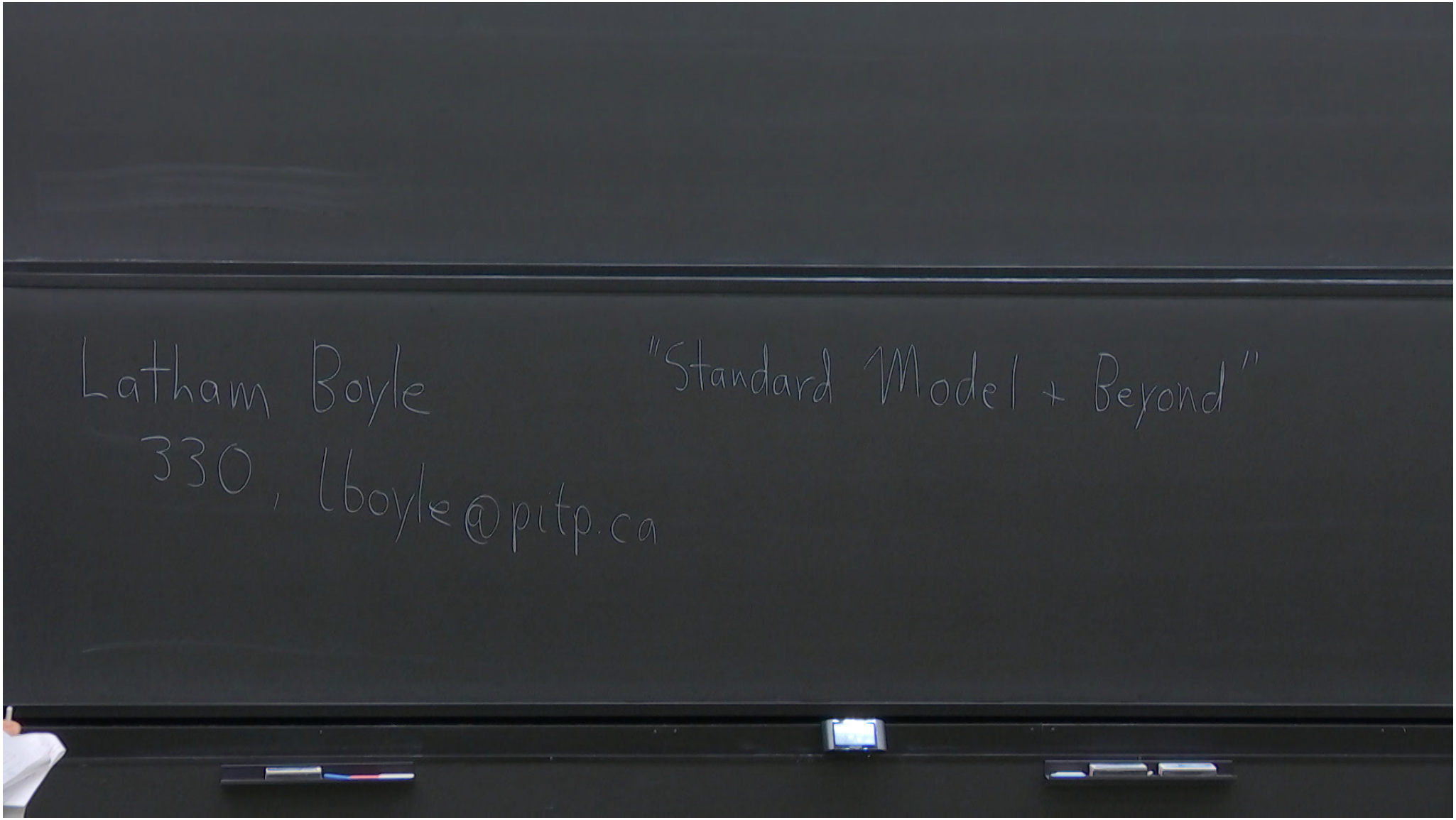
Title: PSI 2019/2020 - Standard Model and Beyond - Part 1 - Lecture 1

Speakers: Latham Boyle

Collection: PSI 2019/2020 - Standard Model and Beyond - Part 1

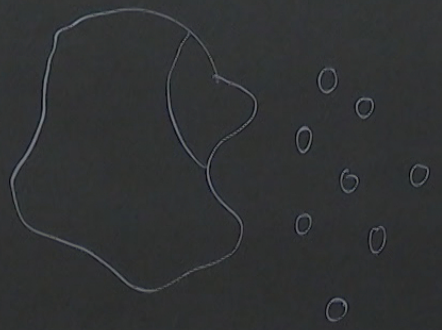
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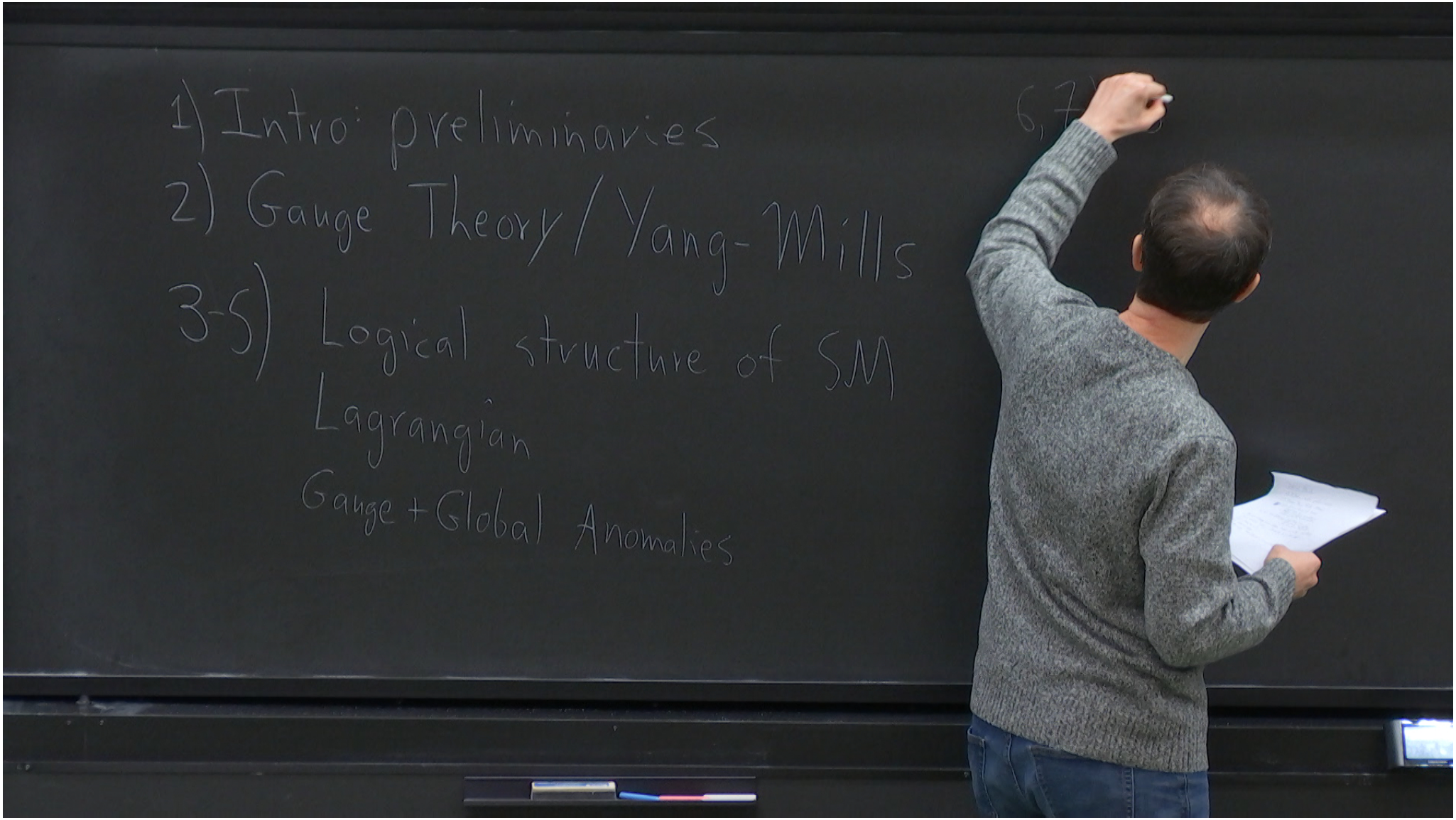
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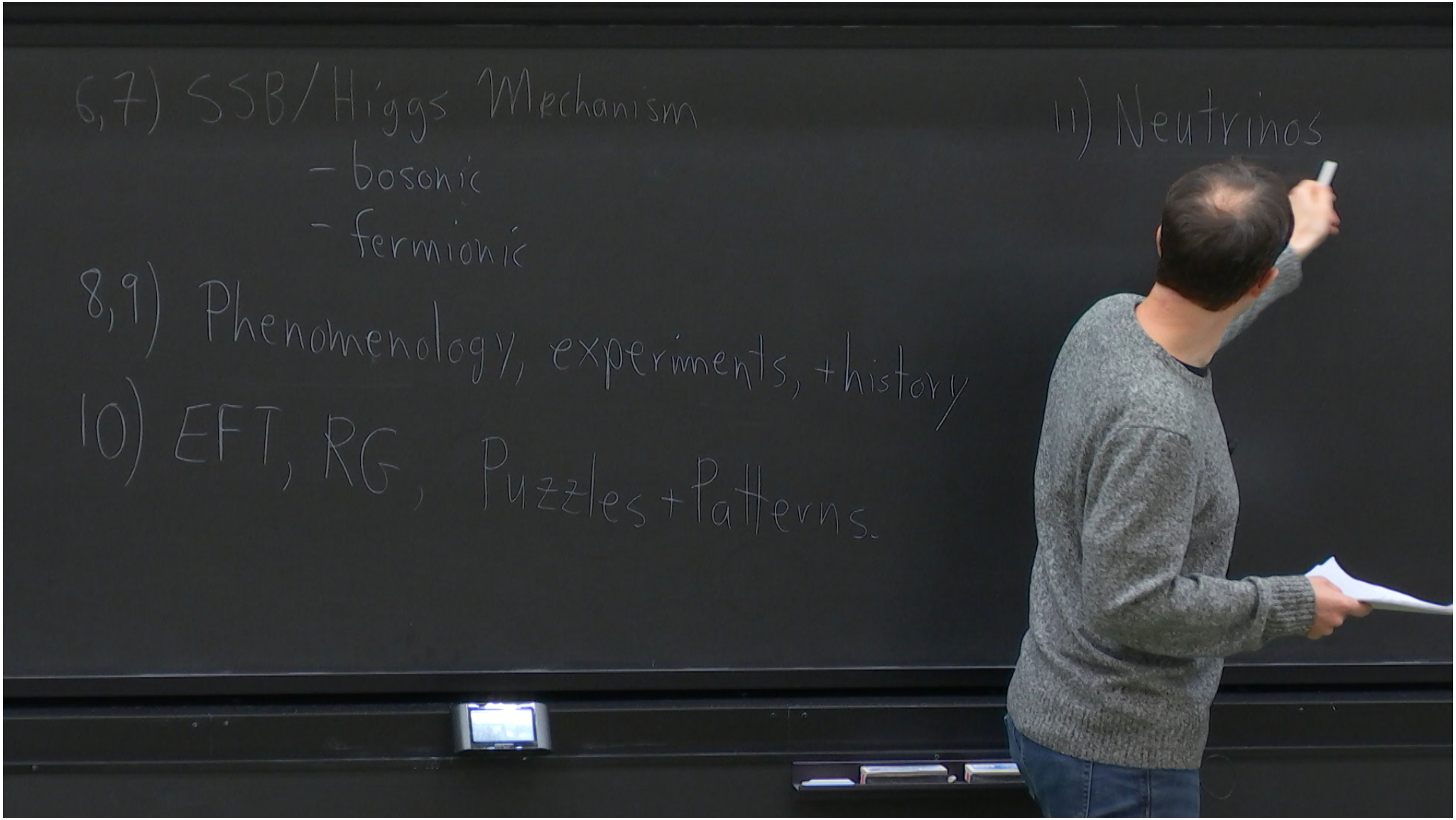

Latham Boyle
330, lboyle@pitp.ca
"Standard Model + Beyond"

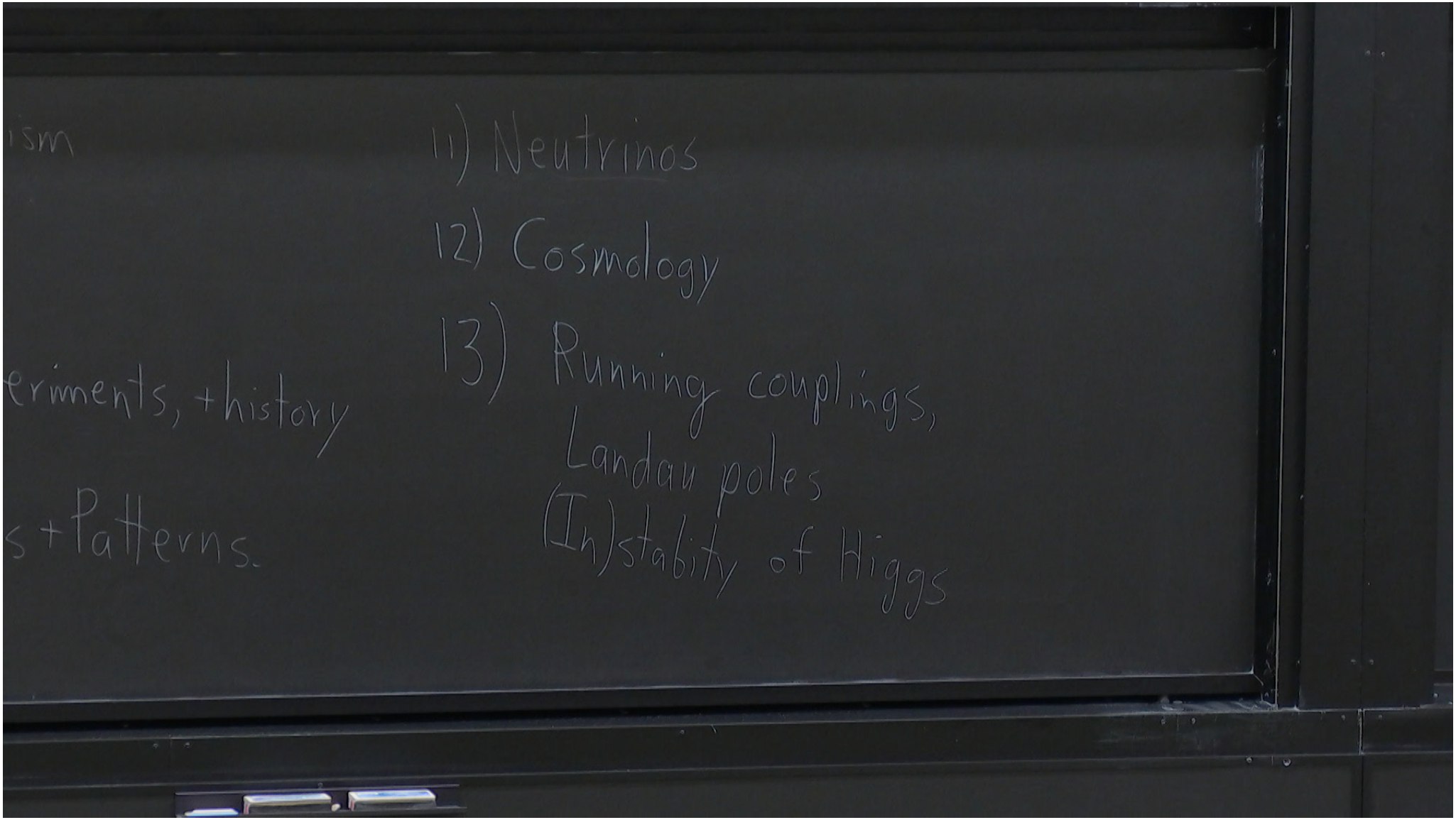
"Standard Model + Beyond"

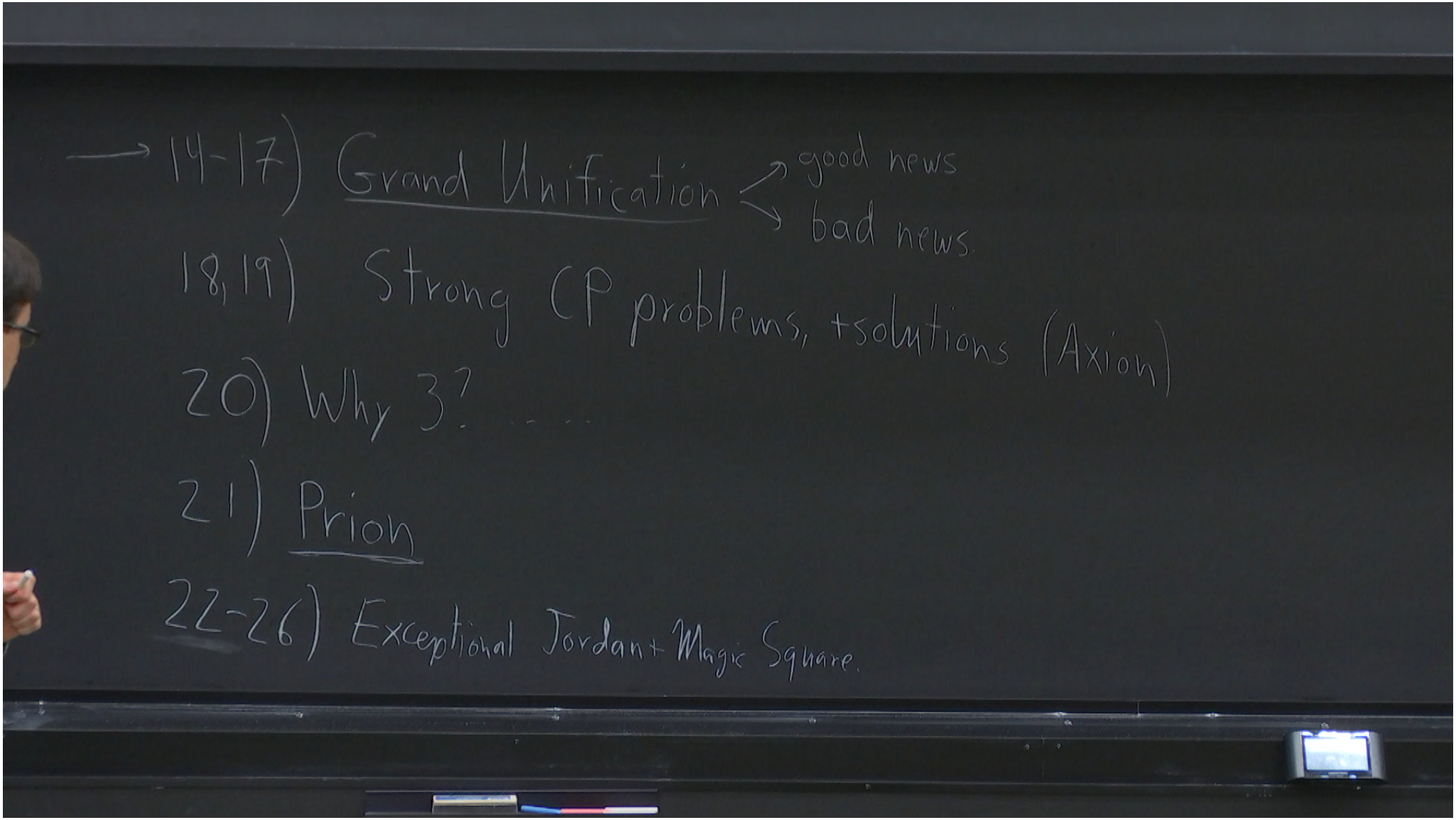
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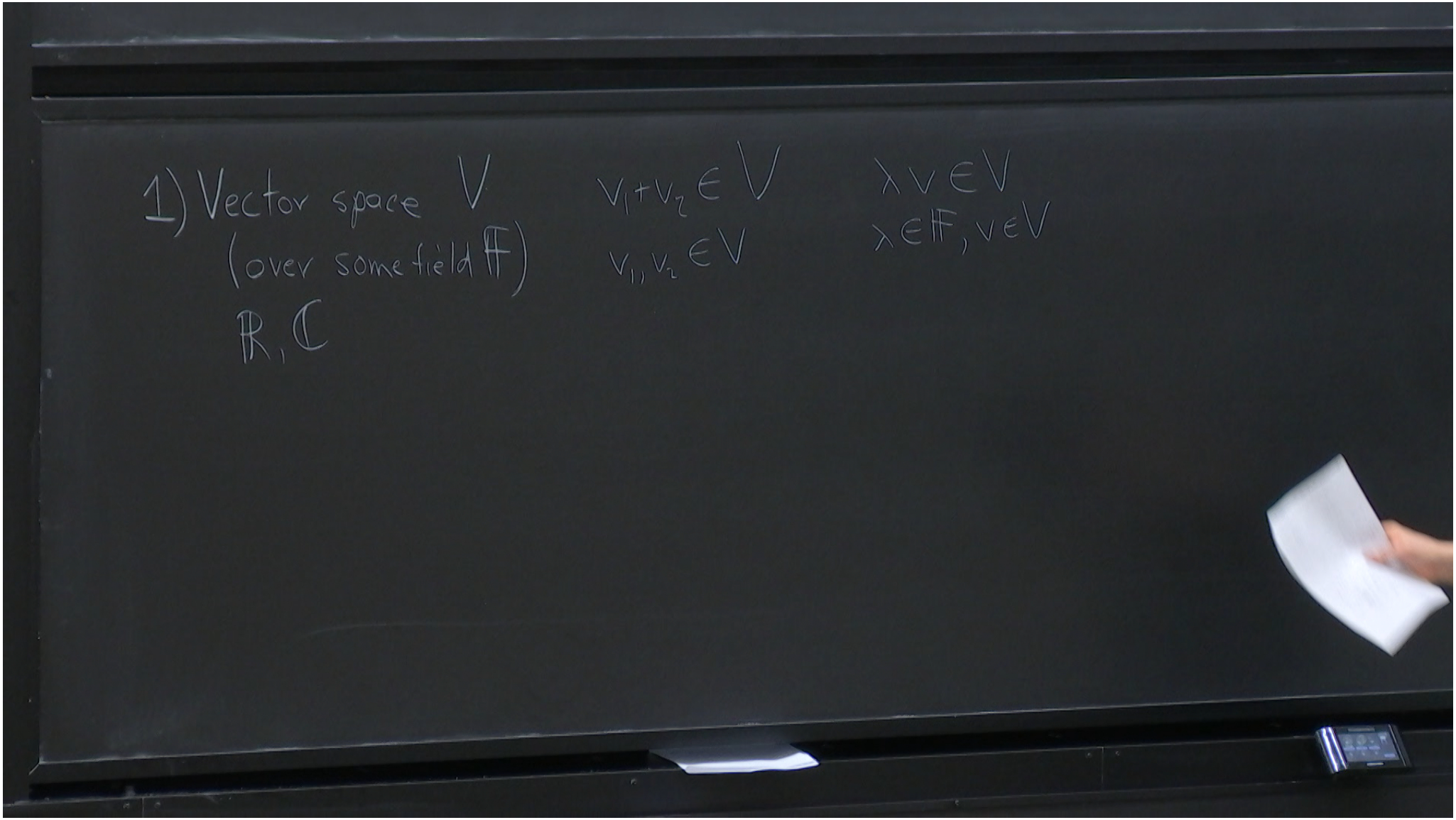


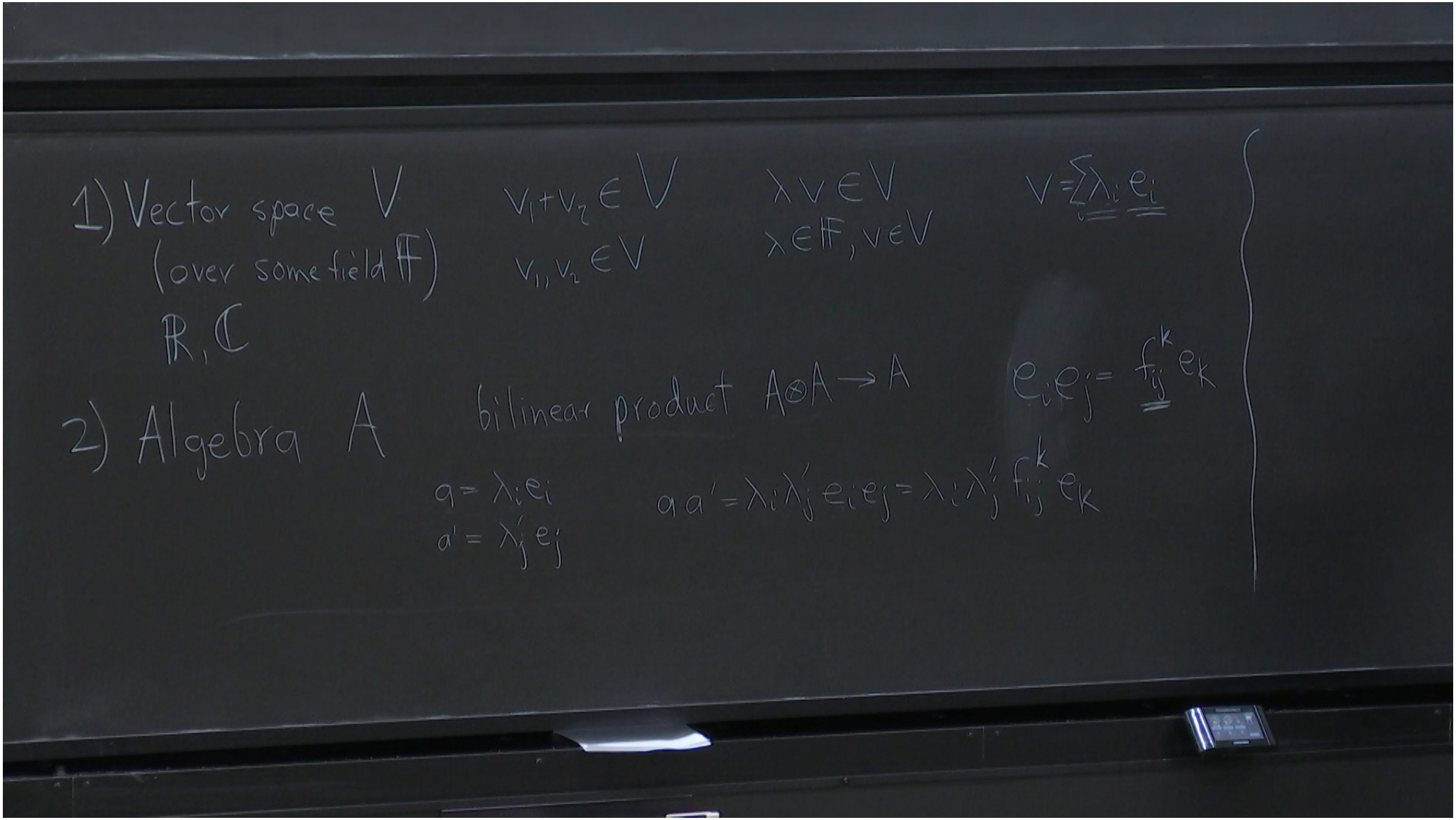

1) Intro: preliminaries
2) Gauge Theory / Yang-Mills
3-5) Logical structure of SM Lagrangian
Gauge + Global Anomalies

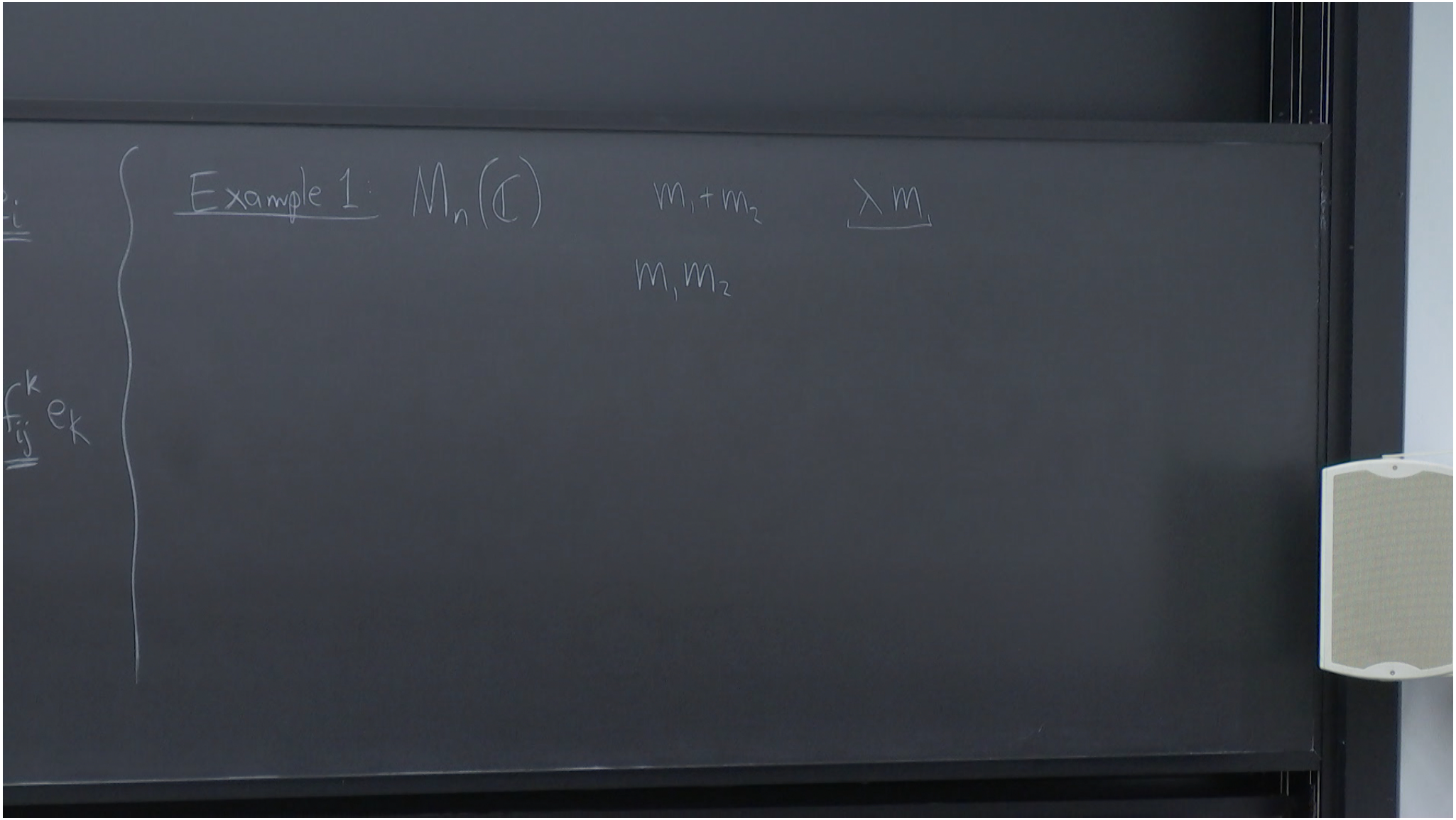

6,7) SSB/Higgs Mechanism
- bosonic
- fermionic
8,9) Phenomenology, experiments, + history
10) EFT, RG, Puzzles + Patterns.
11) Neutrinos

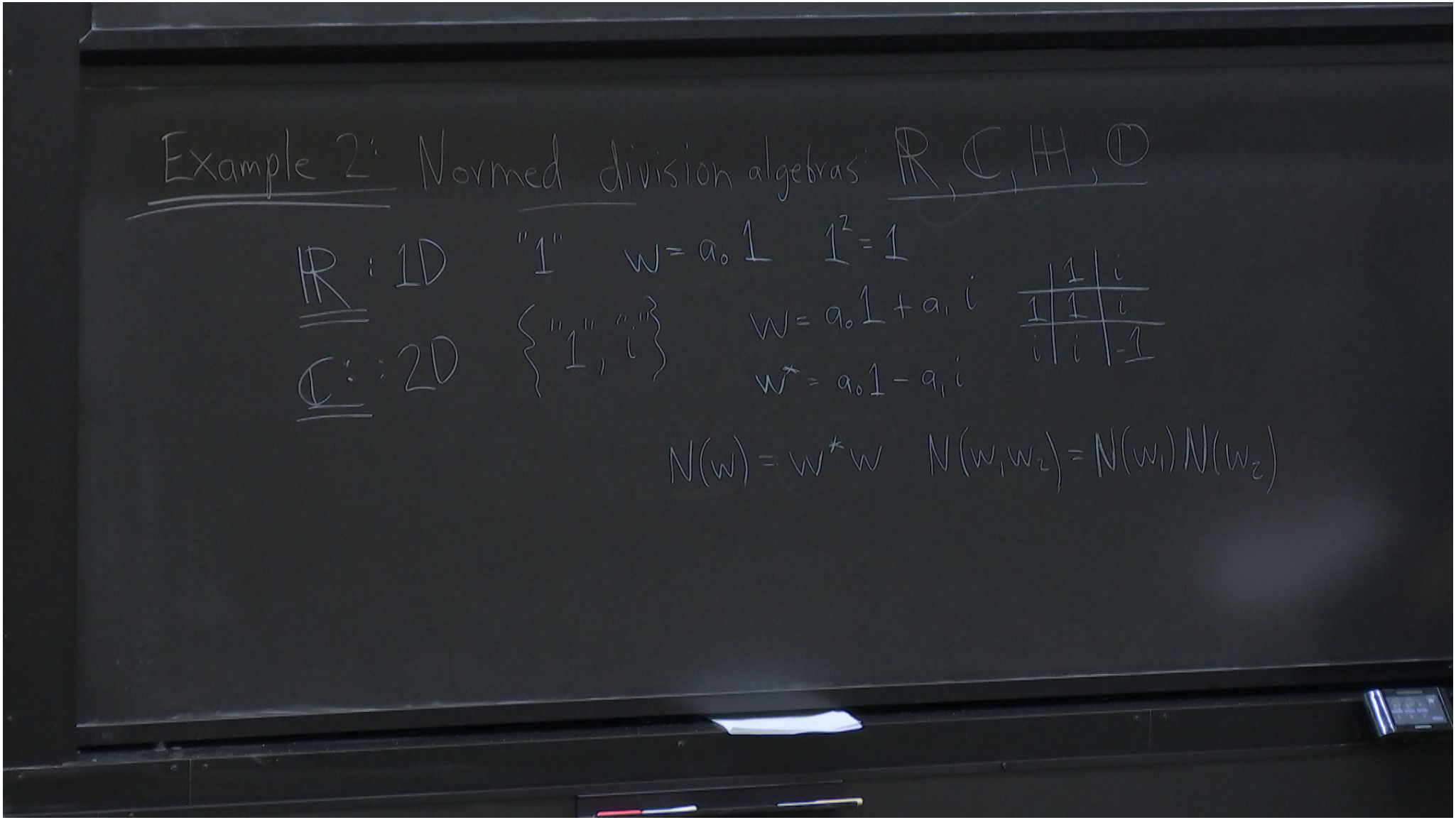

ism
eriments, + history
s + Patterns.
11) Neutrinos
12) Cosmology
13) Running couplings,
Landau poles
(In)stability of Higgs

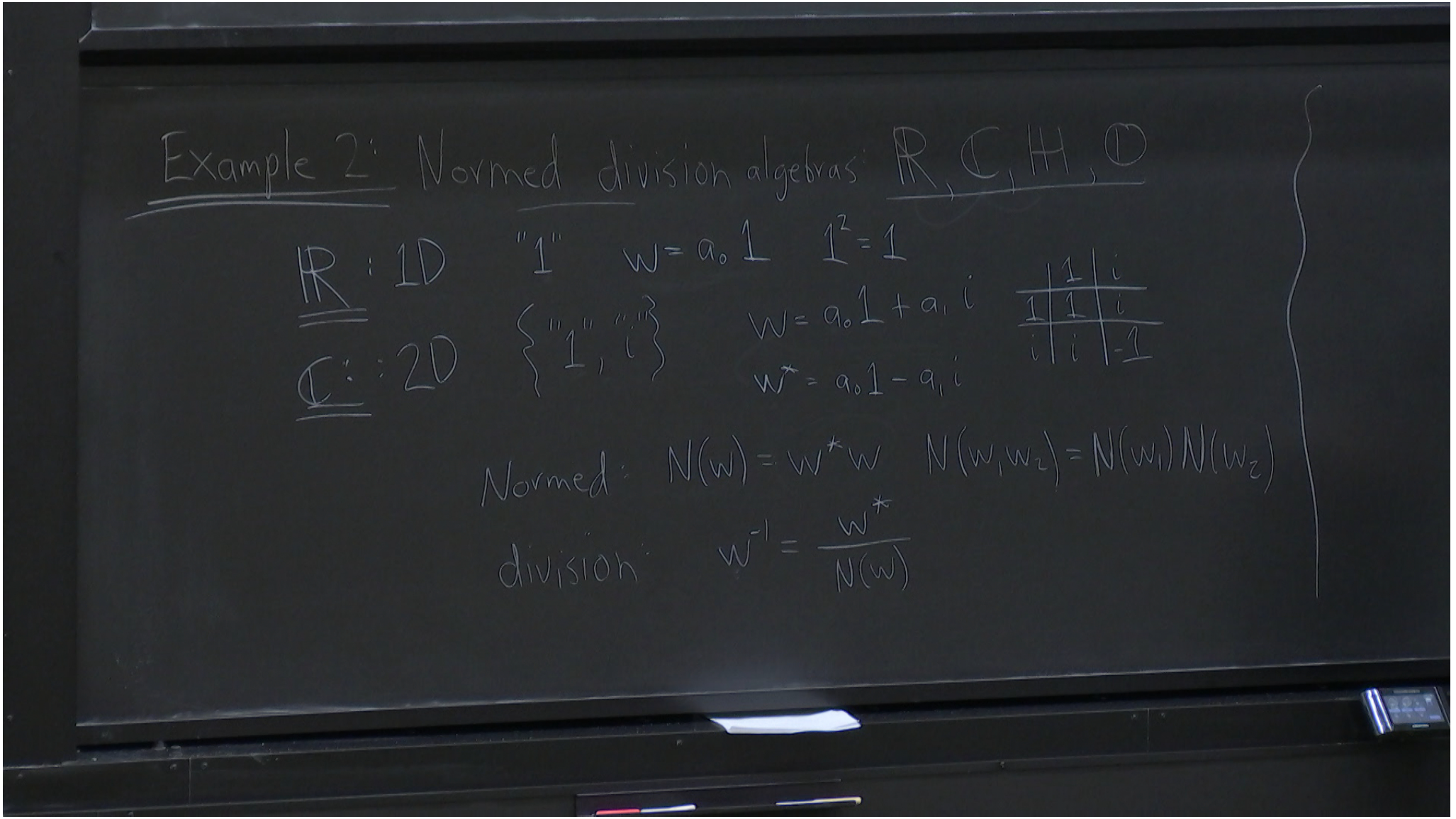

14-17) Grand Unification
good news
bad news
18,19) Strong CP problems, +solutions (Axion)
20) Why 3? ...
21) Prion
22-26) Exceptional Jordan + Magic Square.

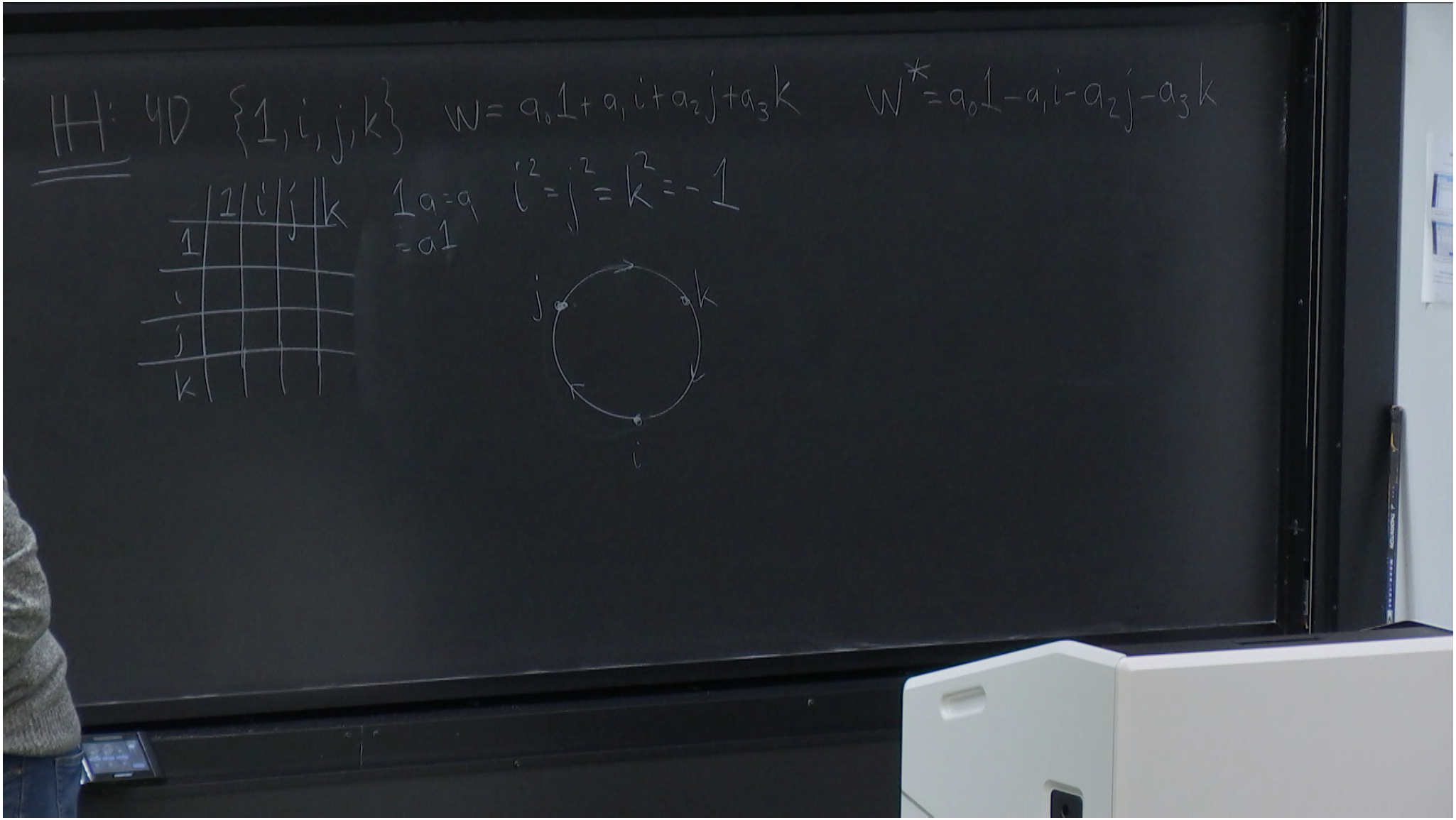

1) Vector space V
(over some field F)
R, C
$v_1 + v_2 \in V$
$v_1, v_2 \in V$
$\lambda v \in V$
$\lambda \in F, v \in V$

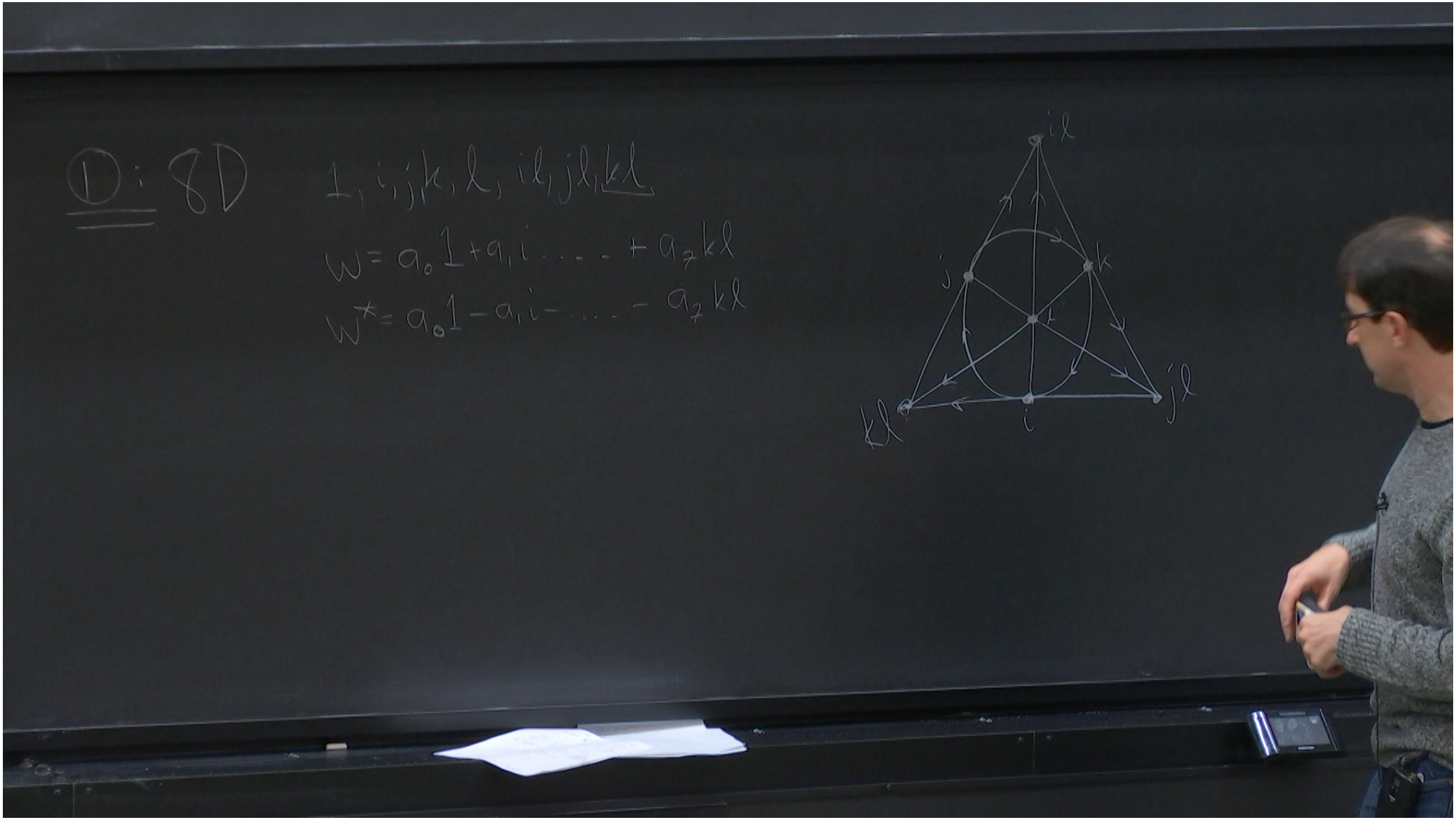

1) Vector space V
(over some field F)
R, C
$v_1 + v_2 \in V$
$v_1, v_2 \in V$
$\lambda v \in V$
$\lambda \in F, v \in V$
$v = \sum_i \lambda_i e_i$
2) Algebra A
bilinear product $A \otimes A \to A$
$e_i e_j = f_{ij}^k e_k$
$a = \lambda_i e_i$
$a' = \lambda'_j e_j$
$a a' = \lambda_i \lambda'_j e_i e_j = \lambda_i \lambda'_j f_{ij}^k e_k$

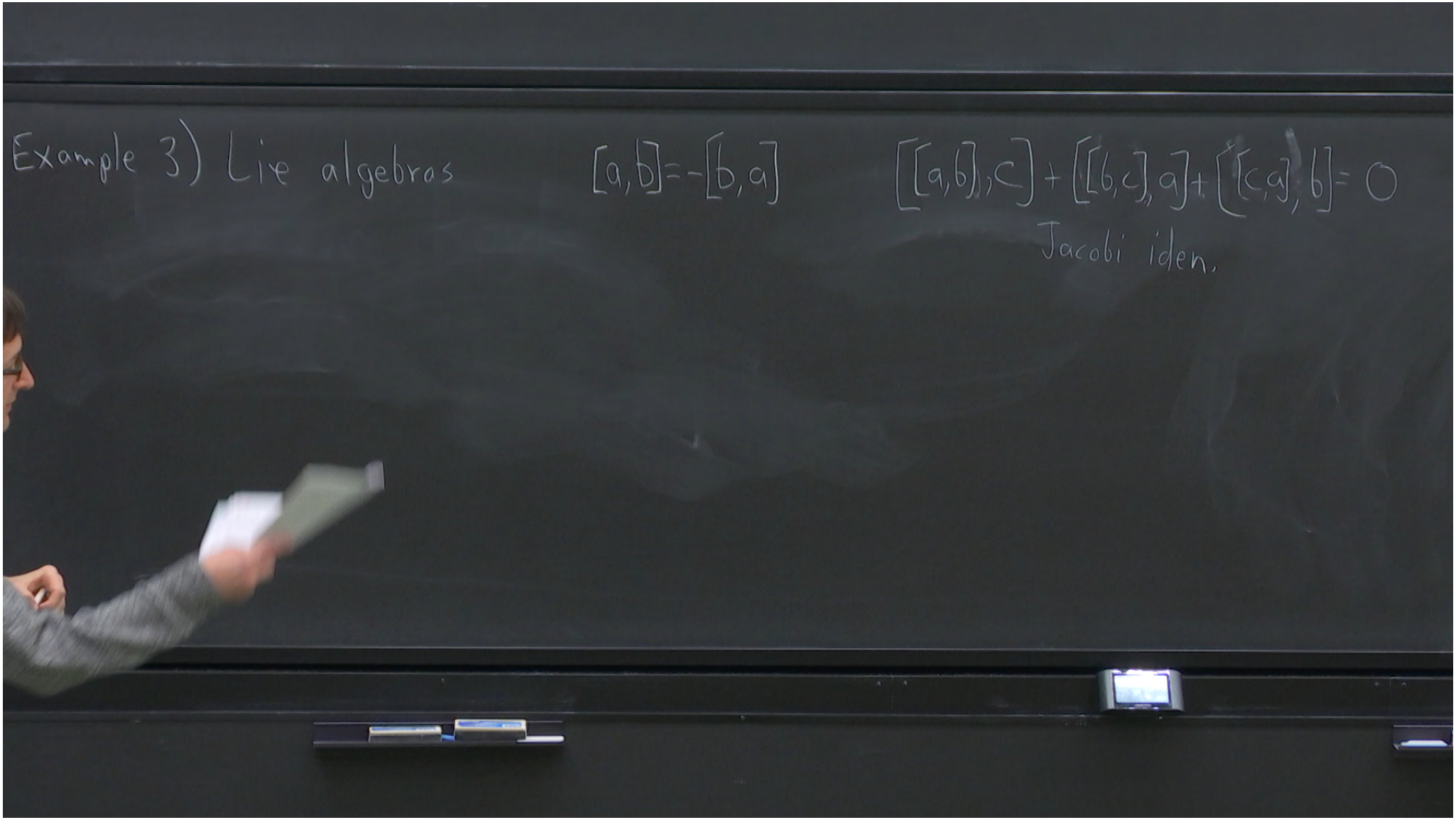

Example 1: $M_n(\mathbb{C})$
$m_1 + m_2$
λm_1
$m_1 m_2$
$f_{ij}^k e_k$


Example 2: Normed division algebras: ℝ, ℂ, ℍ, 𝕆
ℝ : 1D "1" w = a₀1 1² = 1
ℂ : 2D {"1", i} w = a₀1 + a₁i
w* = a₀1 − a₁i
N(w) = w*w N(w₁w₂) = N(w₁)N(w₂)
1 i
1 1 i
i i -1


Example 2: Normed division algebras: R, C, H, O
R : 1D "1" w = a0 1 1² = 1
C : 2D {"1", i} w = a0 1 + a1 i
w* = a0 1 − a1 i
1 | i
1 | 1 | i
i | i | -1
Normed: N(w) = w* w N(w1 w2) = N(w1) N(w2)
division: w⁻¹ = w* / N(w)


H: 4D {1, i, j, k} w = a0 1 + a1 i + a2 j + a3 k w* = a0 1 − a1 i − a2 j − a3 k
1 i j k
1
i
j
k
1a = a
−a1
i² = j² = k² = −1
j
k
i


D: 8D
1, i, j, k, l, il, jl, kl
W = a0 1 + a1 i ... + a7 kl
W* = a0 1 − a1 i − ... − a7 kl
il
j
k
l
kl
i
jl


Example 3) Lie algebras
[a,b]=-[b,a]
[[a,b],c]+[[b,c],a]+[[c,a],b]=0
Jacobi iden.

Example 3) Lie algebras $[a,b] = -[b,a]$ $[[a,b],c] + [[b,c],a] + [[c,a],b] = 0$ Jacobi iden.

$so(n)$: $\{x \in M_n(\mathbb{R}) \mid x^\dagger = -x,\ tr[x] = 0\}$

$su(n)$: $\{x \in M_n(\mathbb{C}) \mid x^\dagger = -x,\ tr[x] = 0\}$

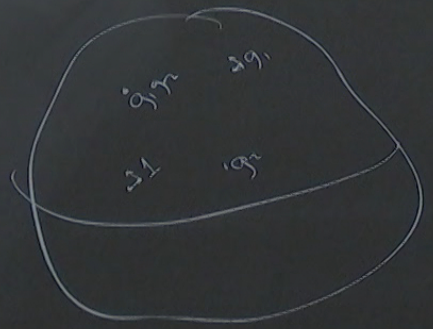
$Sp(n)$: $\{x \in M_n(\mathbb{H}) \mid x^\dagger = -x\}$

g_2, f_4, e_6, e_7, e_8

$[[c,a],b]=0$

Groups: $g_1 g_2$ $1g=g1=g$ $(g_1 g_2)g_3=g_1(g_2 g_3)$

$g^{-1}g=gg^{-1}=1$



$x \in A$ $g=e^{x}$

$g_1 g_2$

Example 3) Lie algebras $[a,b] = -[b,a]$ $[[a,b],c] + [$

Jac

$so(n)$: $\{ g \in M_n(\mathbb{R}) \mid g^t g = 1,\ \det(g) = 1 \}$

$su(n)$: $\{ g \in M_n(\mathbb{C}) \mid g^t g = 1,\ \det(g) = 1 \}$

$Sp(n)$: $\{ g \in M_n(\mathbb{H}) \mid g^t g = 1 \}$

g_2, f_4, e_6, e_7, e_8