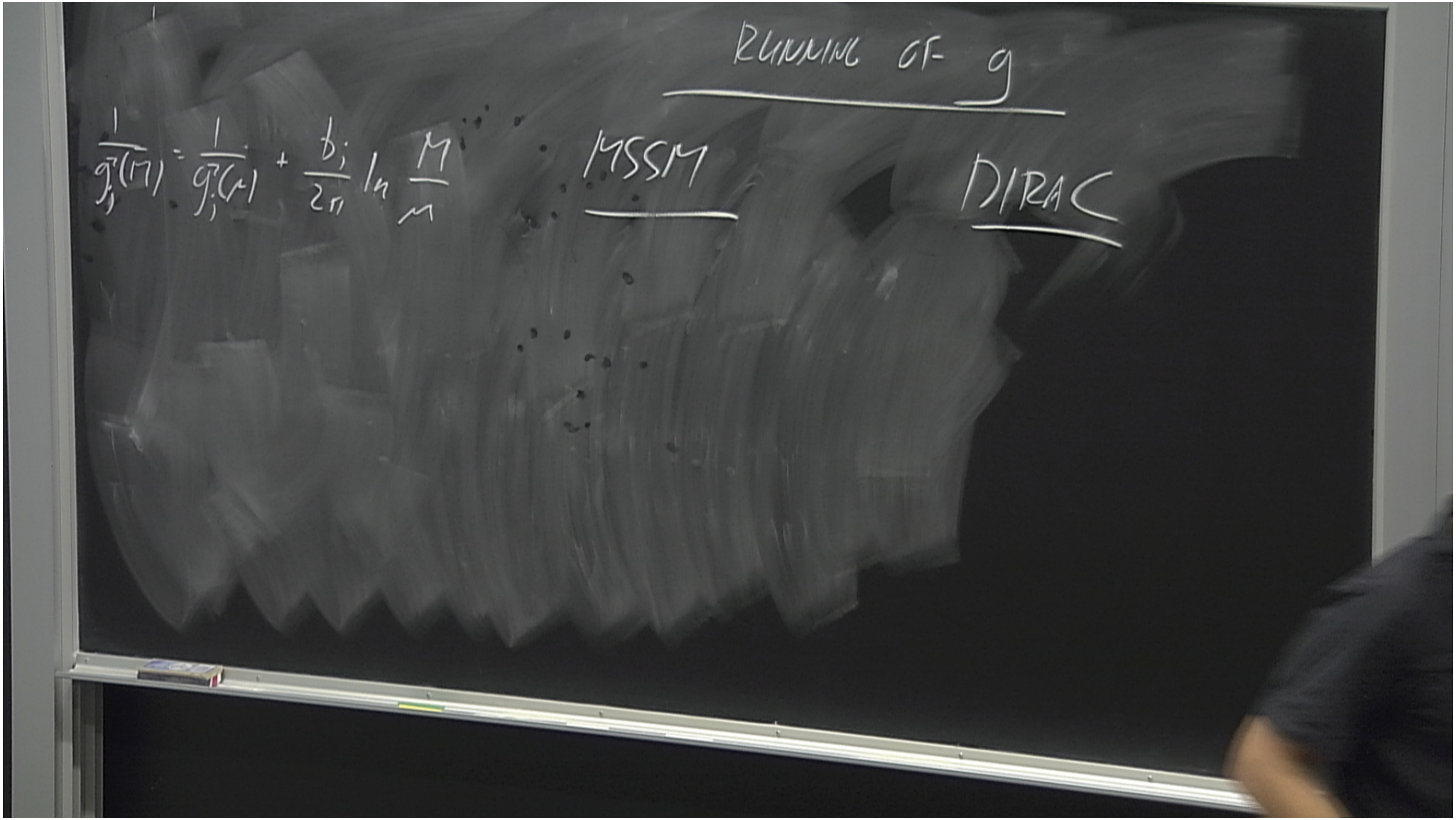
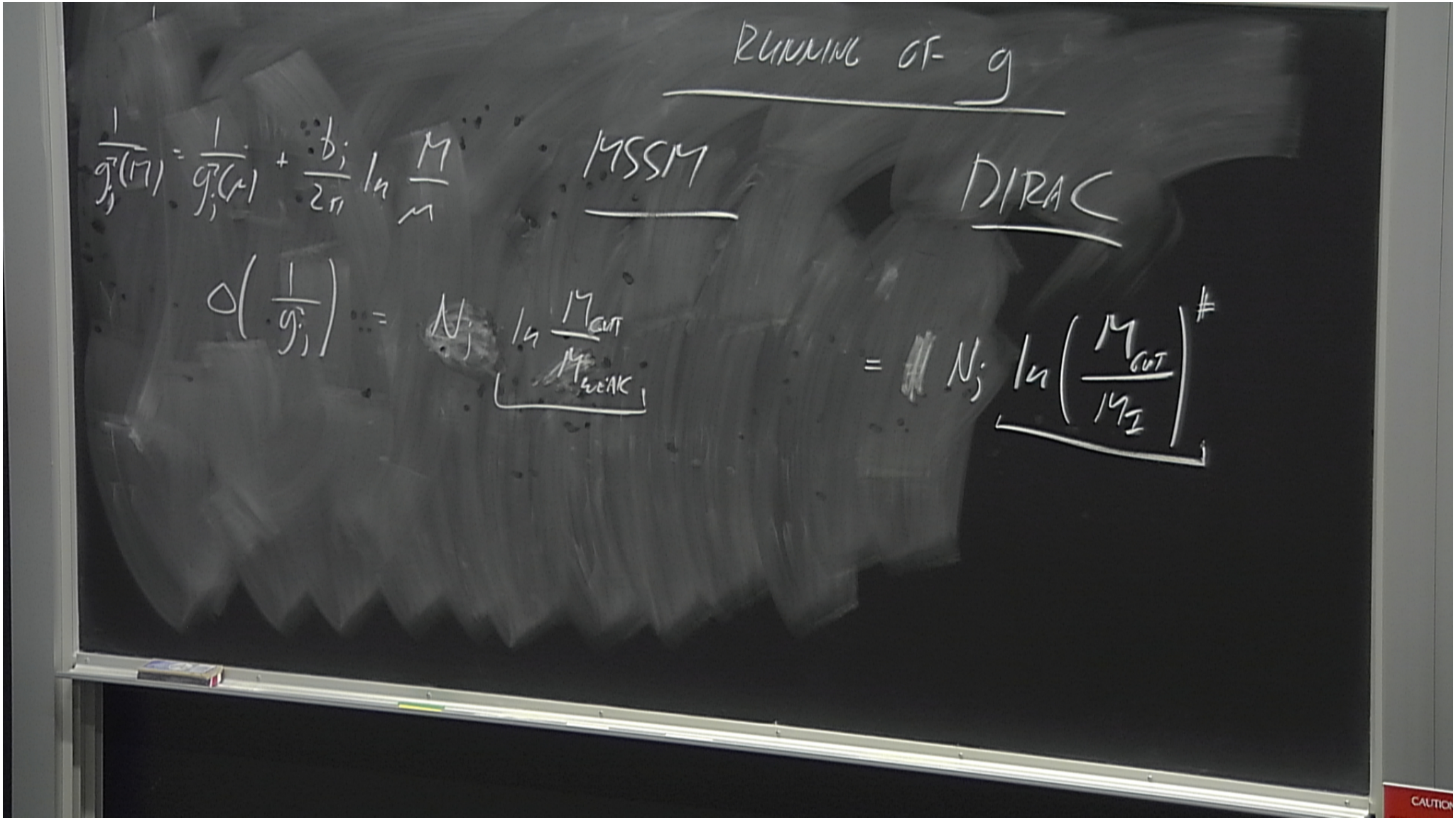
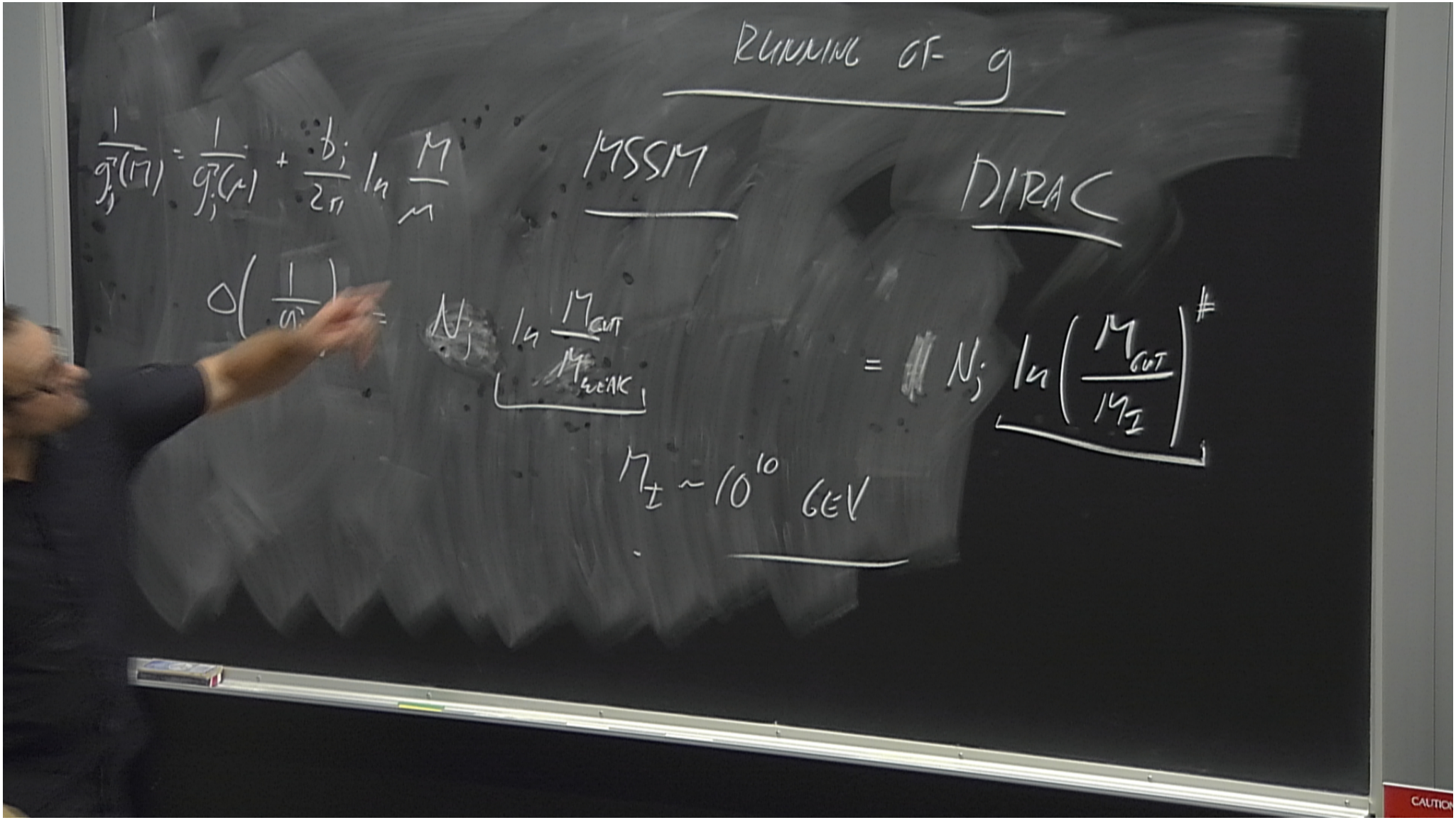
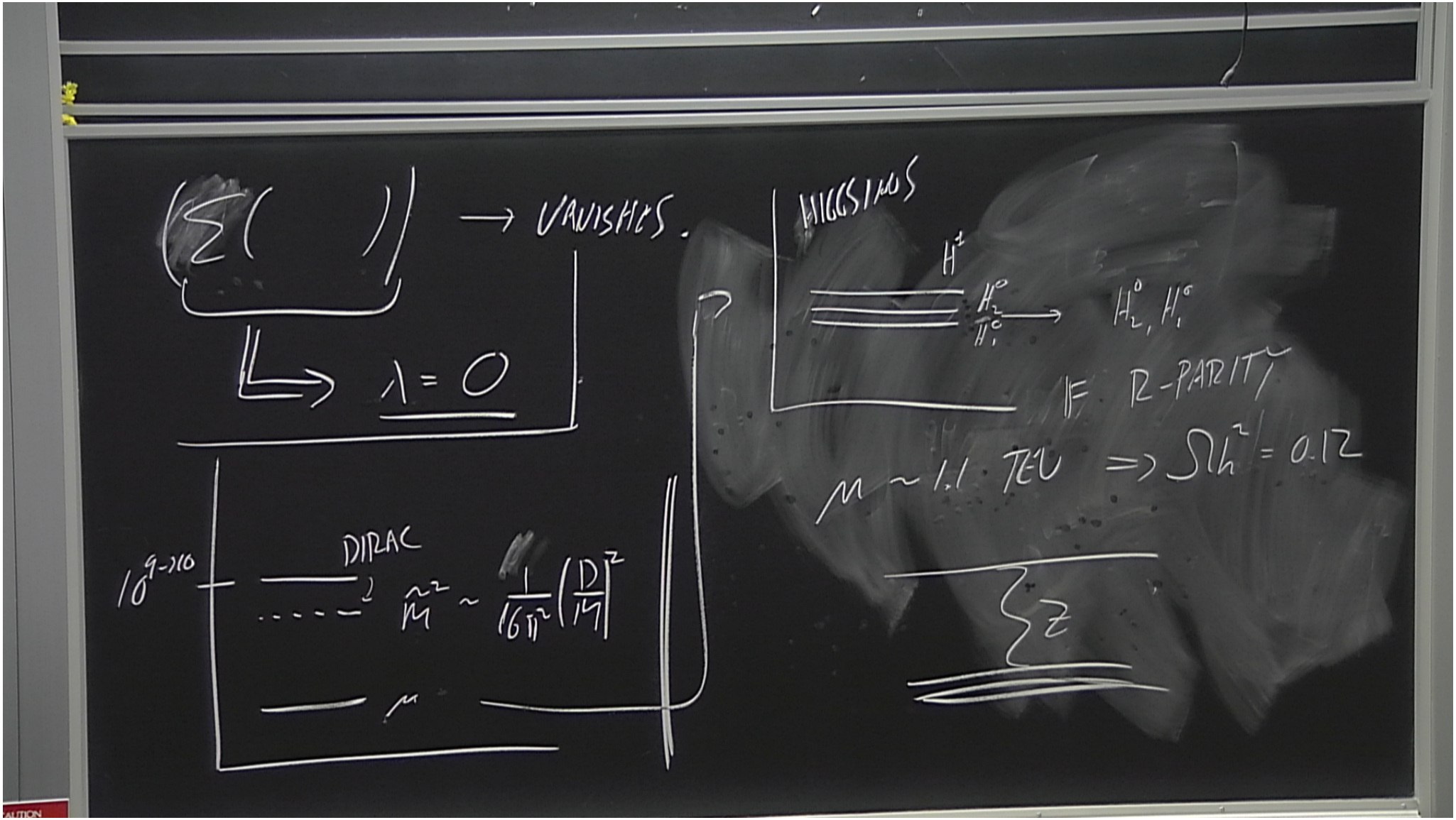
$\int d^2\theta \frac{X}{M} W_\alpha W^\alpha$
$\int d^2\theta \frac{X}{M} H_u H_d$
$\int d^2\theta \frac{W W'}{M^2} H_u H_d$
$\int d^4\theta \frac{W^\dagger W}{M^3} H_u H_d$
$\int d^2\theta \frac{(D)^2}{M} H_u H_d$

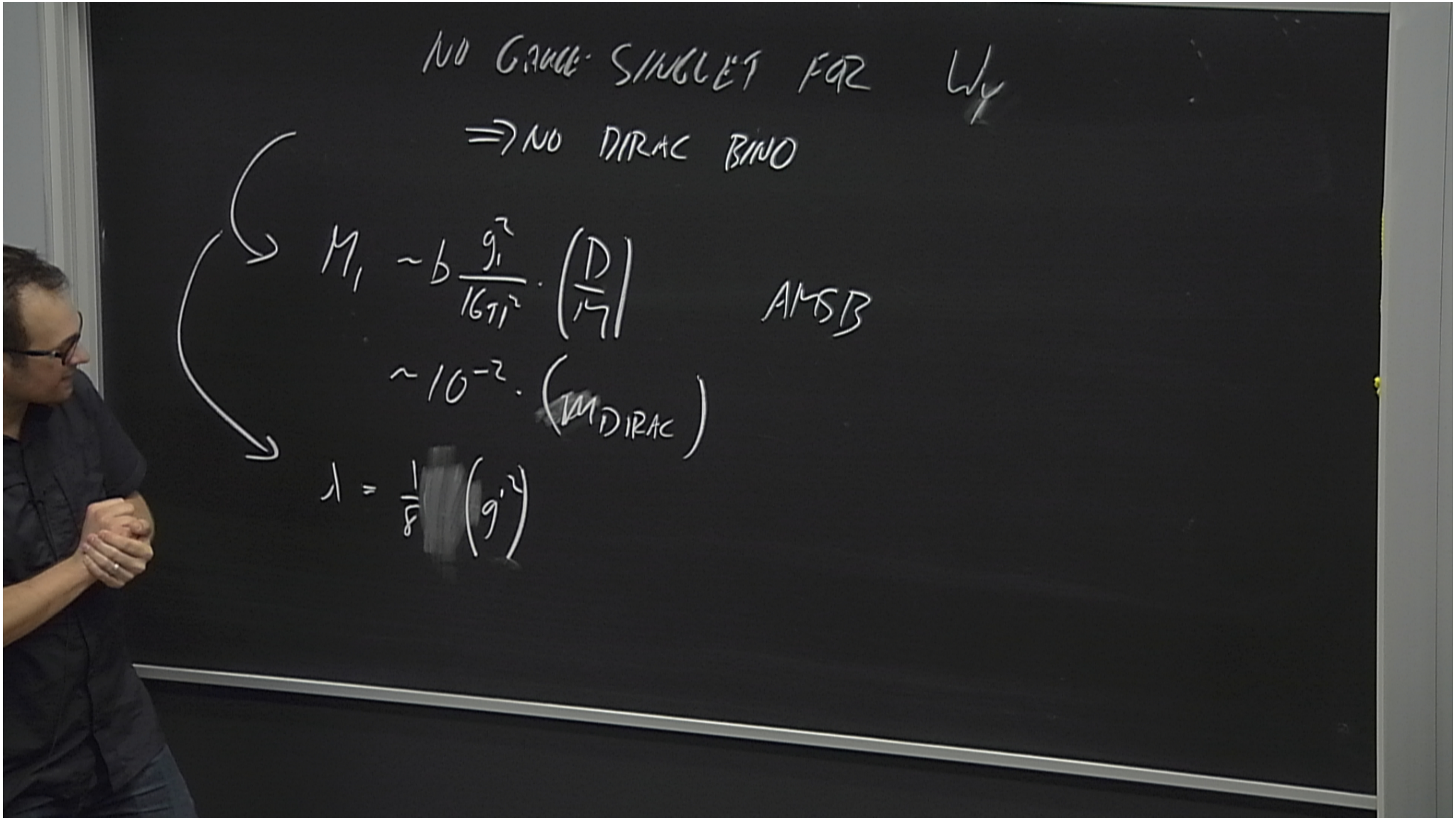

4-1: SUSY ⇒ D ≥ F
NO GAUGE SINGLETS IN HID SECTOR
$\int d^4\theta \frac{X^\dagger X}{M^2} H_u H_d \rightarrow B_\mu \tilde{H}_u \tilde{H}_d$
$\int d^2\theta \frac{X^\dagger}{M} W_\alpha W^\alpha$
$\int d^2\theta \frac{X^\dagger}{M} H_u H_d$
$\int d^2\theta \frac{W_i W^i}{M^2} H_u H_d$
$\frac{W_i^\dagger W^i}{M^3} H_u H_d$
$\frac{1}{1^2}$
$H_u H_d$

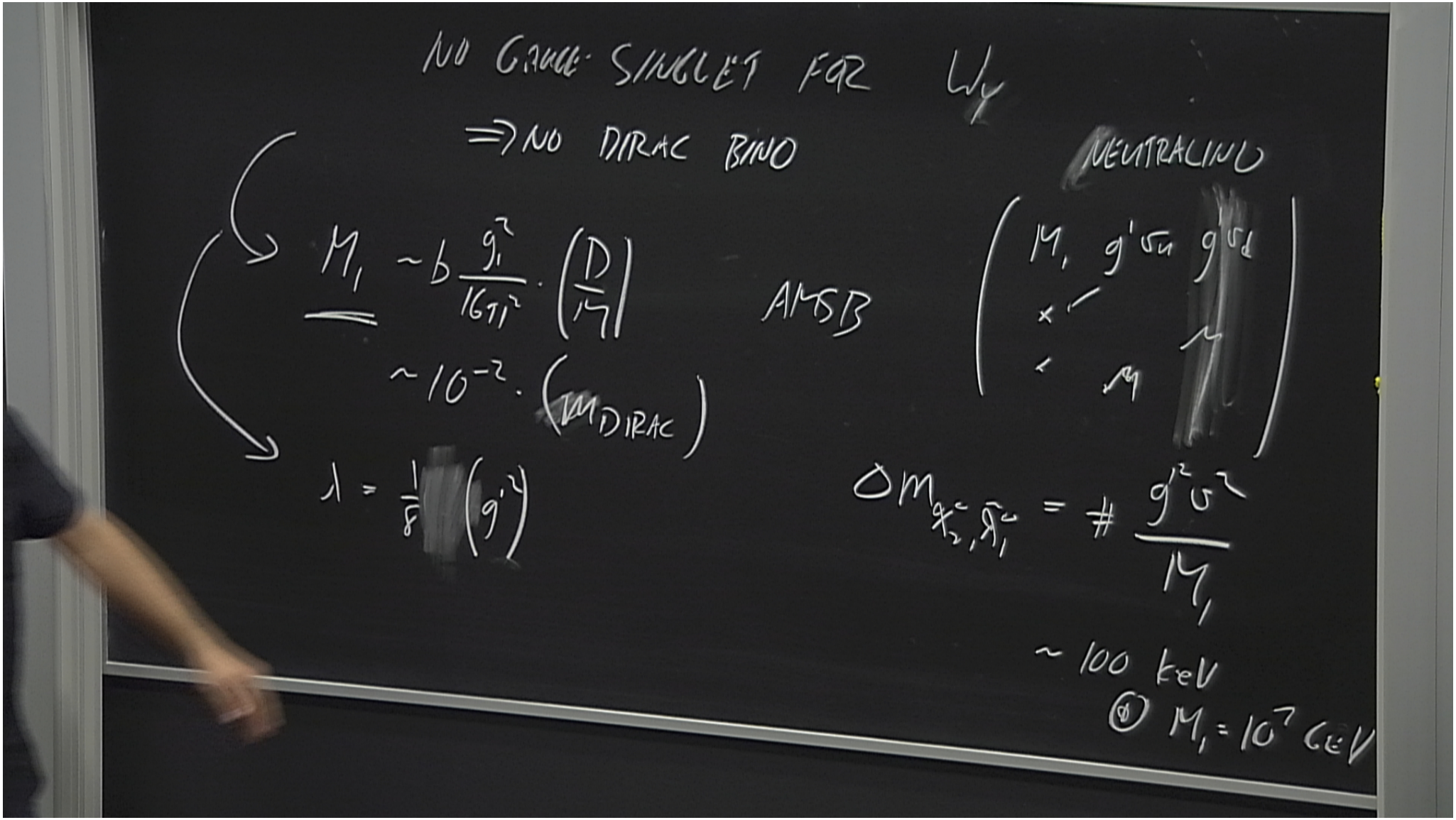

RUNNING OF g
$\frac{1}{g_i^2(M)} = \frac{1}{g_i^2(\Lambda)} + \frac{b_i}{2\pi} \ln \frac{M}{\Lambda}$
MSSM
DIRAC

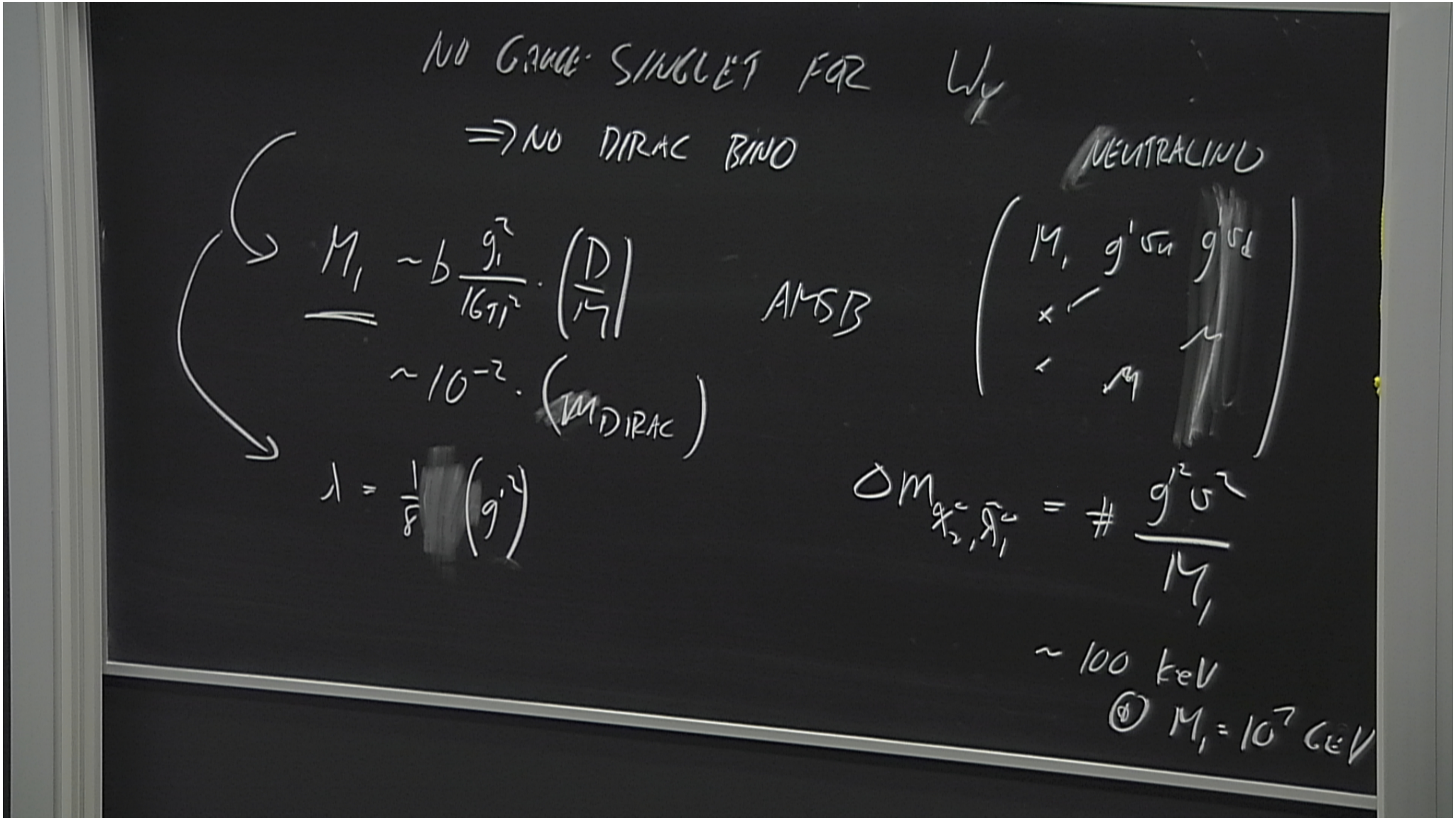

RUNNING OF g
$\frac{1}{g_i^2(M)} = \frac{1}{g_i^2(\Lambda)} + \frac{b_i}{2\pi} \ln \frac{\Lambda}{M}$
MSSM
DIRAC
$\Delta\left(\frac{1}{g_i^2}\right) = N_i \ln \frac{M_{GUT}}{M_{SUSY}}$
$= N_i \ln\left(\frac{M_{GUT}}{M_I}\right)^{\#}$

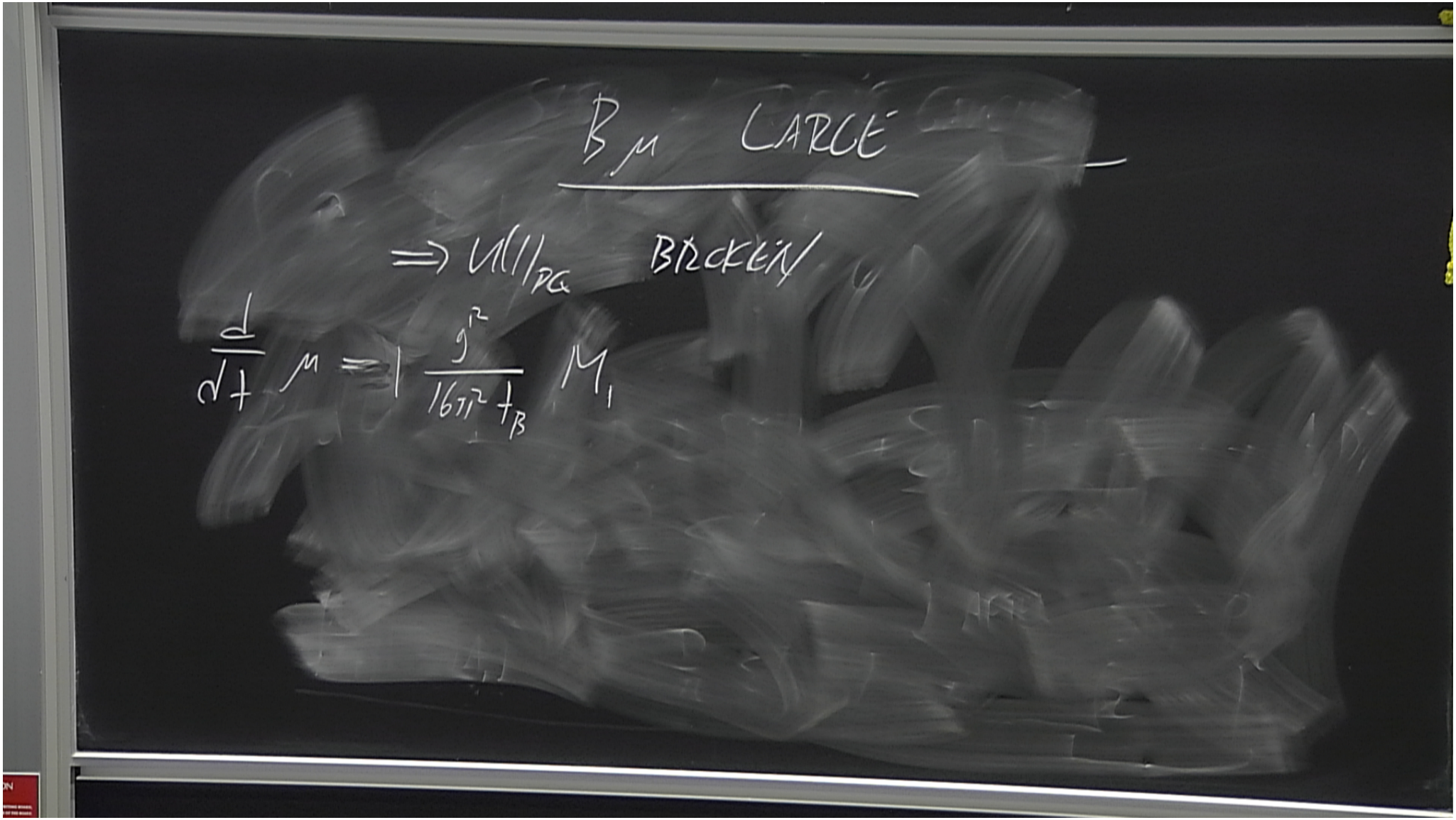

RUNNING OF g
MSSM
DIRAC
$M_I \sim 10^{10}$ GeV

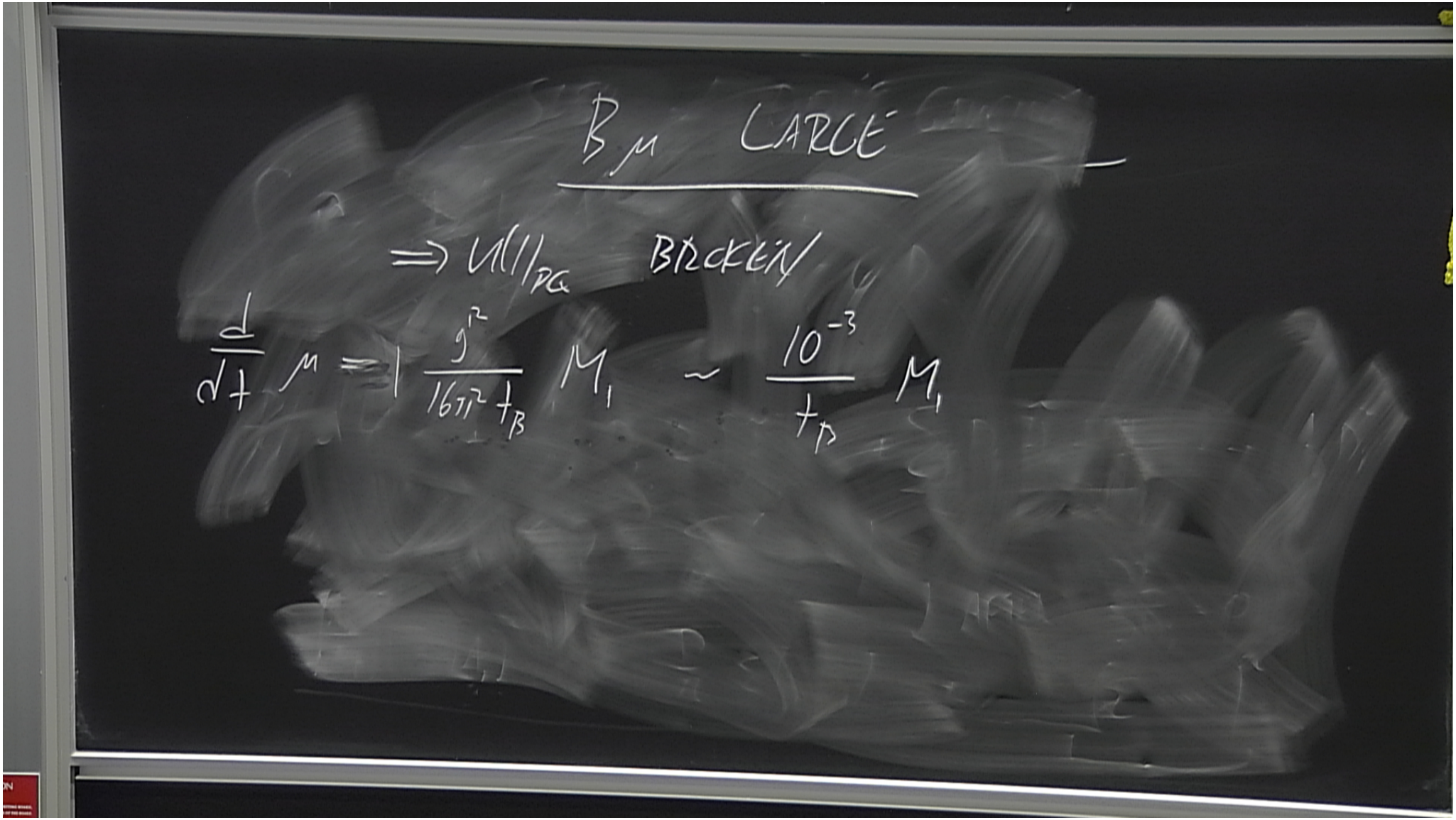

→ VANISHES.
$\hookrightarrow \lambda = 0$
HIGGSINOS
$H^\pm$
H_2^0, H_1^0
IF R-PARITY
$m \sim 1.1$ TEV $\Rightarrow \Omega h^2 = 0.12$
10^{9-10}
DIRAC
$\tilde{m}^2 \sim \frac{1}{16\pi^2}\left(\frac{D}{17}\right)^2$
$\sum z$

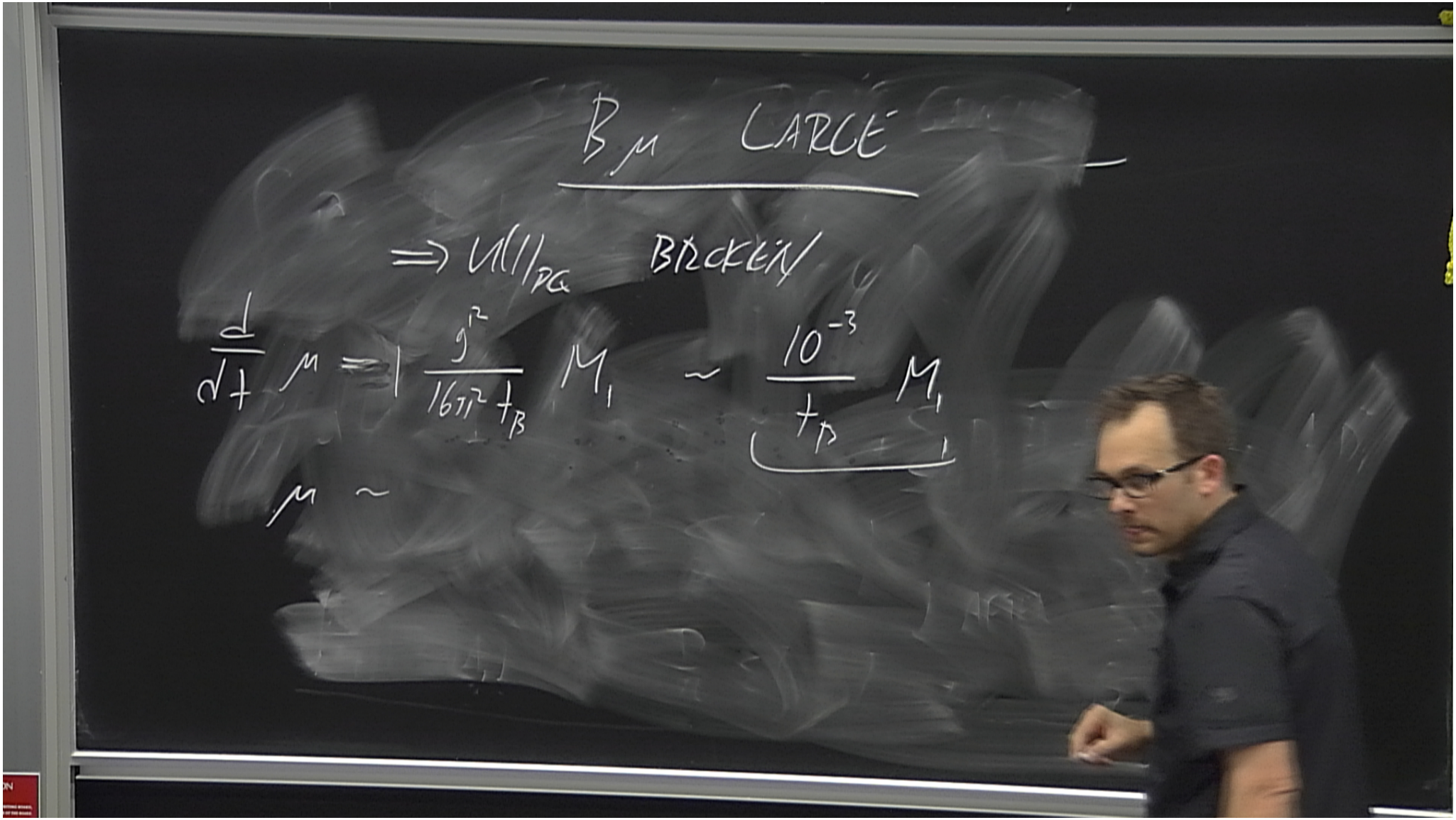

NO GAUGE SINGLET FOR
⇒ NO DIRAC BINO
$M_1 \sim b \frac{g_1^2}{16\pi^2} \cdot \left(\frac{D}{M}\right)$
AMSB
$\sim 10^{-2} \cdot (m_{DIRAC})$
$\lambda = \frac{1}{8}$

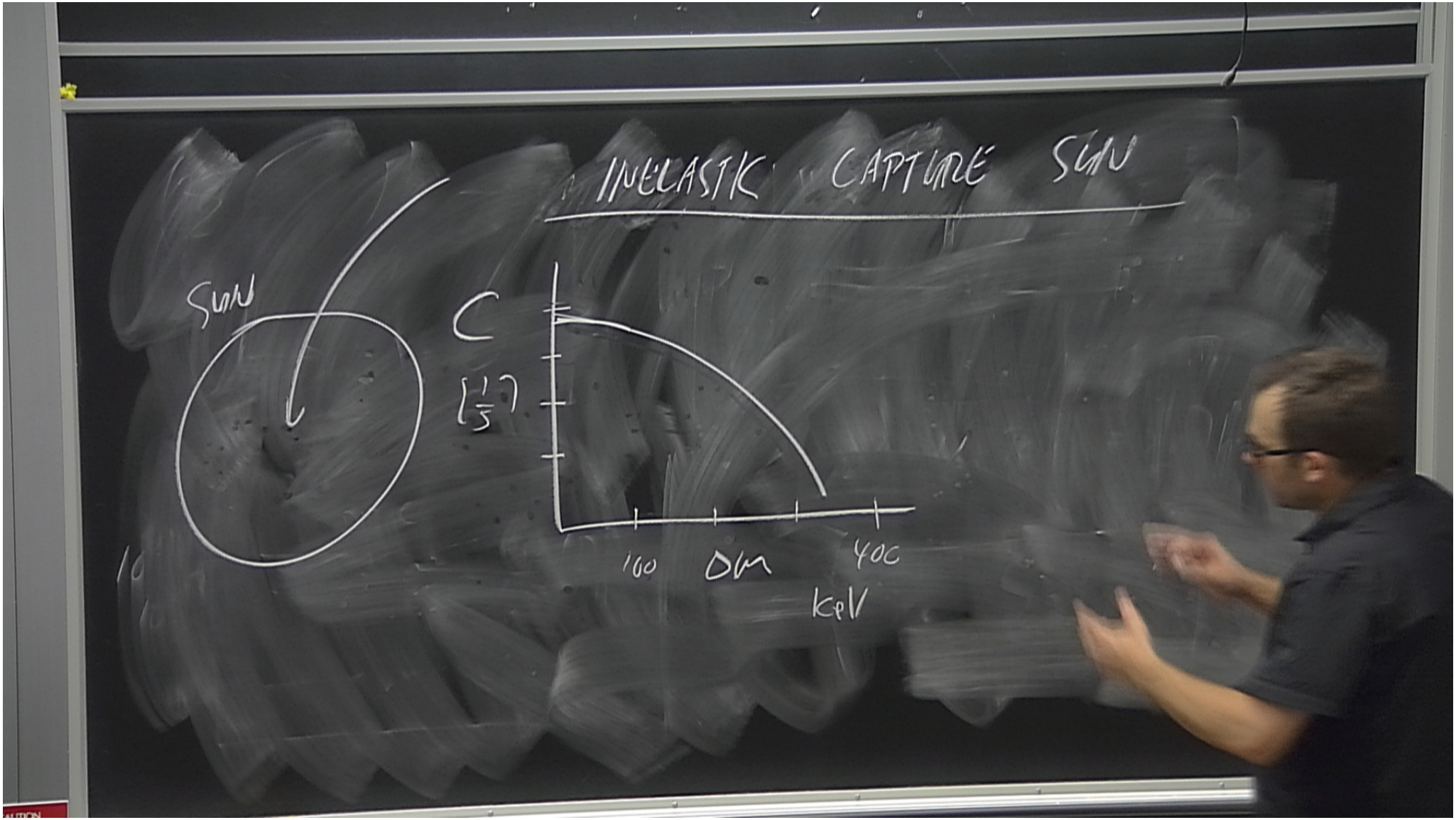

NO GAUGE SINGLET FOR
⇒ NO DIRAC BINO
NEUTRALINO
AMSB
~ 100 keV
M₁ = 10⁷ GeV

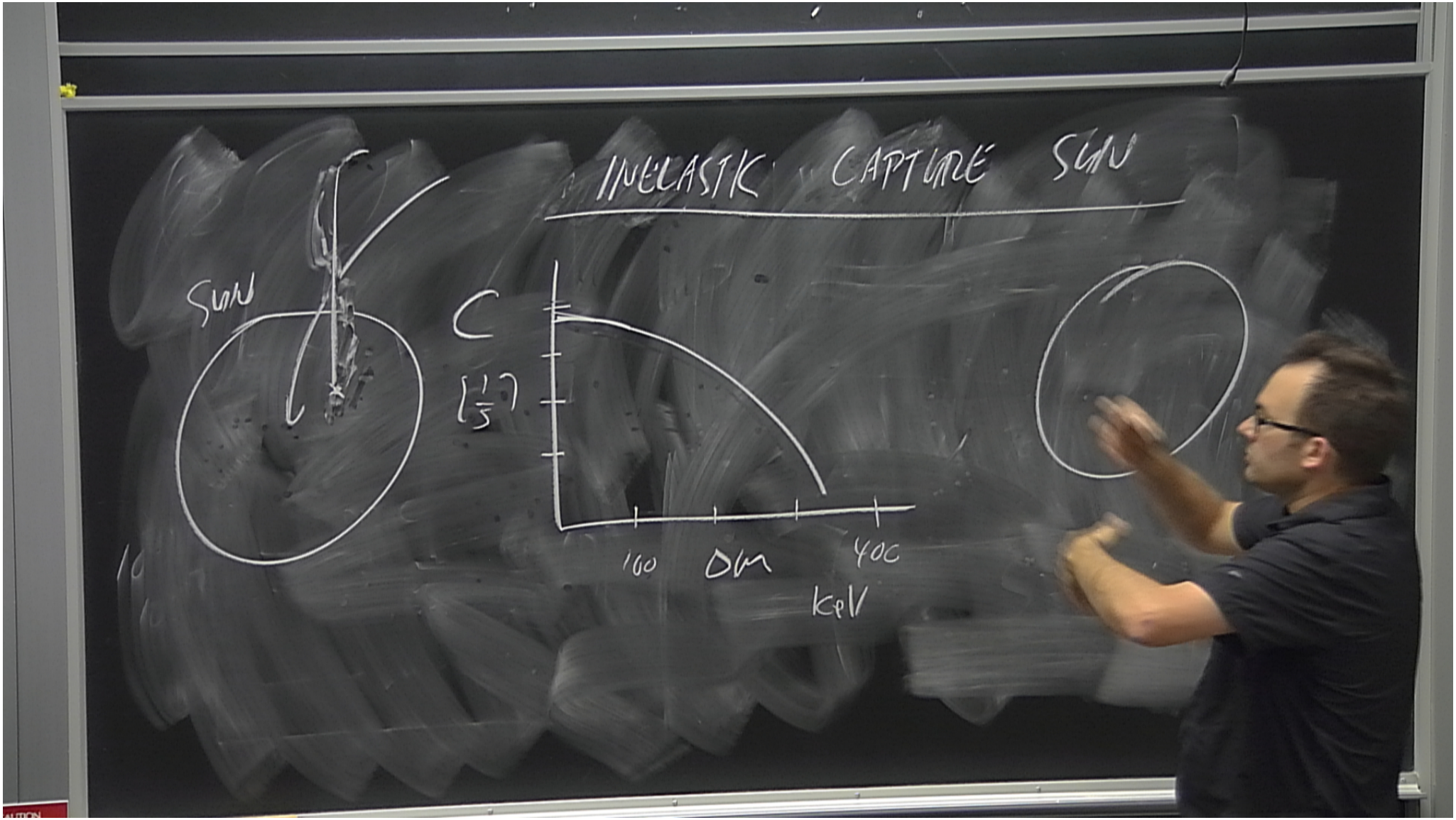

NO GAUGE SINGLET FOR
⇒ NO DIRAC BINO
NEUTRALINO
AMSB
~ 10^-2 · (m_DIRAC)
λ = 1/8 (g')^4
~ 100 keV
M_1 = 10^7 GeV

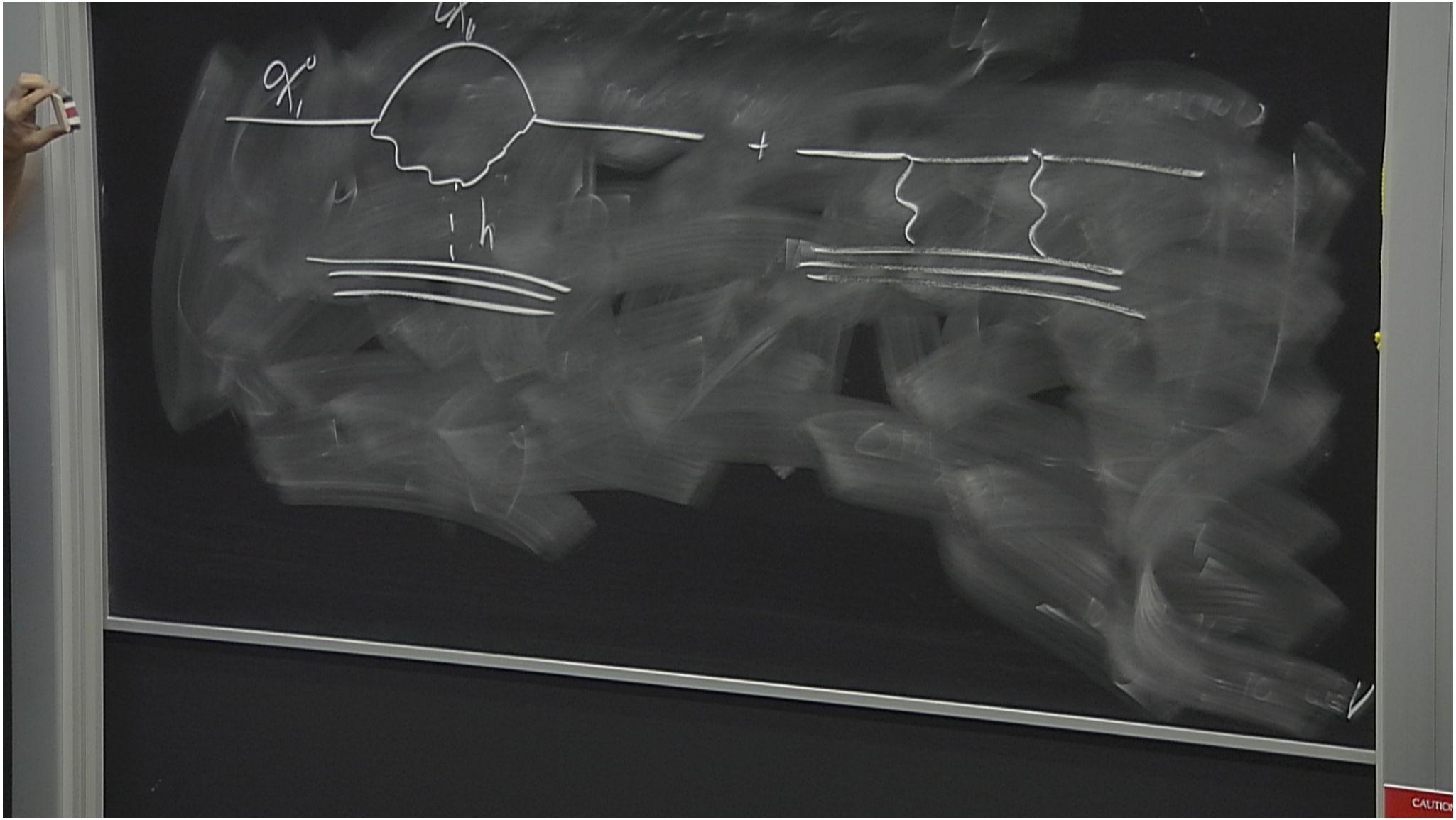

B_μ CARCÉ
$\Rightarrow$ ULL/DG BRÜCKEN
$\frac{d}{dt} m = -\frac{g^2}{16\pi^2 t_B} M_1$

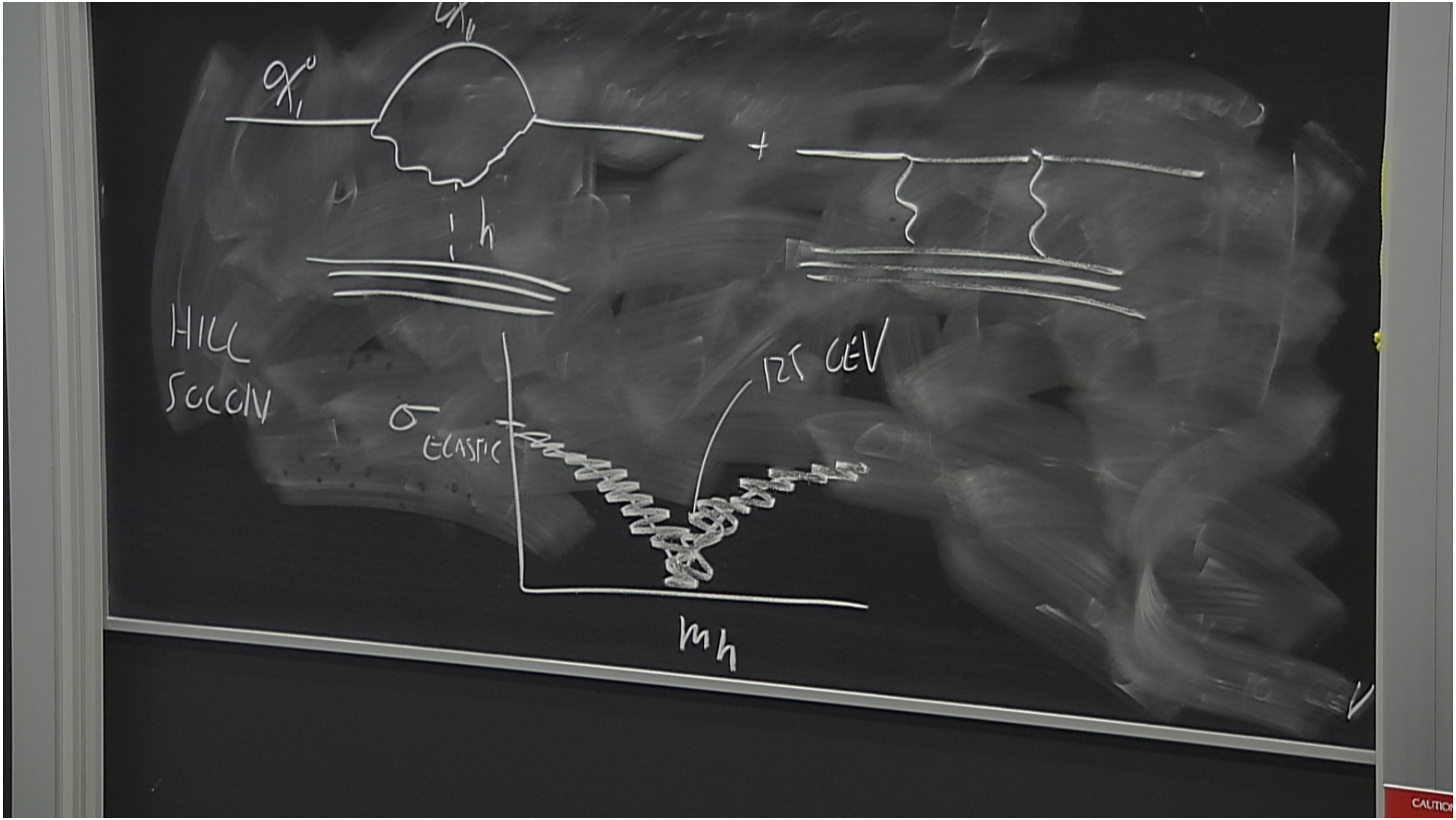

B_μ LARGE
$\Rightarrow$ U(1)$_{PQ}$ BROKEN
$\frac{d}{dt}\mu = -\frac{g^2}{16\pi^2 t_B} M_1 \sim \frac{10^{-3}}{t_B} M_1$

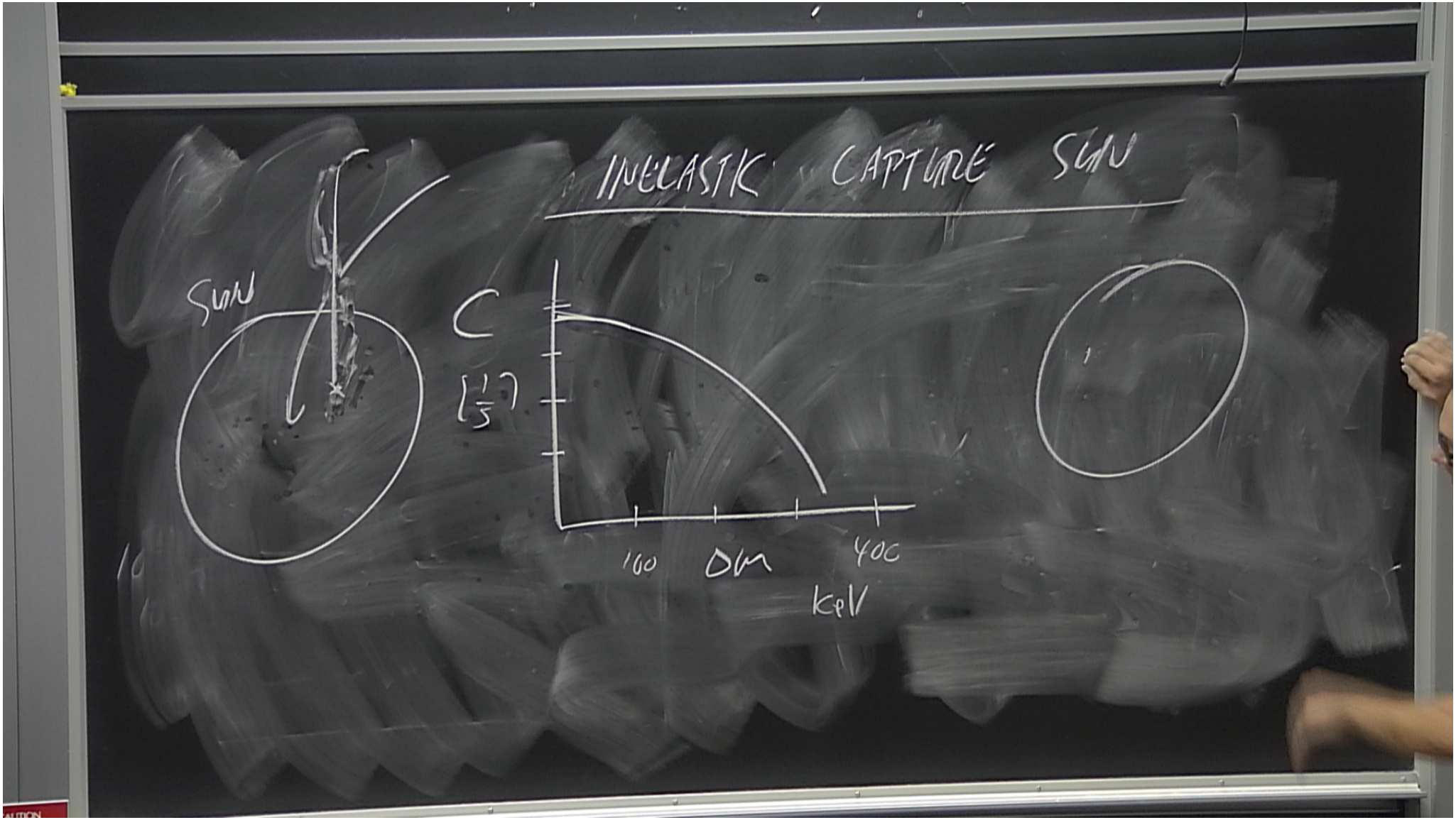

B_μ LARGE
$\Rightarrow$ UV IR BROKEN
$\frac{d}{dt}\mu = -\frac{g^2}{16\pi^2 t_B} M_1 \sim \frac{10^{-3}}{t_B} M_1$
$\mu \sim$


INELASTIC CAPTURE SUN
SUN
C
160
OM
40C
kel


INELASTIC CAPTURE SUN
SUN
C
160
OM
400
KeV


h


HIGGS
SCALAR
125 GeV
m_h


INELASTIC CAPTURE SUN
SUN
C
160
OM
40C
KeV