Title: Goldstone Boson Counting in the Presence of Space-Time Symmetry Breaking, Non-Derivative Couplings and non-Fermi Liquid Behavior

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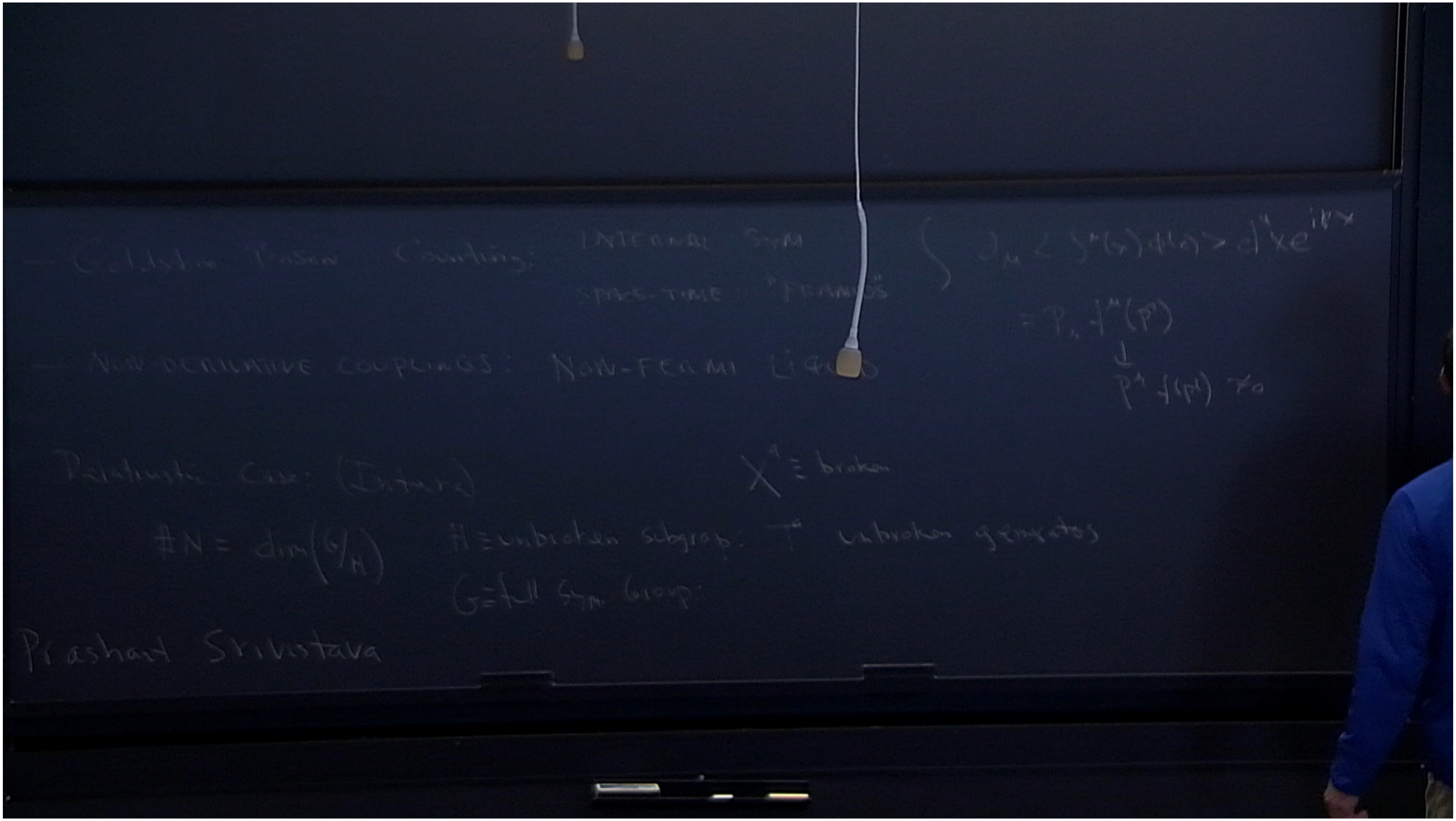
Abstract:


INTERNAL SYM
SPACE-TIME: "FERMIONS"
NON-FERMI
H ≡ unbroken subgroup: T^a unbroken generators
G ≡ full Sym. Group:
X^a ≡ broken
Prashant Srivastava

– Goldstone Boson Counting: INTERNAL SYM

SPACE-TIME: "FRAMIDS"

– NON-DERIVATIVE COUPLINGS: NON-FERMI LIQUID

$$\int \partial_\mu \langle J^\mu(x)\,\phi(0)\rangle\, d^4x\, e^{ipx} = p_\mu f^\mu(p^2)$$

$$\downarrow$$

$$p^\mu f(p^2) \neq 0$$

Relativistic Case: (Internal)

$X^a \equiv$ broken

$\# N = \dim(G/H)$ $\quad H \equiv$ unbroken subgroup: $T^a$ unbroken generators

$G \equiv$ full Sym. Group:

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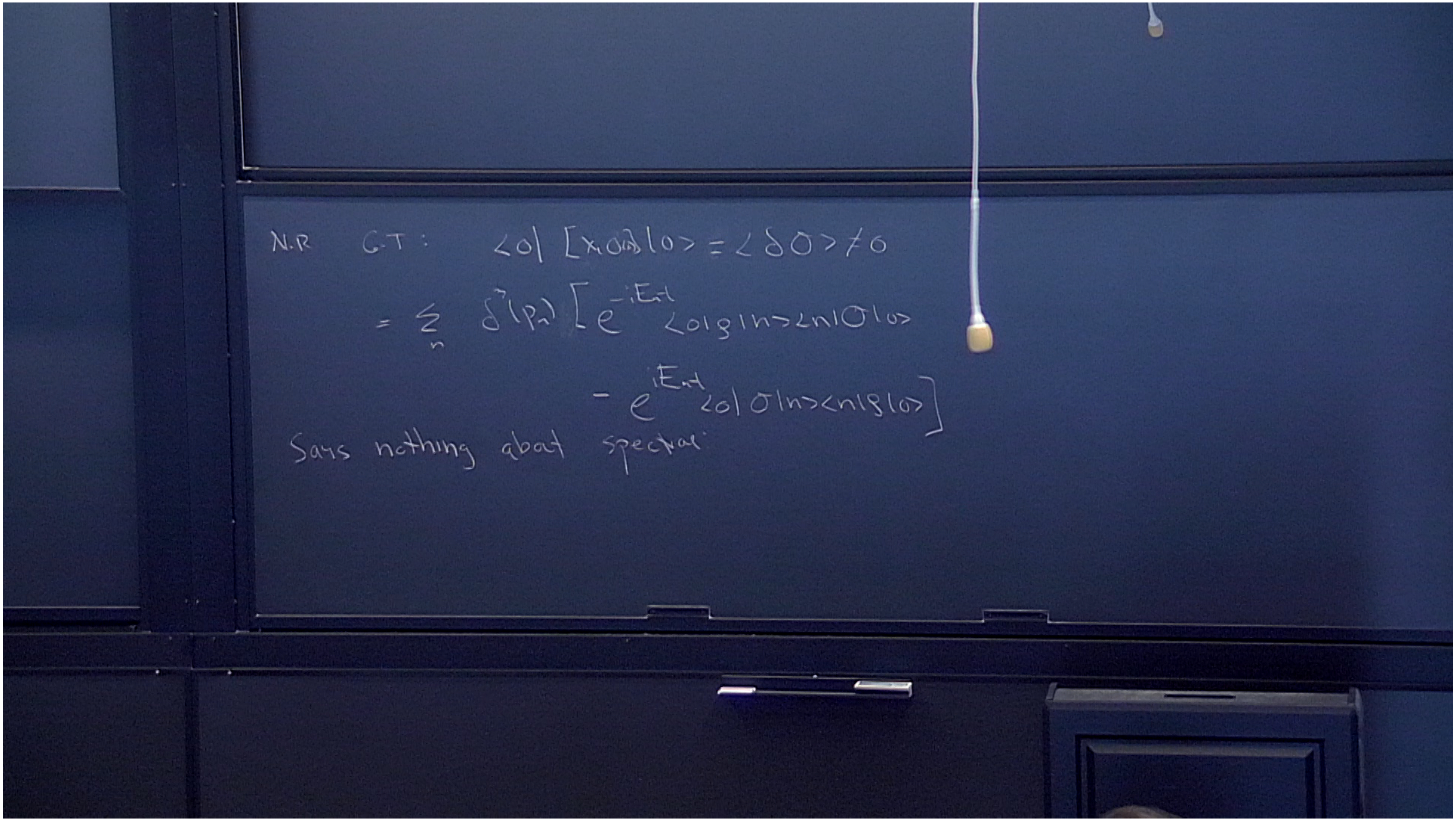
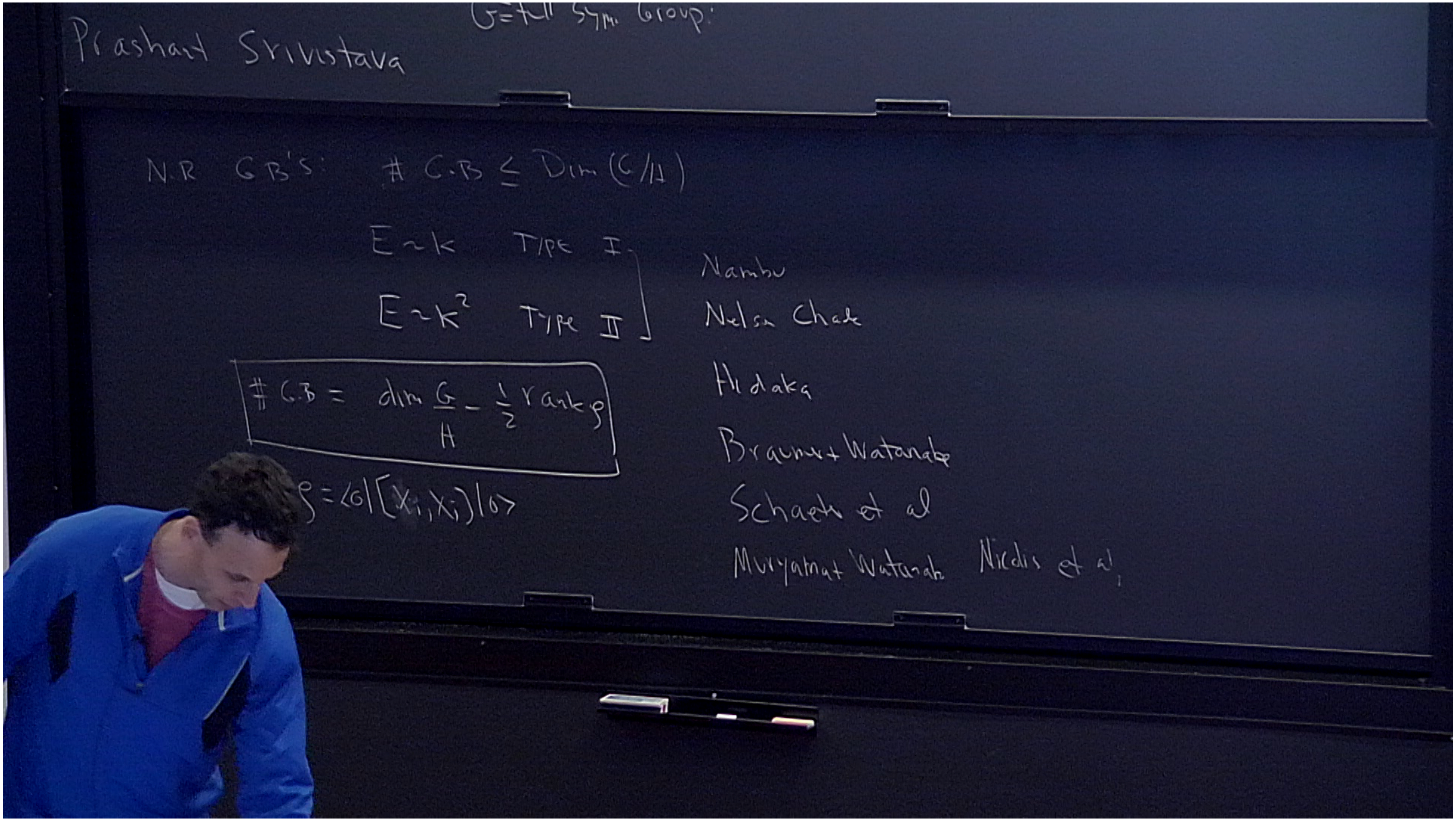

N.R G.T : <0| [X, O(0)] |0> = <δO> ≠ 0
= Σ_n δ³(p_n) [ e^{-iE_n t} <0|ρ|n><n|O|0>
− e^{iE_n t} <0|O|n><n|ρ|0> ]
Says nothing about spectra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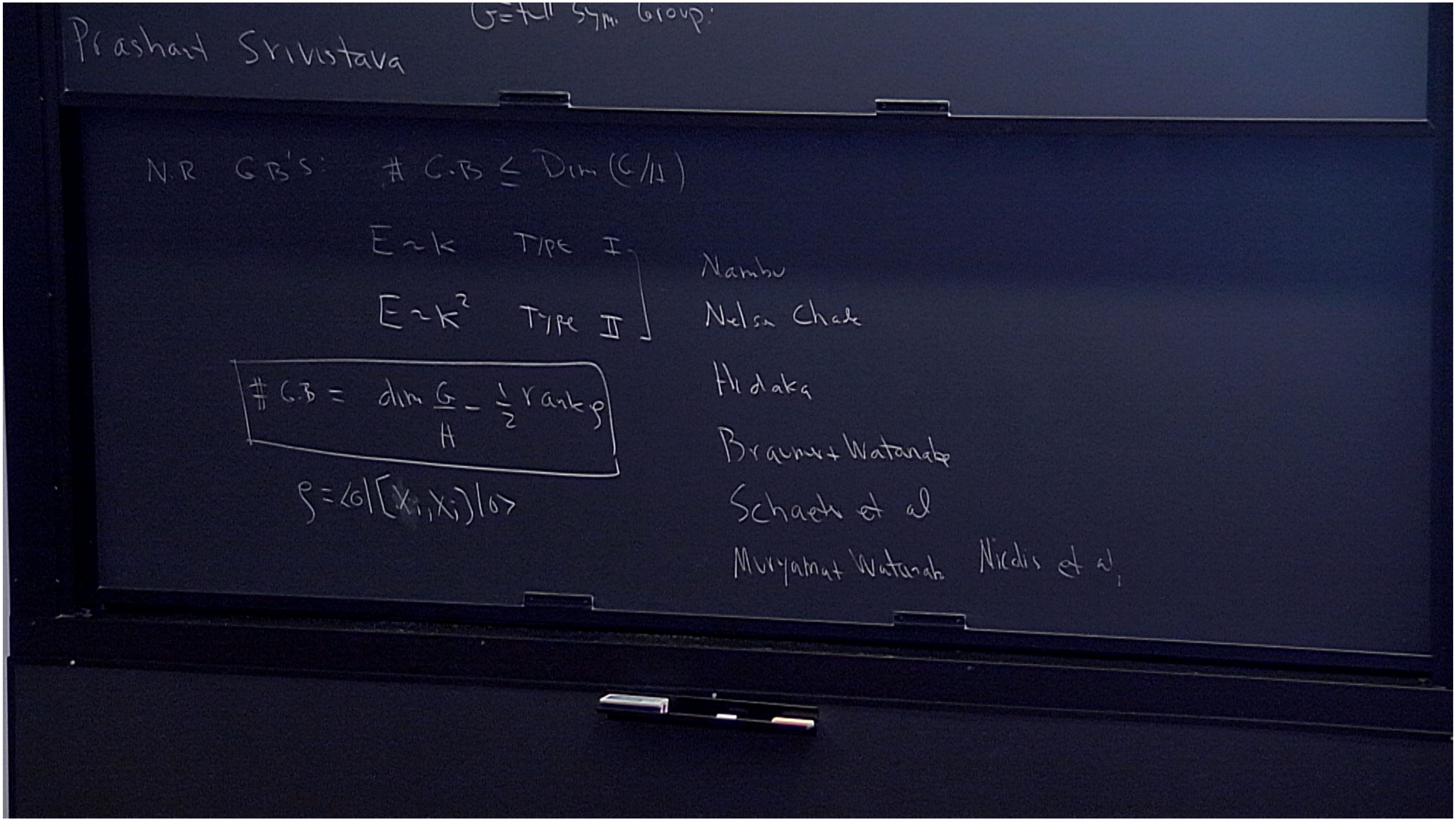
G = full Sym. Group:
N.R G.B's: # G.B ≤ Dim (G/H)
E ~ k Type I
E ~ k^2 Type II
# G.B = dim G/H − 1/2 rank ρ
ρ = <0|[X_i, X_j]|0>
Nambu
Hidaka
Schaefer et al
Nicolis et al



G = full sym. Group:
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N.R GB's: # G.B ≤ Dim (G/H)
E ~ k Type I
E ~ k^2 Type II
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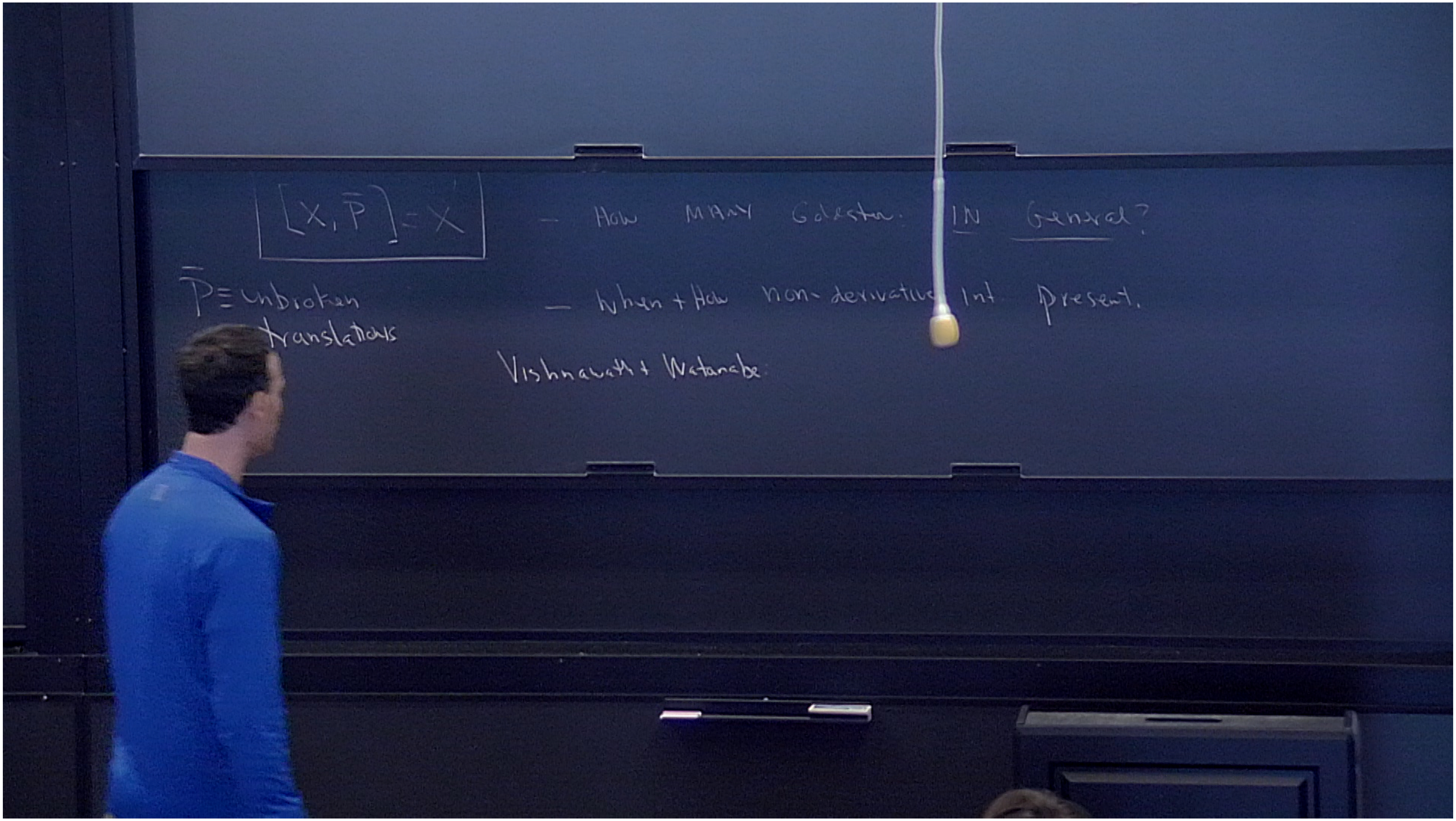
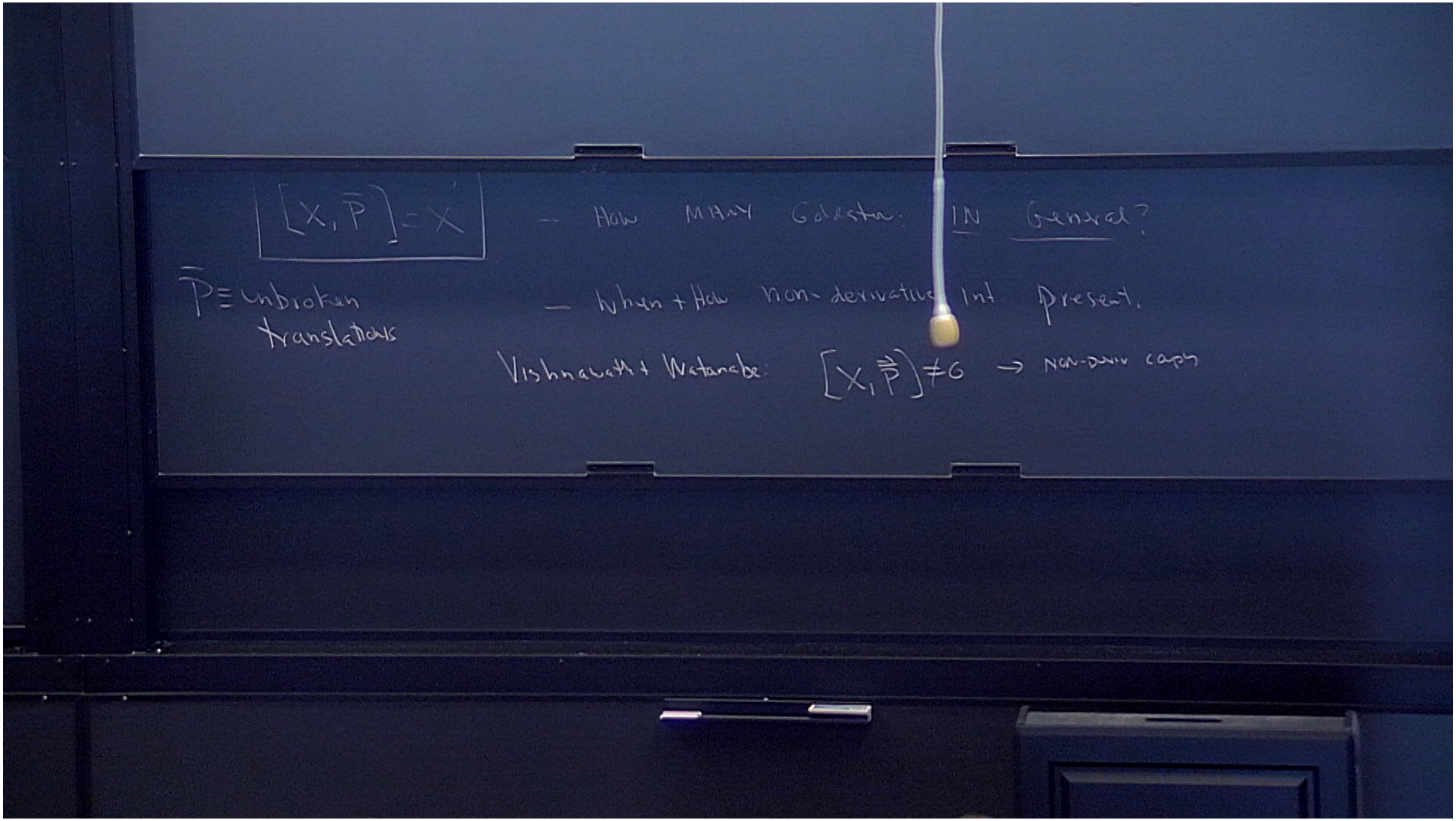
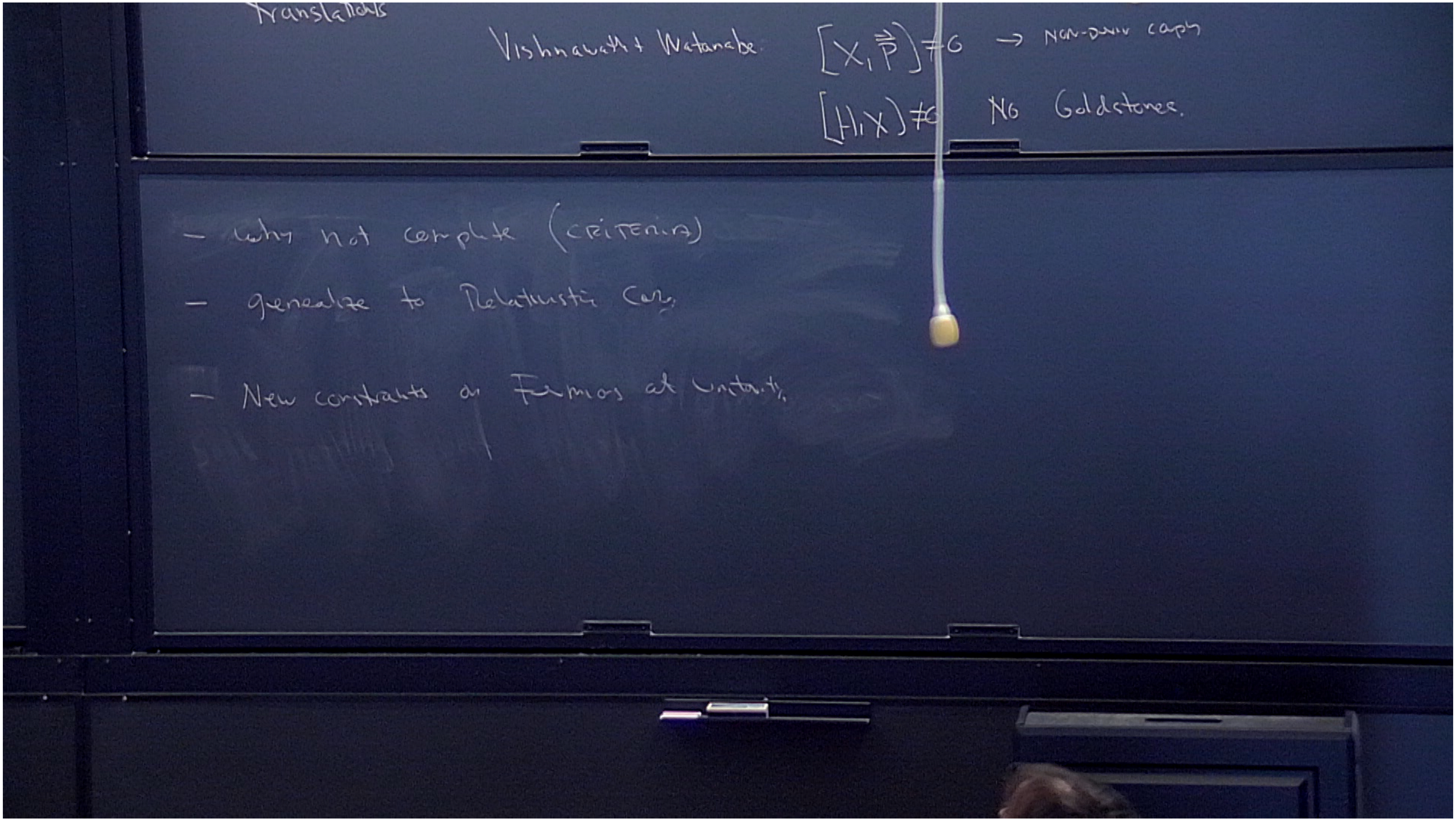
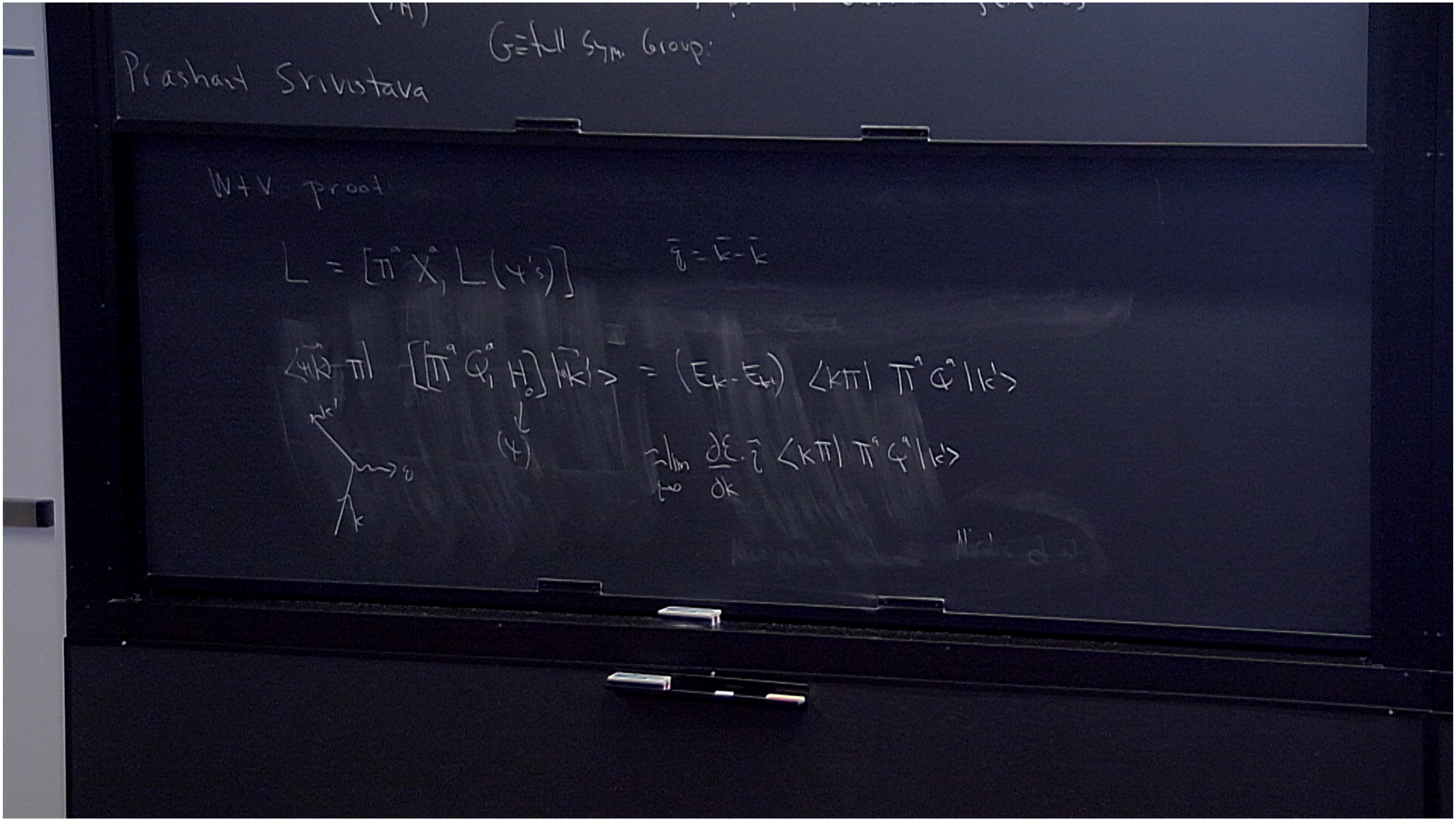
Nelson Chada
Hidaka
# G.B = dim G/H − 1/2 rank ρ
Brauner+Watanabe
ρ = <0|[X_i, X_j]|0>
Schaefer et al
Murayama+Watanabe Nicolis et al


[X, P̄] = X'
— How MANY Goldstones IN General?
P̄ = unbroken translations
— When + How non-derivative Int. present.
Vishnawath + Watanabe:


[X, P̄] = X
P̄ ≡ unbroken translations
— How MANY Goldstone IN General?
— When + How non-derivative Int present.
Vishnawath + Watanabe: [X, P̄] ≠ 0 → Non-deriv coup


Translations
Vishnawath + Watanabe:
[X, P] ≠ 0
[H, X] ≠ 0 No Goldstones.
– why not complete (CRITERIA)
– generalize to Relativistic Case
– New constraints on Fermions at Unitarity


G=full Sym. Group:
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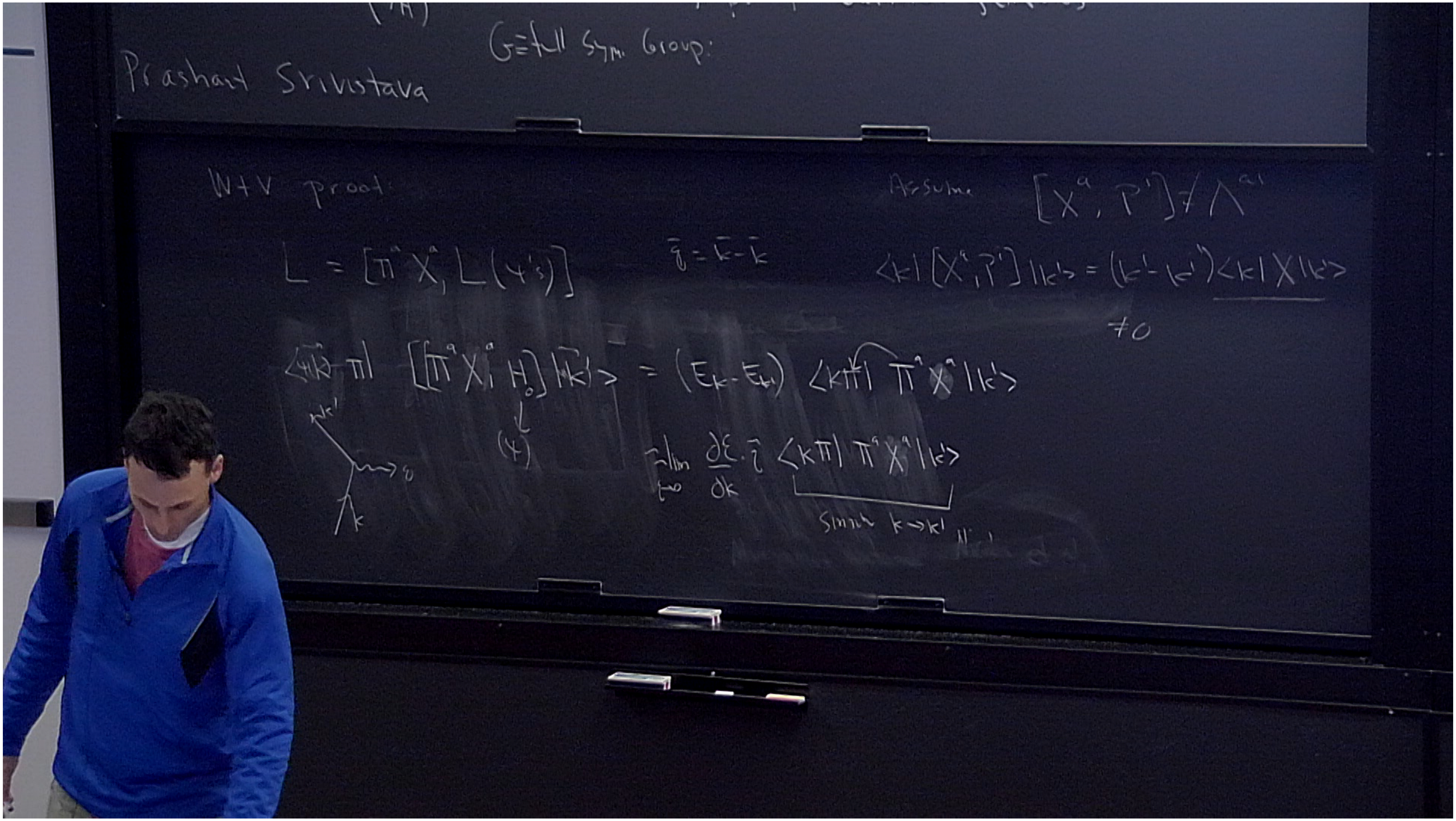
proof

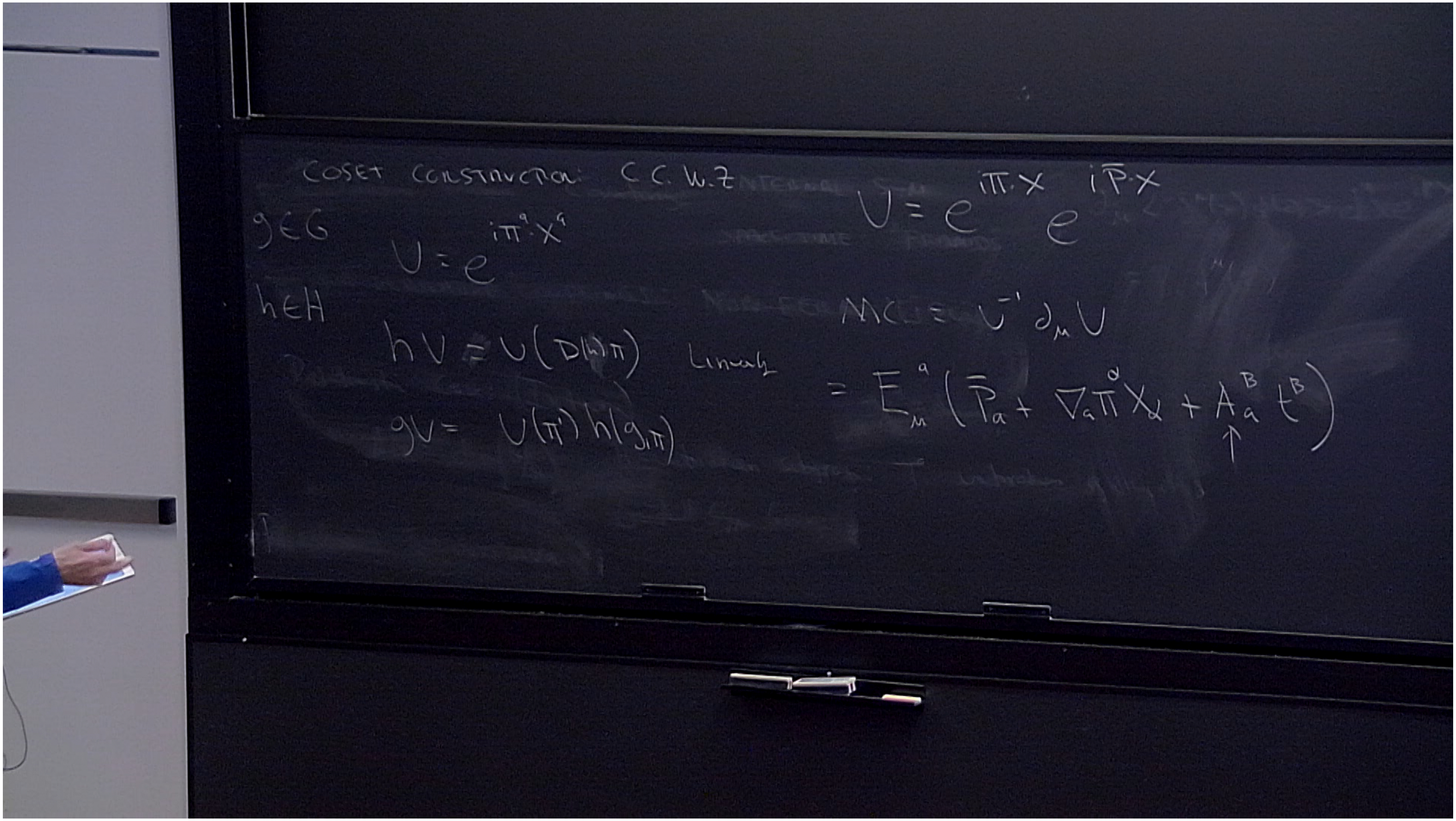

G=full Sym. Group:
Prashant Srivistava
W+V proof:
Assume

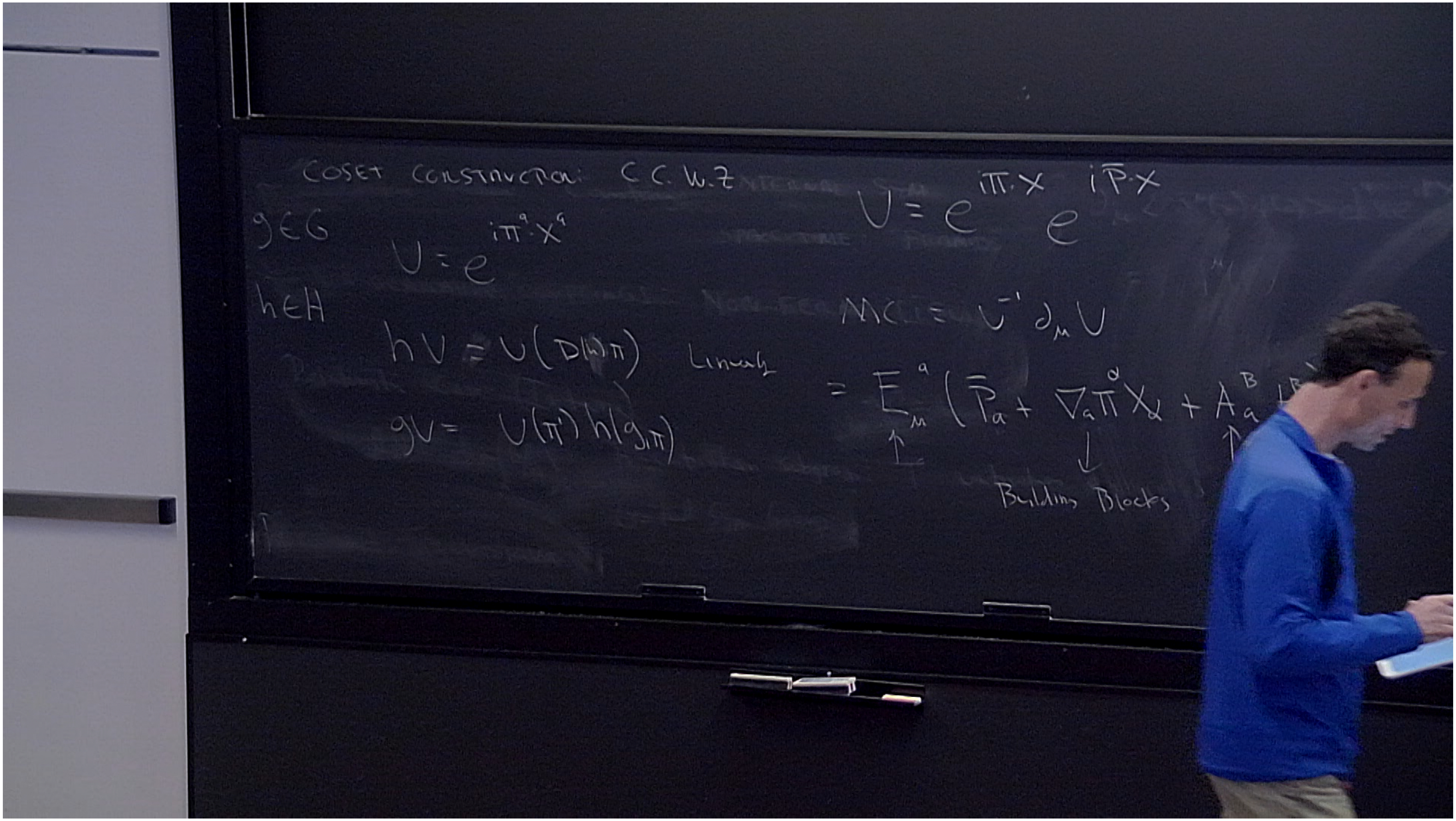
COSET CONSTRUCTION: C.C.W.Z

$$U = e^{i\pi^a \cdot X^a}$$

$$hU = U(D(h)\pi) \quad \text{Linearly}$$

$$gU = U(\pi')\, h(g,\pi)$$


COSET CONSTRUCTION: C.C.W.Z
g∈G
U = e^{iπ^a·X^a}
h∈H
hU = U(D(h)π) Linearly
gU = U(π') h(g,π)
U = e^{iπ·X} e^{iP̄·x}
MC = U^{-1} ∂_μ U
= E_μ^a (P̄_a + ∇_a π^α X_α + A_a^B t^B)


COSET CONSTRUCTION: C.C.W.Z
g∈G
U = e^{iπ^a·X^a}
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hU = U(D(h)π) Linearly
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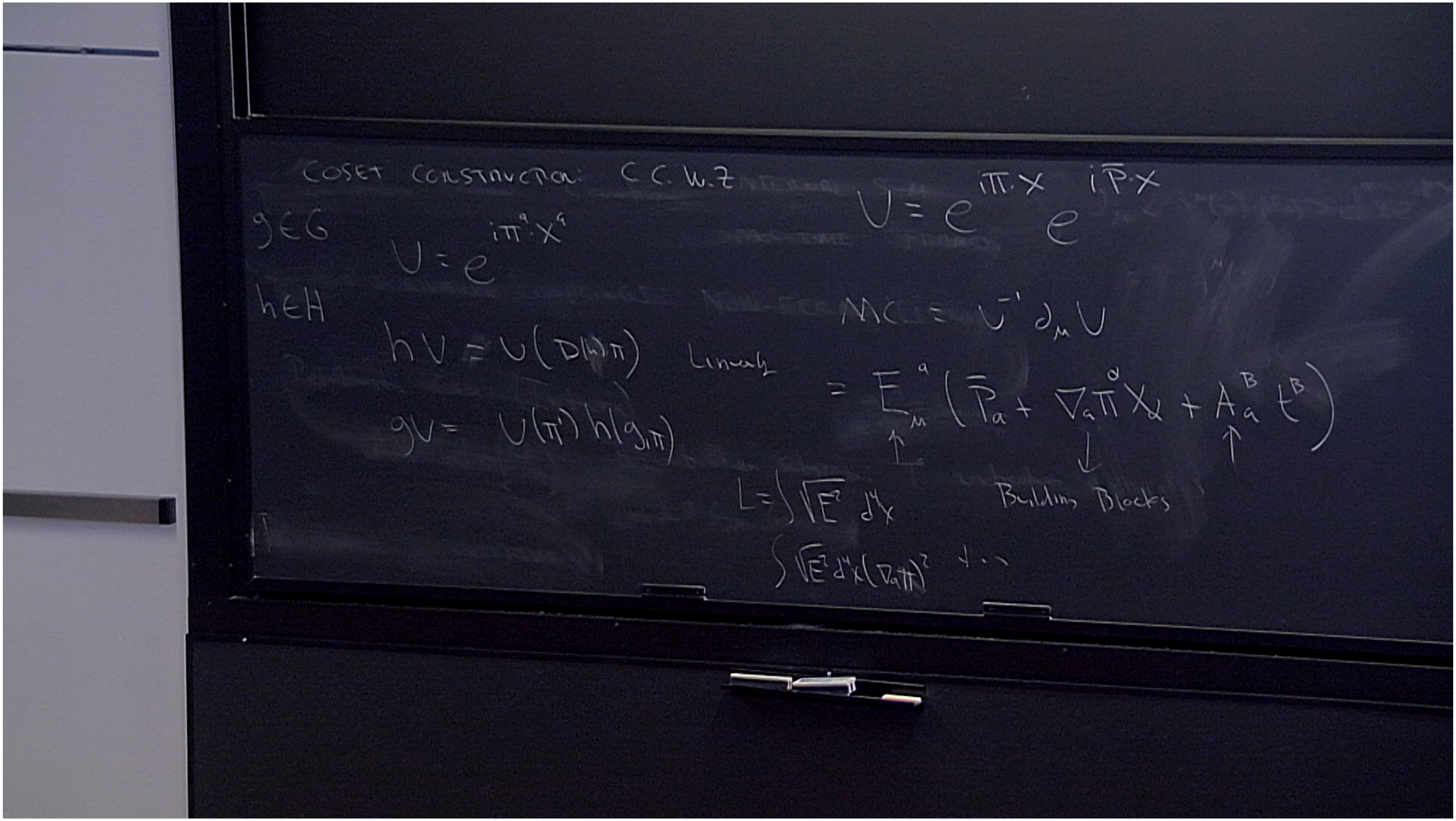
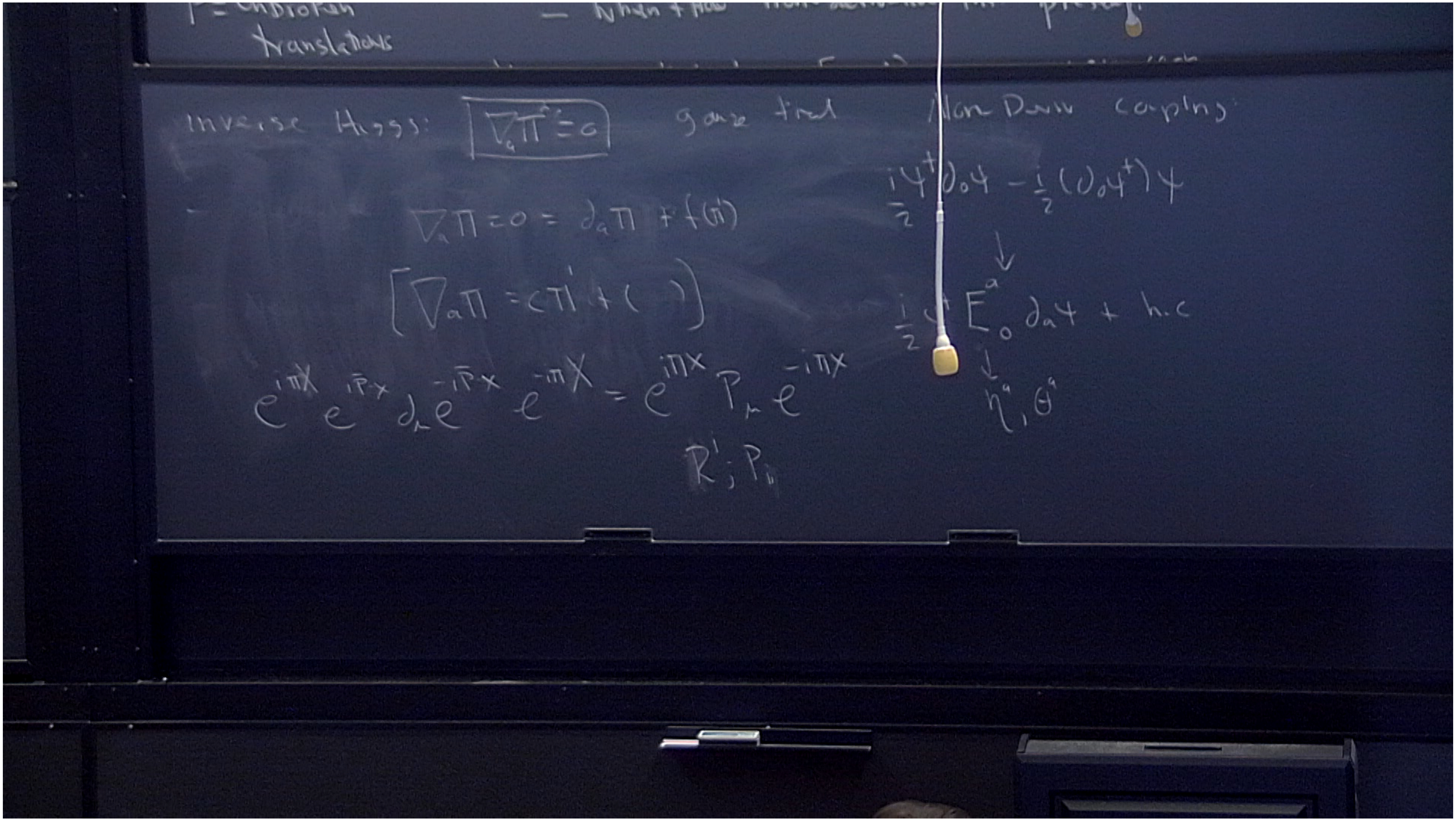
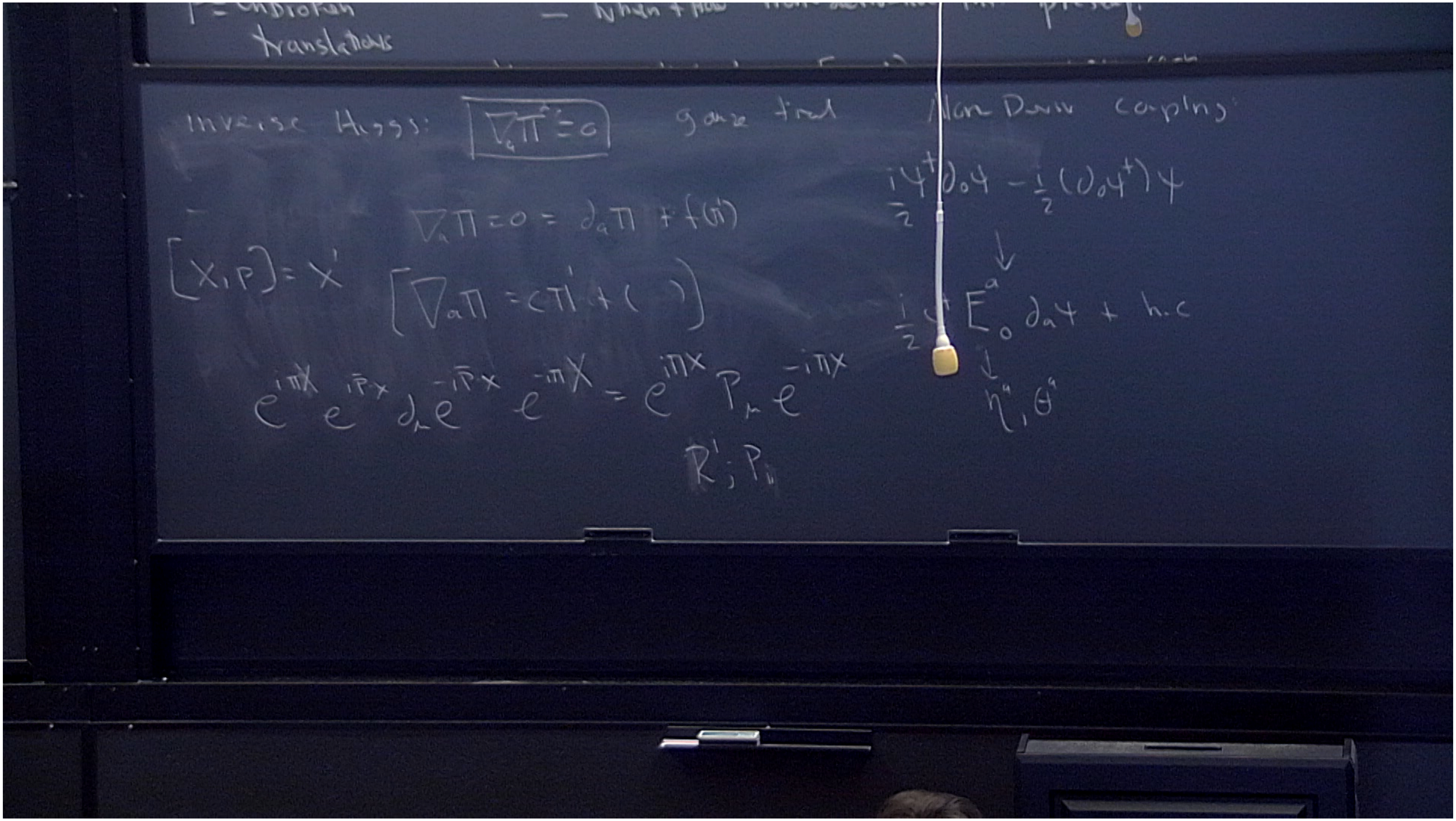
= E_μ^a (P̄_a + ∇_a π^α X_α + A_a^B
Building Blocks


COSET CONSTRUCTION: C.C.W.Z
$g \in G$
$U = e^{i\pi^a \cdot X^a}$
$h \in H$
$hU = U(D(h)\pi)$ Linearly
$gU = U(\pi') h(g,\pi)$
$U = e^{i\pi \cdot X} e^{i\bar{P} \cdot x}$
$MC = U^{-1} \partial_\mu U$
$= E^a_\mu (\bar{P}_a + \nabla_a \pi^\alpha X_\alpha + A^B_a t^B)$
$L = \int \sqrt{E^2}\, d^4x$
$\int \sqrt{E^2}\, d^4x (\nabla_a \pi)^2 + \ldots$
Building Blocks


translations
inverse Higgs:
gauge fixed
h.c


translations
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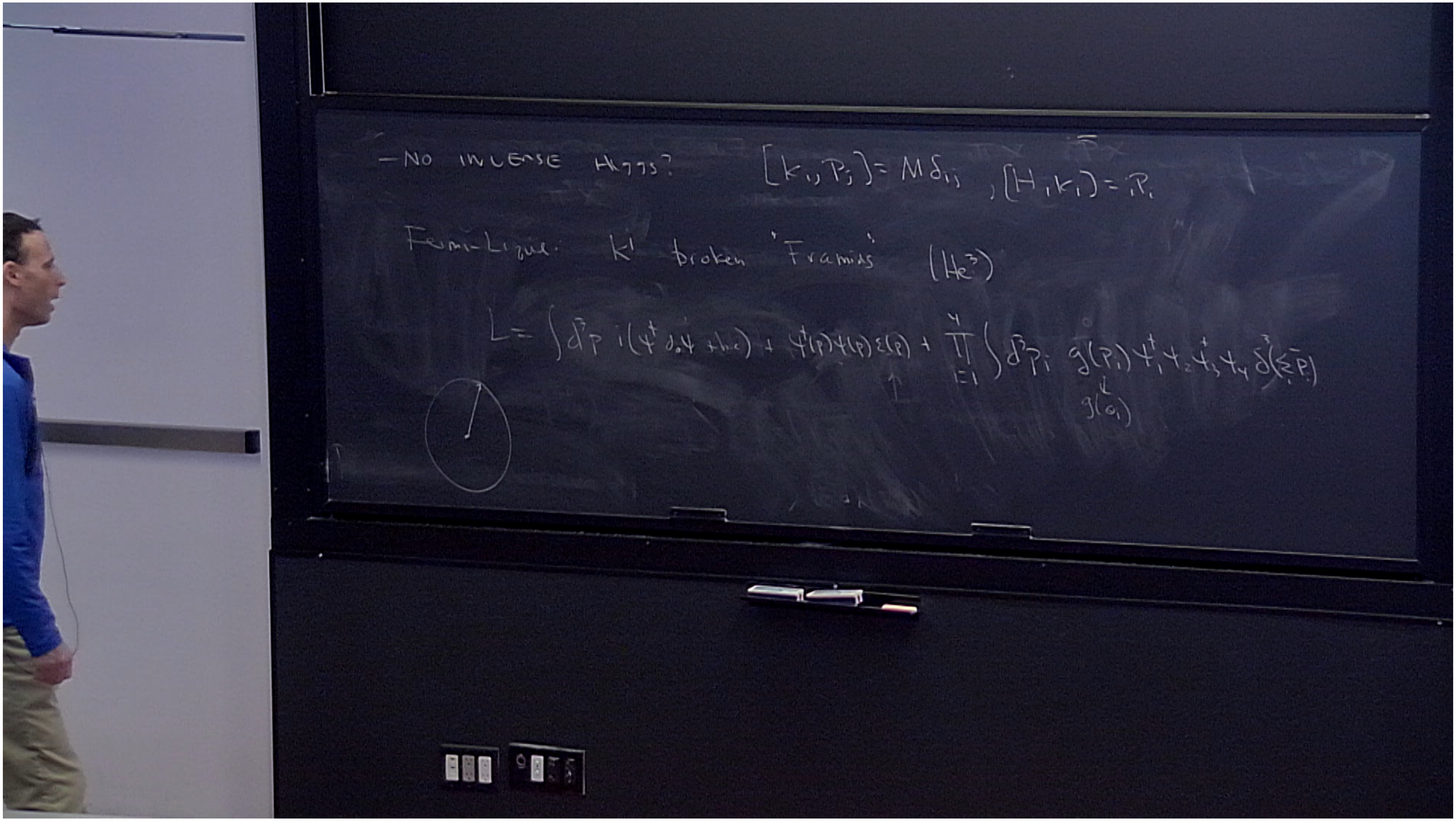
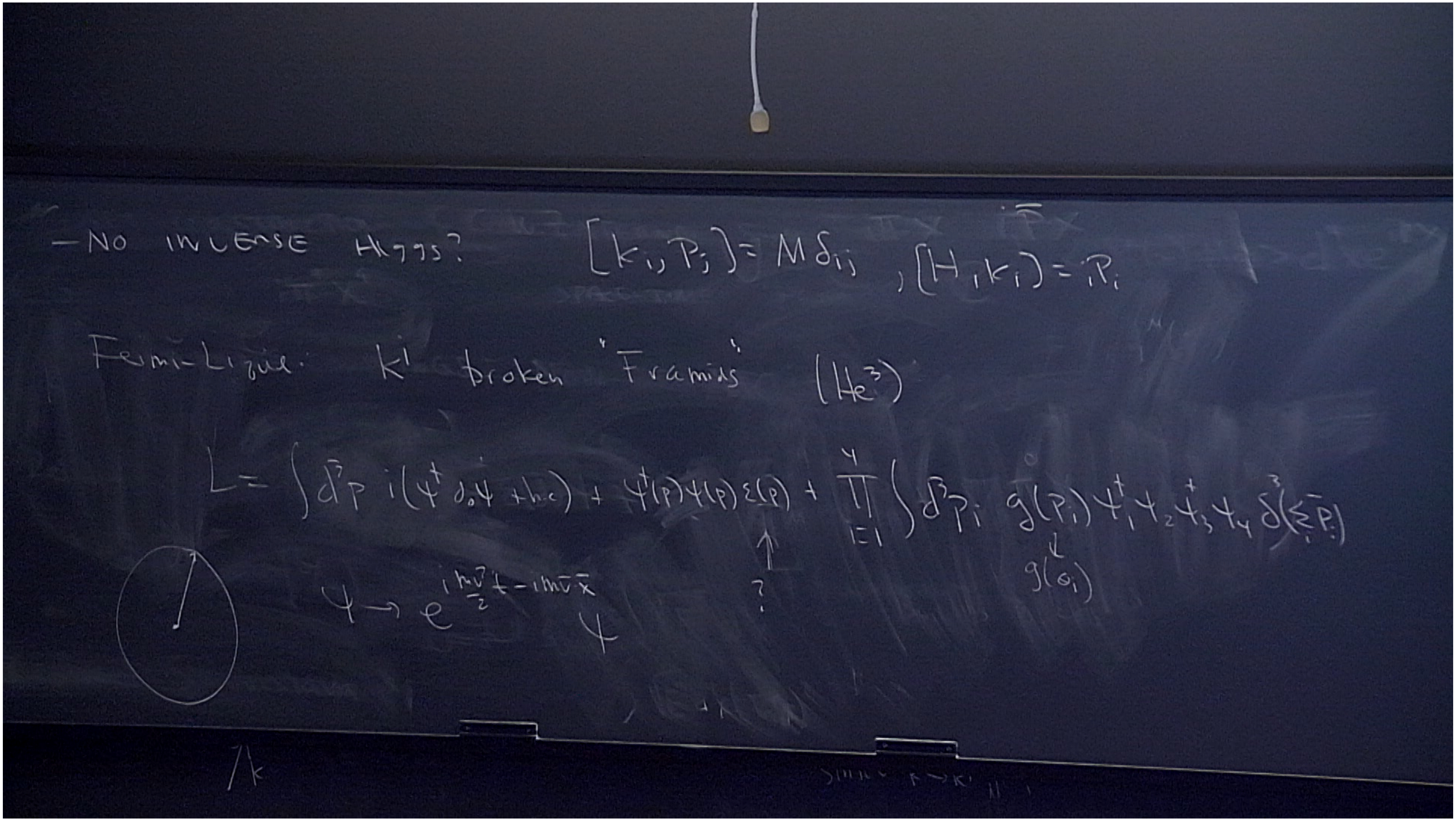
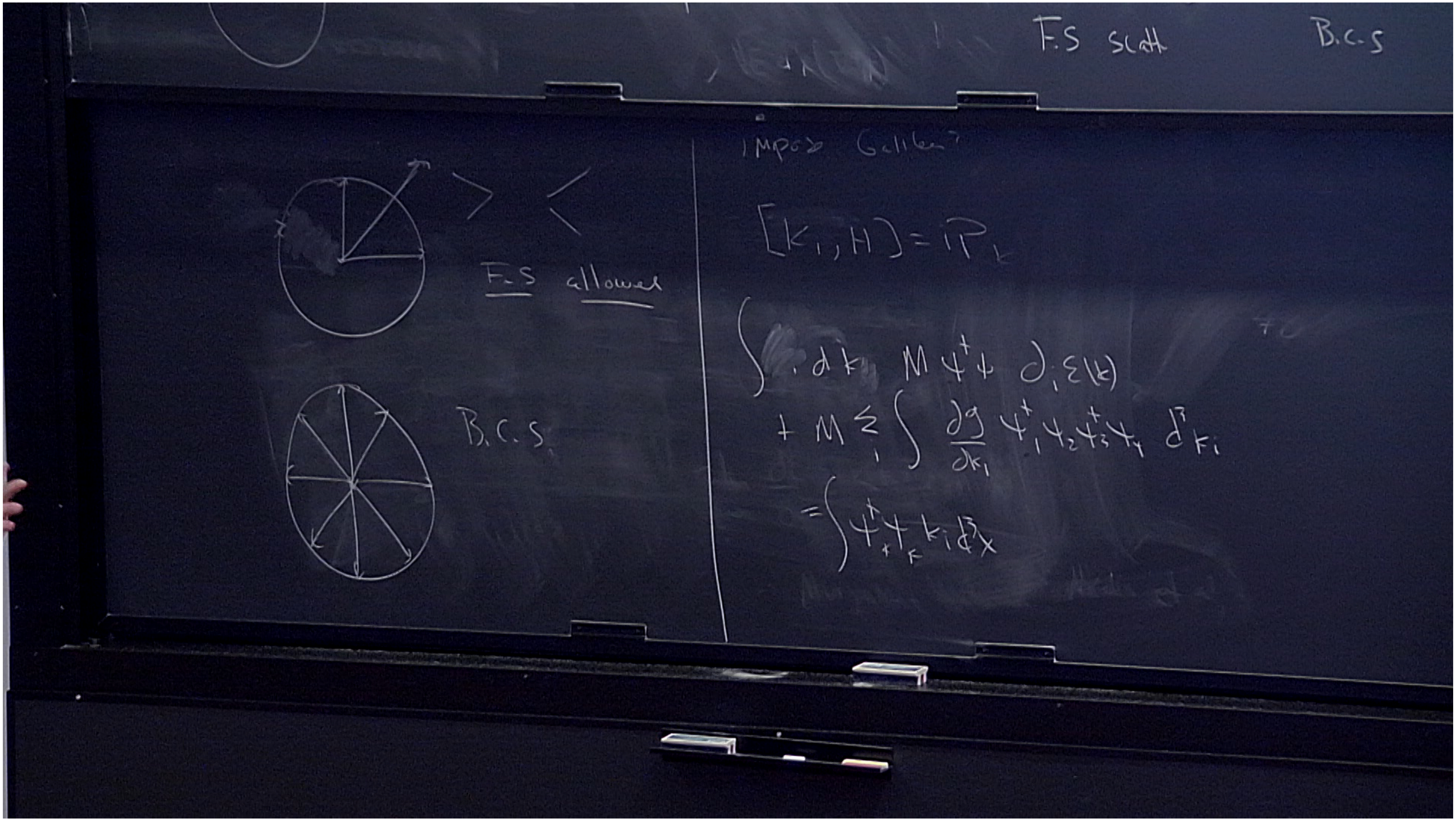
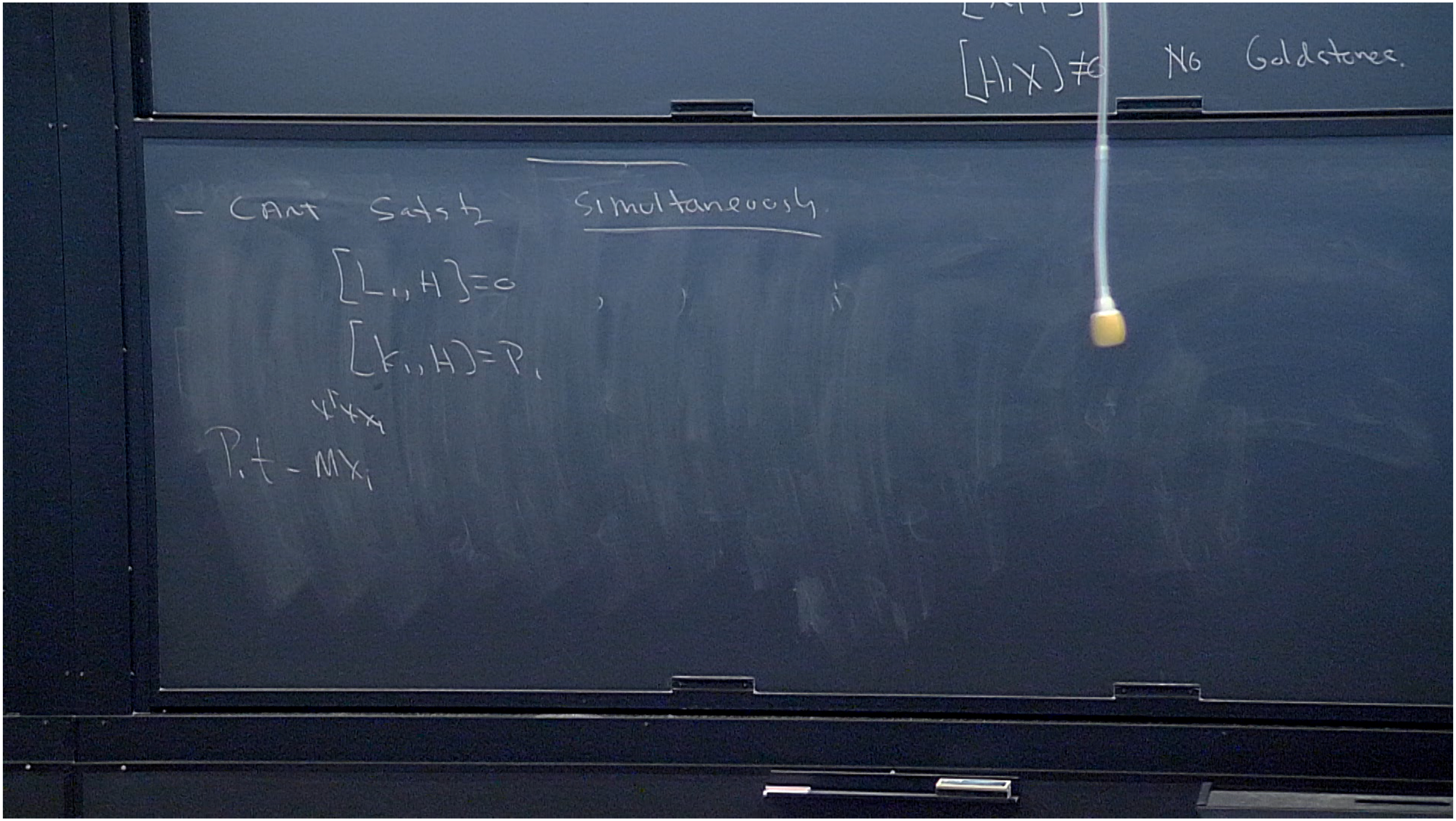


— NO INVERSE Higgs?
[K_i, P_j] = M δ_ij , [H, K_i] = P_i
Fermi-Liquid: K^i broken 'Fermions' (He^3)
L = ∫d^3p i(ψ† ∂_0 ψ + h.c.) + ψ†(p)ψ(p)ε(p) + ∏_{i=1}^{4} ∫d^3p_i g(p_i) ψ†_1 ψ_2 ψ†_3 ψ_4 δ^3(Σ p_i)
g(θ_i)


— NO INVERSE Higgs?
$[K_i, P_j] = M\delta_{ij}$ , $[H, K_i] = iP_i$
Fermi-Liquid: $K^i$ broken "Fermions" ($He^3$)
$L = \int d^3p \, i(\psi^\dagger \partial_0 \psi + h.c.) + \psi^\dagger(p)\psi(p)\varepsilon(p) + \prod_{i=1}^{4} \int d^3p_i \, g(p_i)\psi_1^\dagger \psi_2 \psi_3^\dagger \psi_4 \delta^3(\sum_i p_i)$
$g(\theta_i)$
$\psi \to e^{i\frac{mv^2}{2}t - im\bar{v}\bar{x}} \psi$


F.S scatt
B.C.S
impose Galilei?
[K_i, H] = iP_k
F.S allowed
B.C.S


[H, X] ≠ 0 No Goldstones.
- Can't satisfy simultaneously
[L_i, H] = 0
[K_i, H] = P_i
P_i t - M x_i