Title: PSI 2018/2019 - Beyond Standard Model - Lecture 14

Speakers: Latham Boyle

Collection: PSI 2018/2019 - Beyond Standard Model (Boyle)

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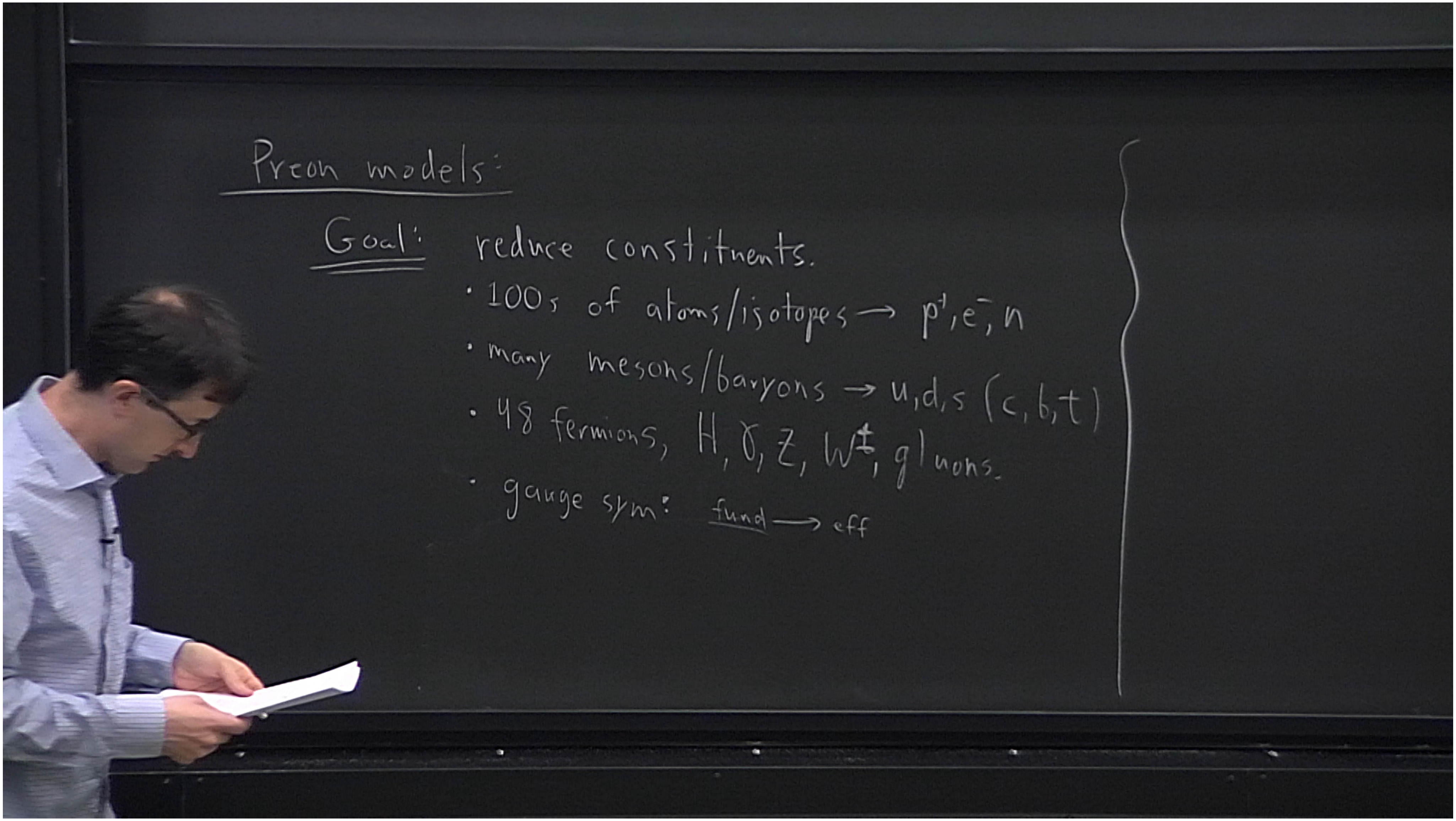
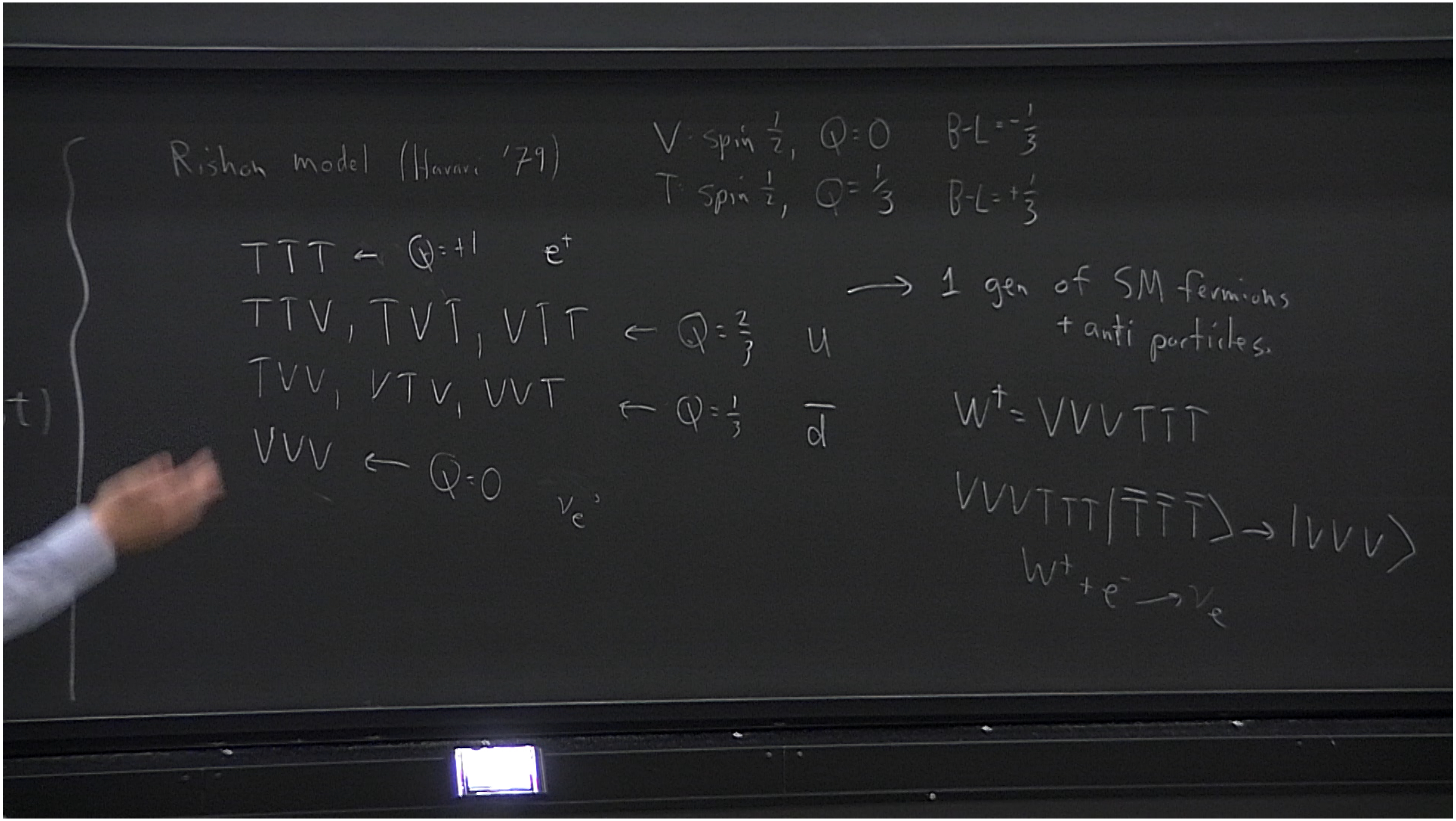
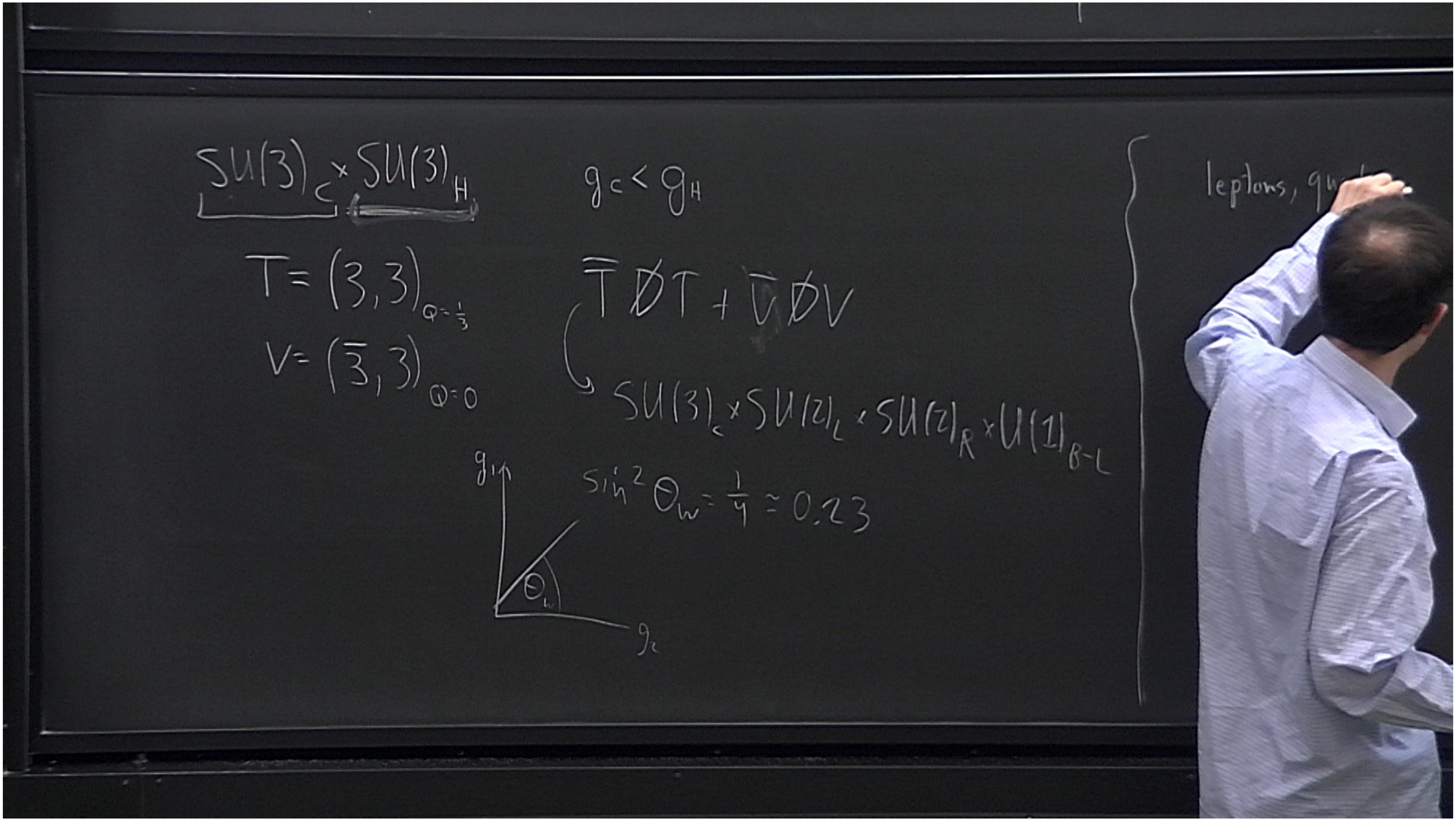
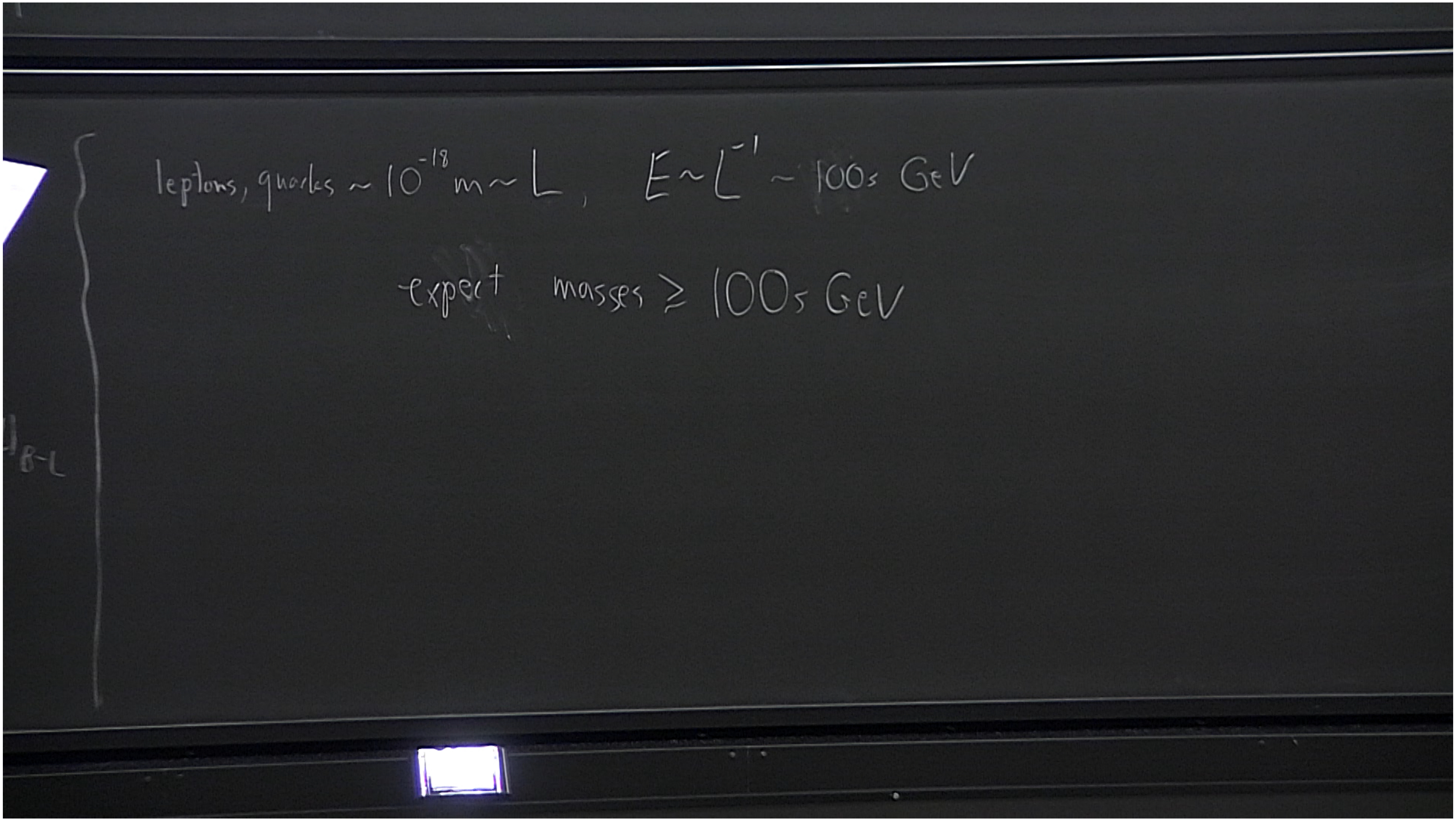

Preon models:
Goal: reduce constituents.
• 100s of atoms/isotopes → p⁺, e⁻, n
• many mesons/baryons → u, d, s (c, b, t)
• 48 fermions, H, γ, Z, W±, gluons.
• gauge sym: fund → eff


Rishon model (Harari '79)
V: spin $\frac{1}{2}$, $Q=0$ $B-L=-\frac{1}{3}$
T: spin $\frac{1}{2}$, $Q=\frac{1}{3}$ $B-L=+\frac{1}{3}$
TTT ← $Q=+1$ e^+
TTV, TVT, VTT ← $Q=\frac{2}{3}$ u
TVV, VTV, VVT ← $Q=\frac{1}{3}$ $\bar{d}$
VVV ← $Q=0$ ν_e
→ 1 gen of SM fermions + anti particles.
$W^+ = VVVTTT$
$VVVTTT|\bar{T}\bar{T}\bar{T}\rangle \to |VVV\rangle$
$W^+ + e^- \to \nu_e$


$\underbrace{SU(3)_C}\times\underbrace{SU(3)_H}$
$g_C < g_H$
$T = (3,3)_{Q=-\frac{1}{3}}$
$V = (\bar{3},3)_{Q=0}$
$\bar{T}\cancel{\partial}T + \bar{V}\cancel{\partial}V$
$SU(3)_c \times SU(2)_L \times SU(2)_R \times U(1)_{B-L}$
$\sin^2\theta_W = \frac{1}{4} \simeq 0.23$
g_1
θ_W
g_2
leptons,


leptons, quarks ~ 10^-18 m ~ L, E ~ L^-1 ~ 100s GeV
expect masses ≳ 100s GeV
B-L

$e \to \nu_e$

- leptons, quarks $\sim 10^{-18}\,\mathrm{m} \sim L$, $E \sim L^{-1} \sim$ 100s GeV

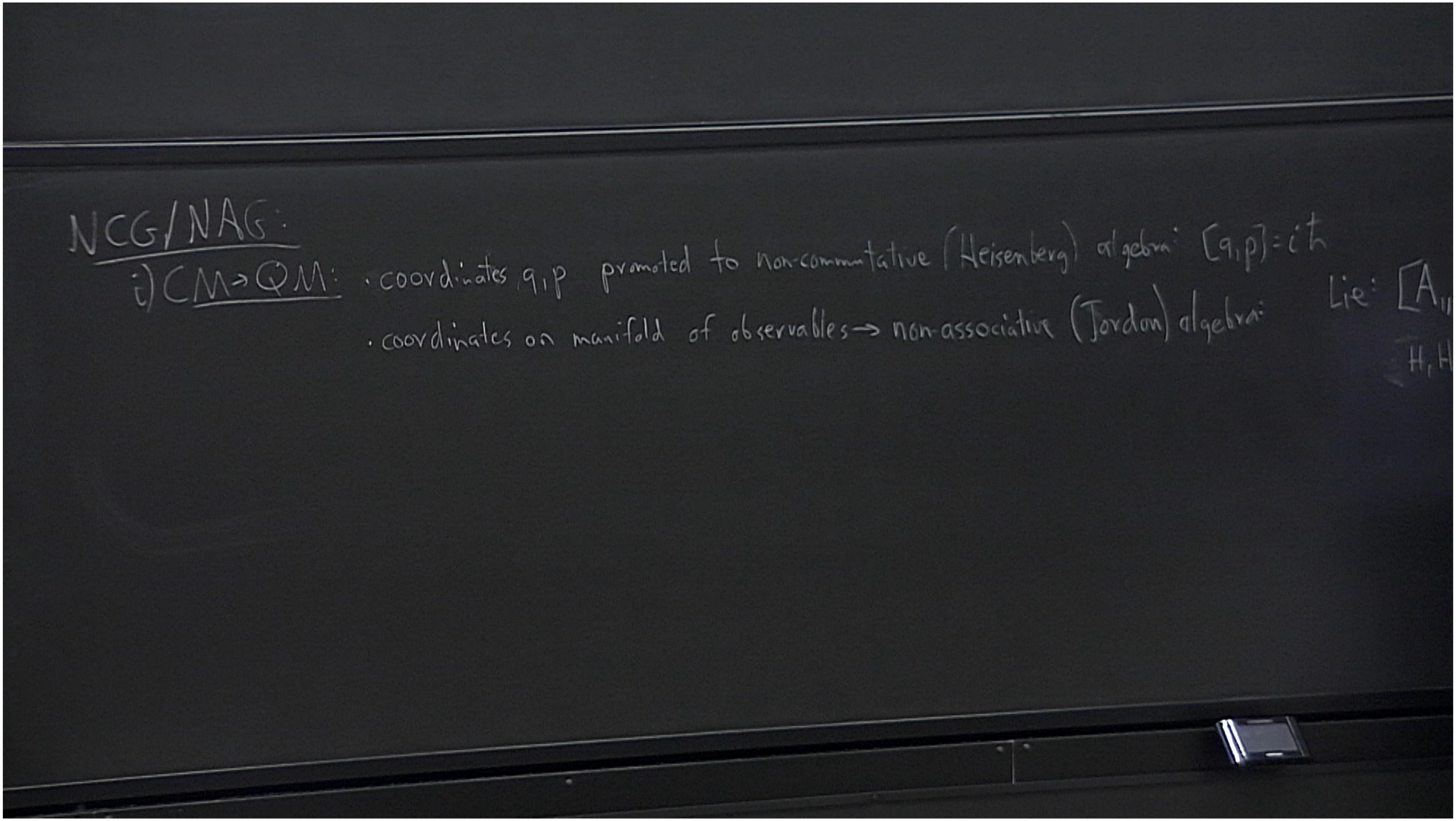
  expect masses $\geq$ 100s GeV

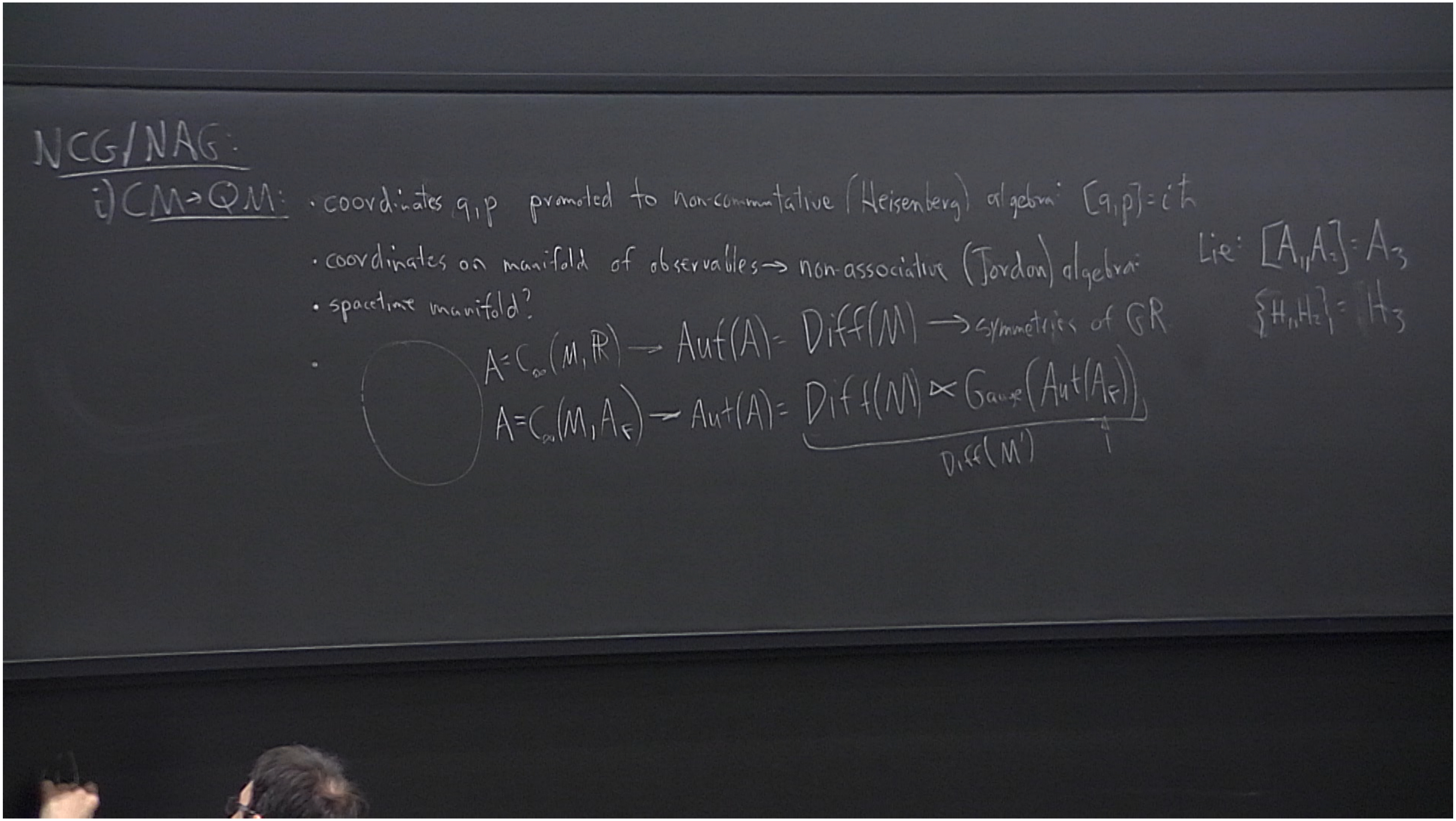
- arXiv:1808.... Dubois-Violette, Todorov $J_3(\mathbb{O})$

Jordan algs classified by
Wigner, Von Neumann, + Jordan

$J_n(\mathbb{R}),\ J_n(\mathbb{C}),\ J_n(\mathbb{H})$ $J_3(\mathbb{O})$

Clifford symmetrized


NCG/NAG:
i) CM→QM:
· coordinates q,p promoted to non-commutative (Heisenberg) algebra: [q,p]=iħ
· coordinates on manifold of observables → non-associative (Jordan) algebra:
Lie:

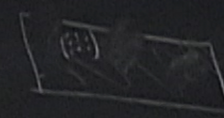

NCG/NAG:
i) CM→QM:
· coordinates q, p promoted to non-commutative (Heisenberg) algebra: [q, p] = iℏ
· coordinates on manifold of observables → non-associative (Jordan) algebra:
Lie: [A1, A2] = A3
{H1, H2} = H3
· spacetime manifold?
A = C∞(M, ℝ) → Aut(A) = Diff(M) → symmetries of GR
A = C∞(M, AF) → Aut(A) = Diff(M) ⋉ Gauge(Aut(AF))
Diff(M')

ii) $\psi_A(x)$

$A=1,\dots,48$

instead of 48 spinors on M

1 spinor on $(\underbrace{M}_{\text{4d manifold}} \times \underbrace{F}_{\text{finite/discrete.}})$



iii) Can we reformulate: massless?

$$\bar{\psi}^i(i\not{\partial}-m)\psi^i \to \psi \not{D} \psi$$

Pati-Salam:

$$A_F = M_4(\mathbb{C}) \oplus M_2^L(\mathbb{C}) \oplus M_2^R(\mathbb{C}) \longrightarrow \underbrace{\begin{pmatrix} \begin{matrix} M_2^L & \\ & M_2^R \end{matrix} & \\ & M_4 \end{pmatrix}}_{A_F} \qquad \underbrace{\begin{pmatrix} 0_{4\times 4} & \psi_{4\times 4} \\ \bar{\psi}_{4\times 4} & 0_{4\times 4} \end{pmatrix}}_{H_F}$$

$$\begin{matrix} \downarrow & & \downarrow & & \downarrow \\ SU(4) & \times & SU(2)_L & \times & SU(2)_R \end{matrix}$$

$$B_F = A_F \oplus H_F$$

$M \times F$

H_1

M_1: $D_1, \gamma_1 \longrightarrow i\partial\!\!\!/, \gamma_5$

M_2: $D_2, \gamma_2 \longrightarrow D_F, \gamma_F$

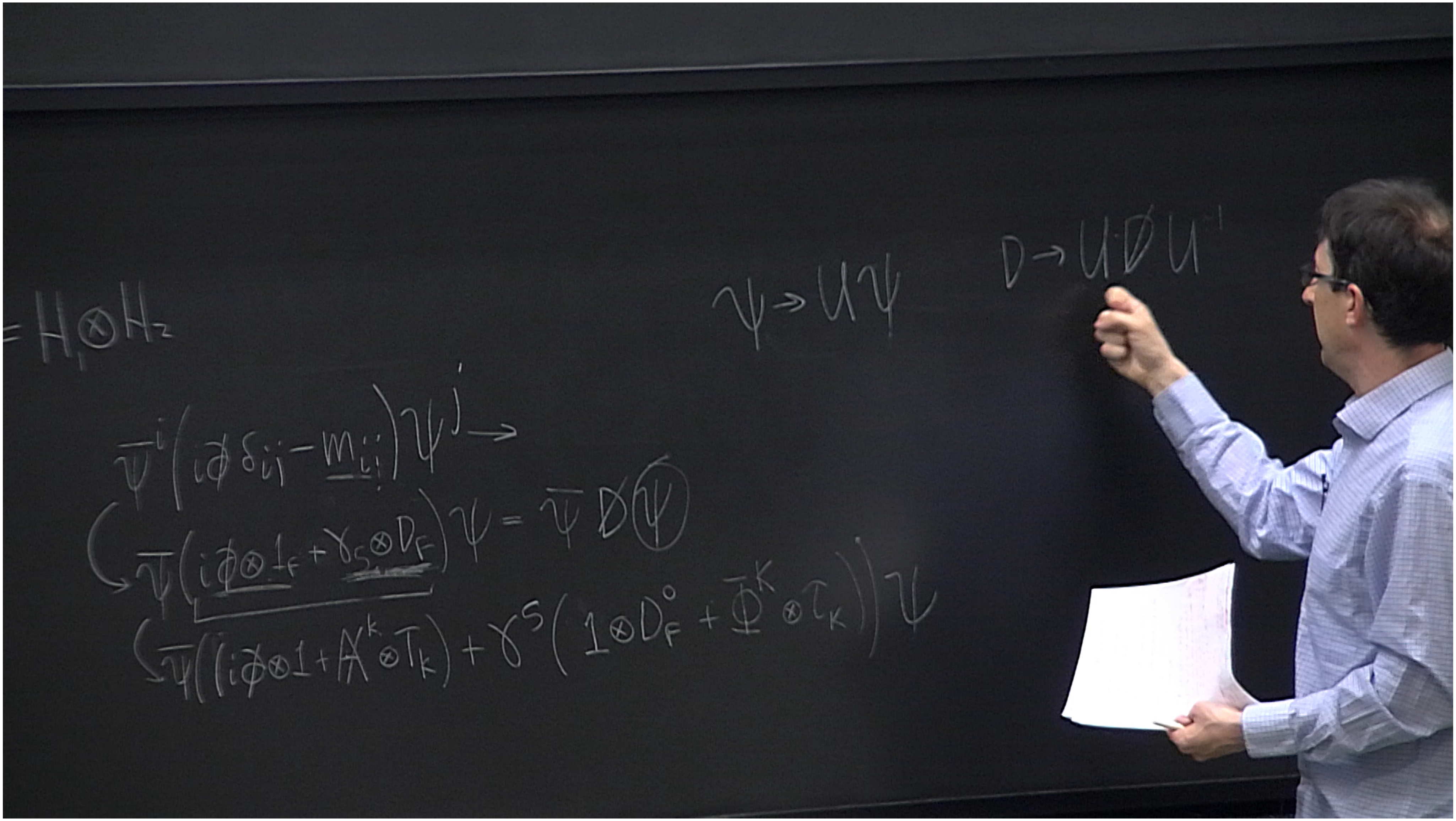
H_2

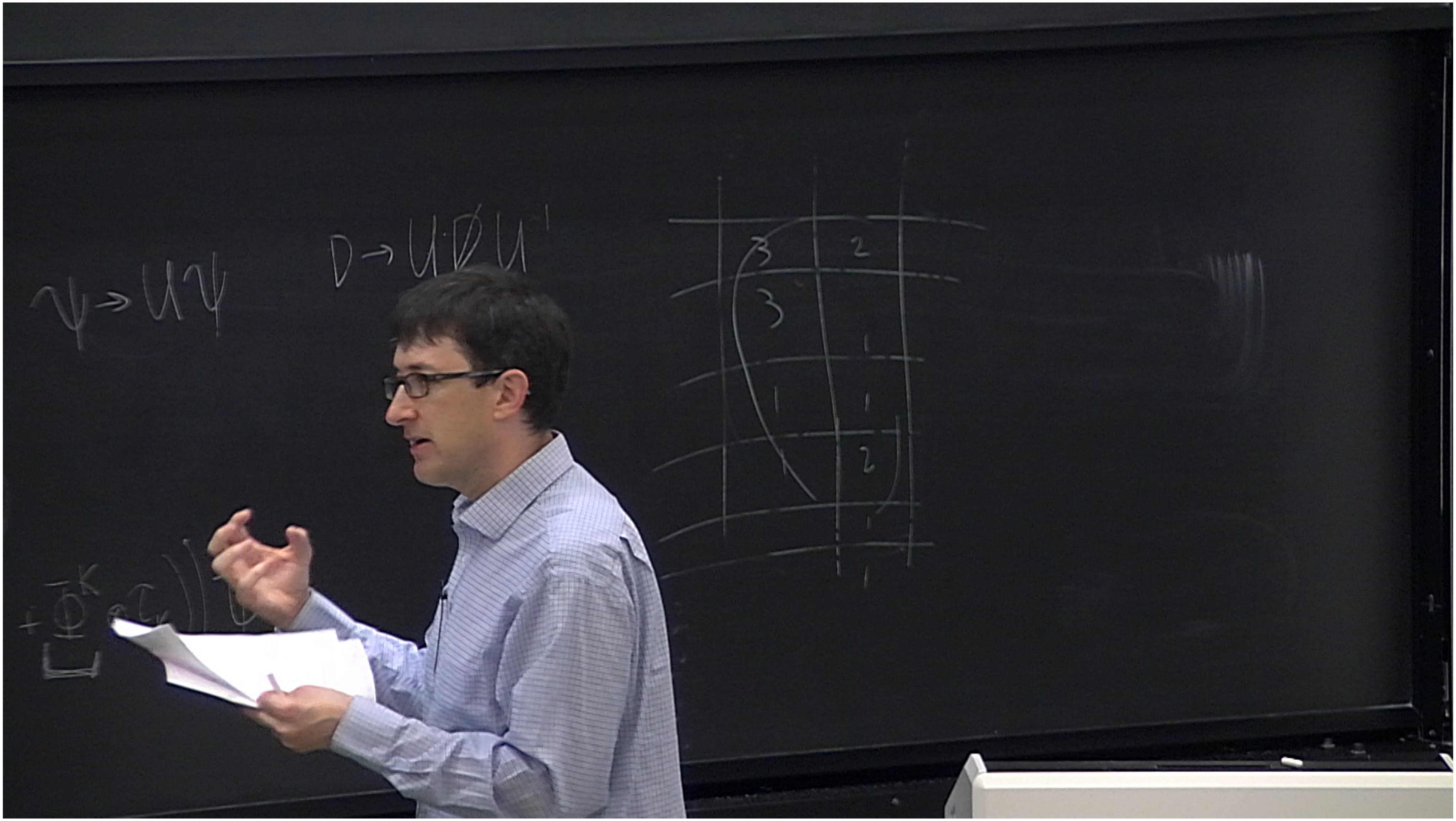
$$D = i\partial\!\!\!/ \otimes 1_F \oplus \gamma_5 \otimes D_F$$

$$H = H_1 \otimes H_2$$

$$\bar{\psi}^i \left(i\partial\!\!\!/ \, \delta_{ij} - \underline{m_{ij}} \right) \psi^j \longrightarrow$$

$$\bar{\psi} \left(i\partial\!\!\!/ \otimes 1_F + \gamma_5 \otimes \underline{D_F} \right) \psi = \bar{\psi} D\!\!\!/ \psi$$


$= H_1 \otimes H_2$
$\psi \to U\psi$
$D \to U D U^{-1}$
$\bar{\psi}^i (i\partial\!\!\!/ \delta_{ij} - \underline{m_{ij}}) \psi^j \to$
$\bar{\psi}(i\partial\!\!\!/ \otimes 1_F + \gamma_5 \otimes D_F)\psi = \bar{\psi} D\!\!\!/ \psi$
$\bar{\psi}((i\partial\!\!\!/ \otimes 1 + A\!\!\!/^k \otimes T_k) + \gamma^5(1 \otimes D_F^0 + \Phi^K \otimes \tau_K))\psi$


ψ → Uψ
D → U·D̸U⁻¹