Title: Particle Physics Lecture

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Collection: Particle Physics

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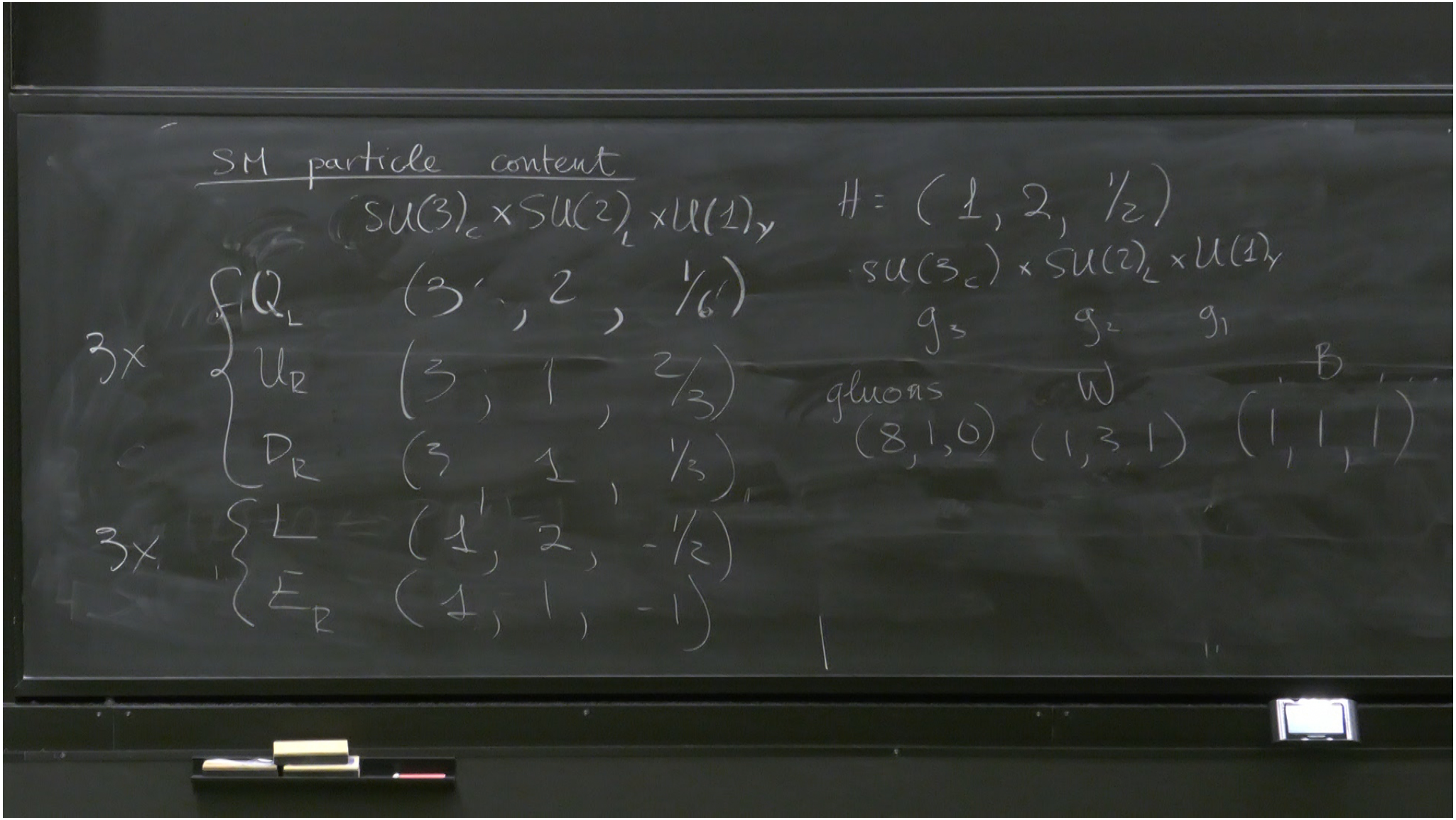
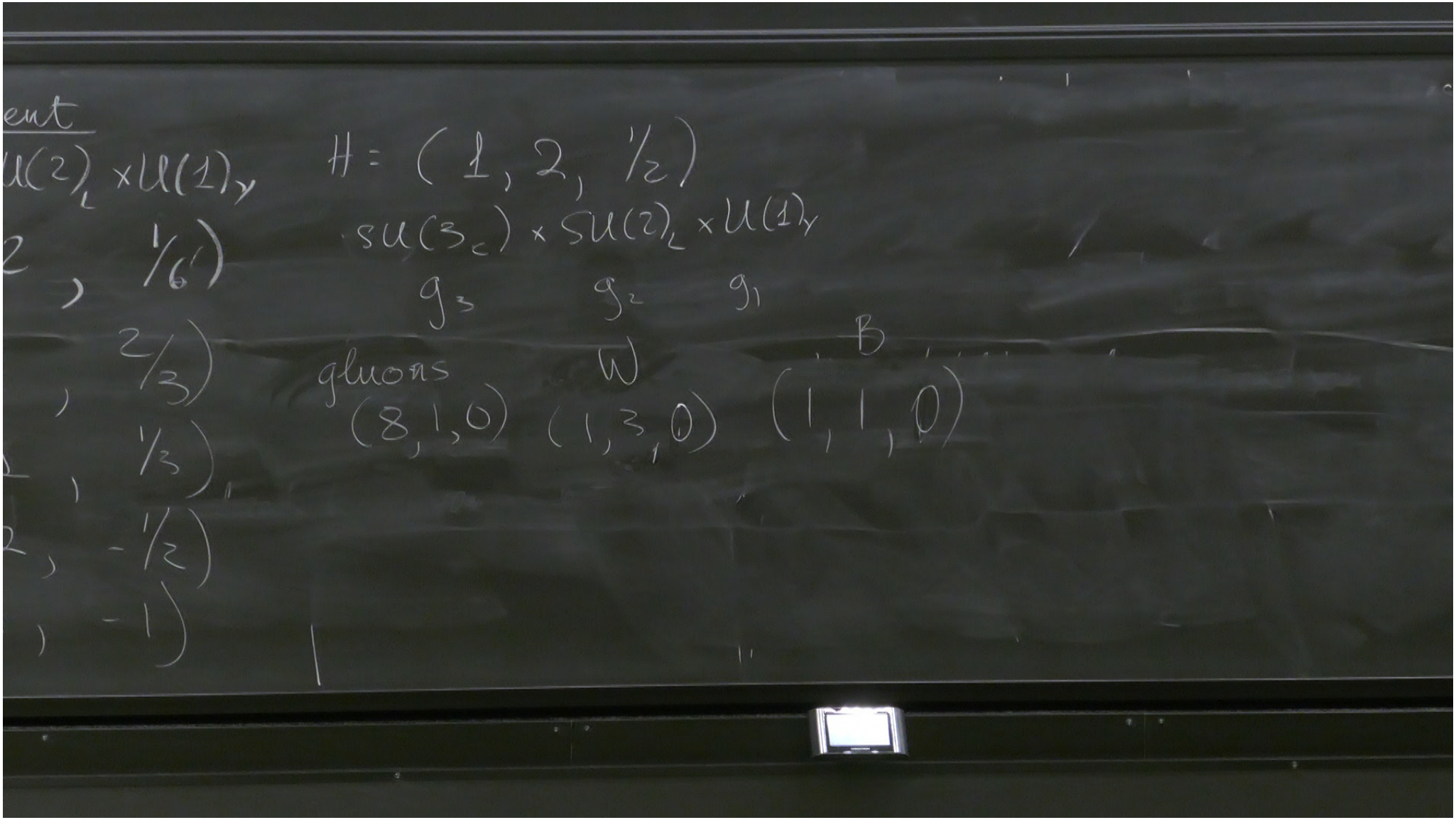

SM particle content
$SU(3)_c \times SU(2)_L \times U(1)_Y$
$H = (1, 2, 1/2)$
$SU(3_c) \times SU(2)_L \times U(1)_Y$
g_3 g_2 g_1
gluons W B
$(8,1,0)$ $(1,3,1)$ $(1,1,1)$
3x
Q_L $(3, 2, 1/6)$
U_R $(3, 1, 2/3)$
D_R $(3, 1, 1/3)$
3x
L $(1, 2, -1/2)$
E_R $(1, 1, -1)$


ent
$U(2)_L \times U(1)_Y$
$H = (1, 2, 1/2)$
$SU(3_c) \times SU(2)_L \times U(1)_Y$
g_3 g_2 g_1
gluons W B
$(8,1,0)$ $(1,3,0)$ $(1,1,0)$

quarks $m_u = 2$ MeV, $m_c = 1.3$ GeV, $m_t = 173$ GeV

$m_d = 4.8$ MeV, $m_s = 96$ MeV, $m_b = 4.2$ GeV

+3 mixing angles, +1 $\not{CP}$ phase

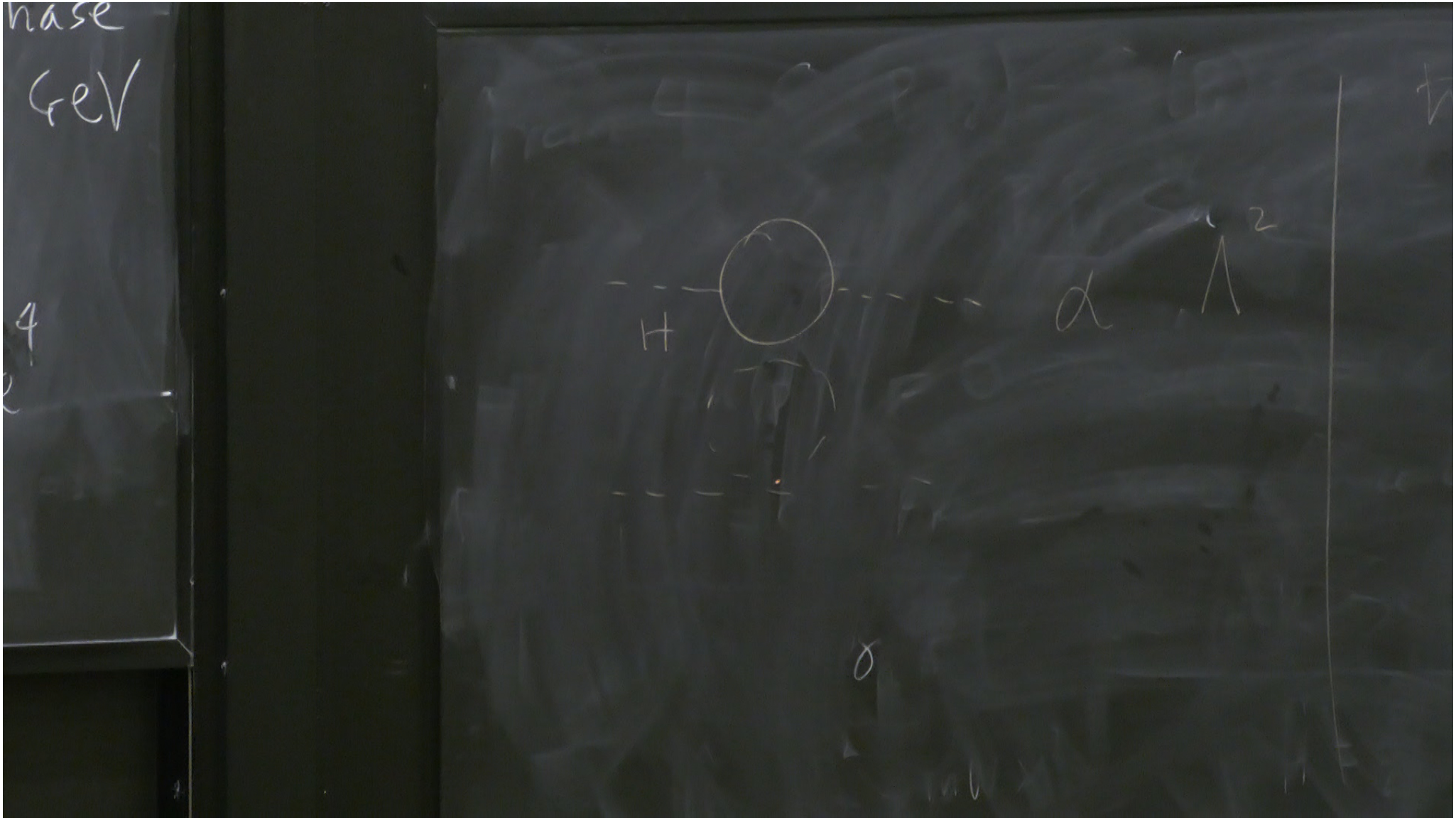
leptons: $m_e = 511$ keV, $m_\mu = 105$ MeV, $m_\tau = 1.8$ GeV

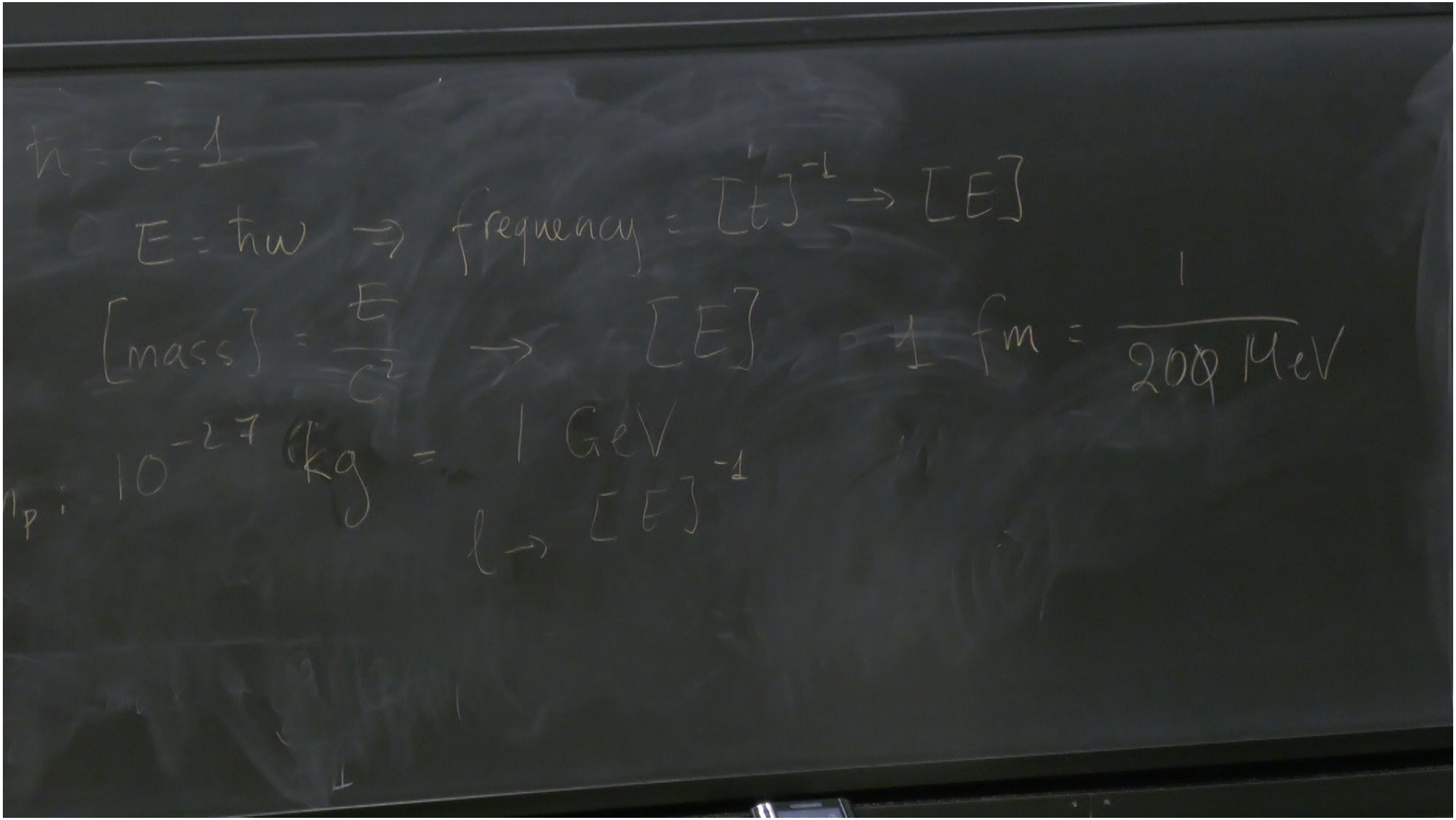
(+ (neutrino masses $\ll m_e$))

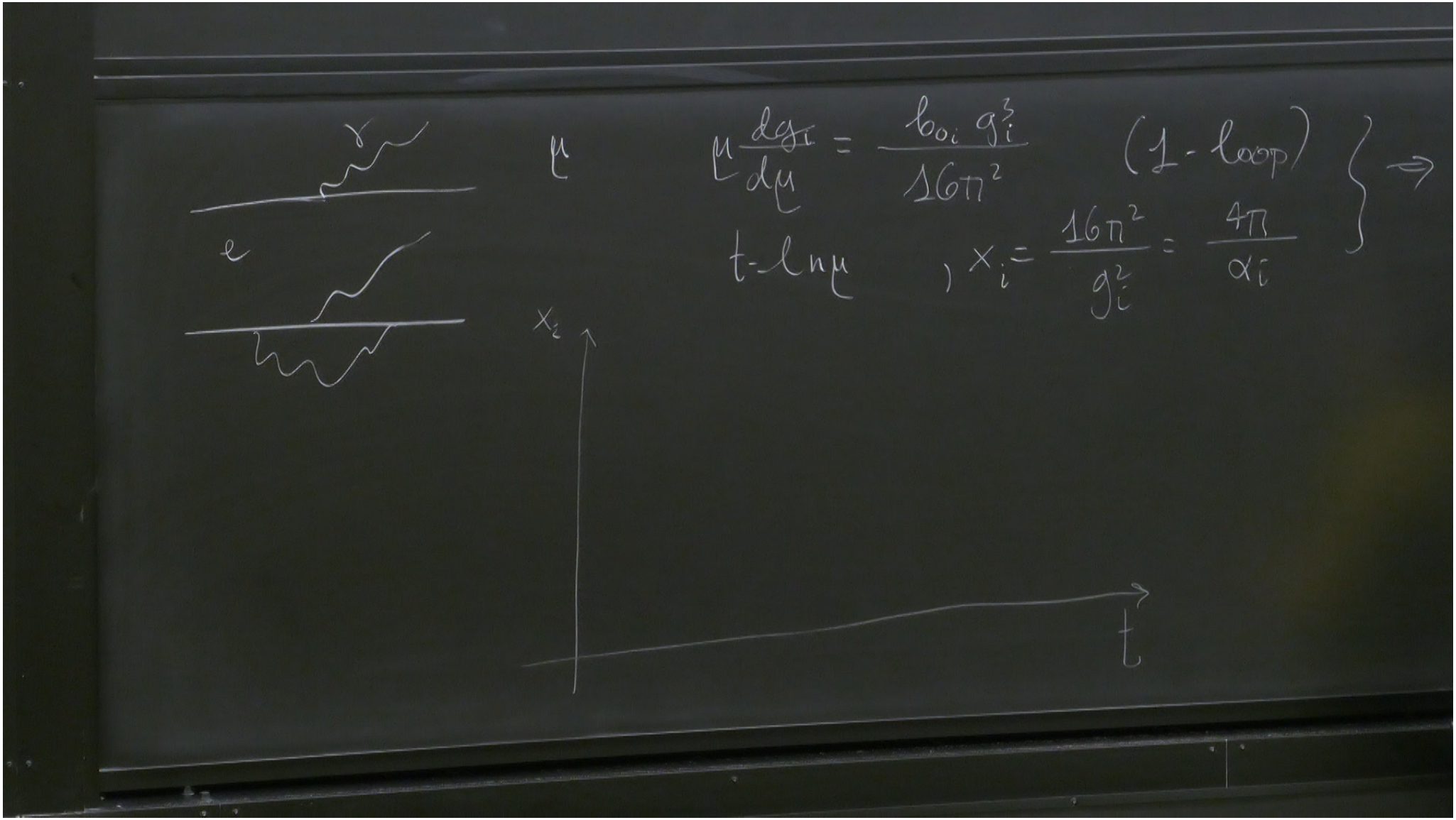
$$+ \left(\theta_{QCD}\right) \frac{g_s^2}{32\pi^2} G\tilde{G}$$

$M_{pl} = 1.22 \times 10^{19}$ GeV, $\Lambda = 2.8 \times 10^{-12} M_{pl}^4$

Higgs vev: 245 GeV, $m_h = 125$ GeV


hase
GeV
H
α
Λ
2


$\hbar = c = 1$
$E = \hbar\omega \Rightarrow$ frequency $= [t]^{-1} \to [E]$
$[\text{mass}] = \frac{E}{c^2} \to [E]$
$1\ \text{fm} = \frac{1}{200\ \text{MeV}}$
$m_p : 10^{-27}\ \text{kg} = 1\ \text{GeV}$
$l \to [E]^{-1}$


γ
e
μ
$\mu \frac{dg_i}{d\mu} = \frac{b_{0i} g_i^3}{16\pi^2}$ (1-loop)
$t = \ln \mu$, $x_i = \frac{16\pi^2}{g_i^2} = \frac{4\pi}{\alpha_i}$
x_i
t

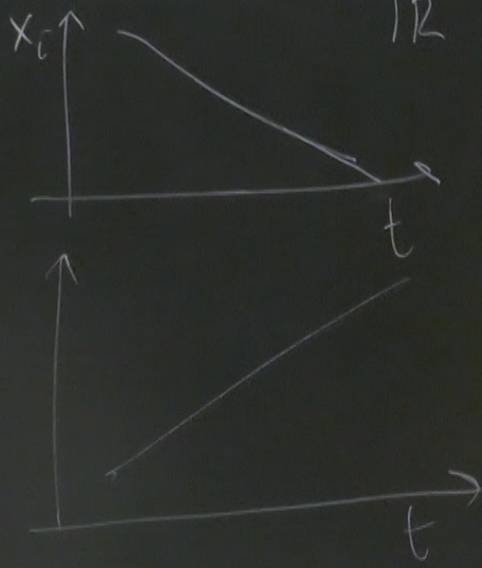
$$\mu \frac{dg_i}{d\mu} = \frac{b_{0i} g_i^3}{16\pi^2} \quad (1\text{-loop}) \quad \Big\} \Rightarrow \frac{dx_i}{dt} = -2 b_{0i} \Rightarrow x_i(t) = x_i(0) - 2 b_{0i} t$$

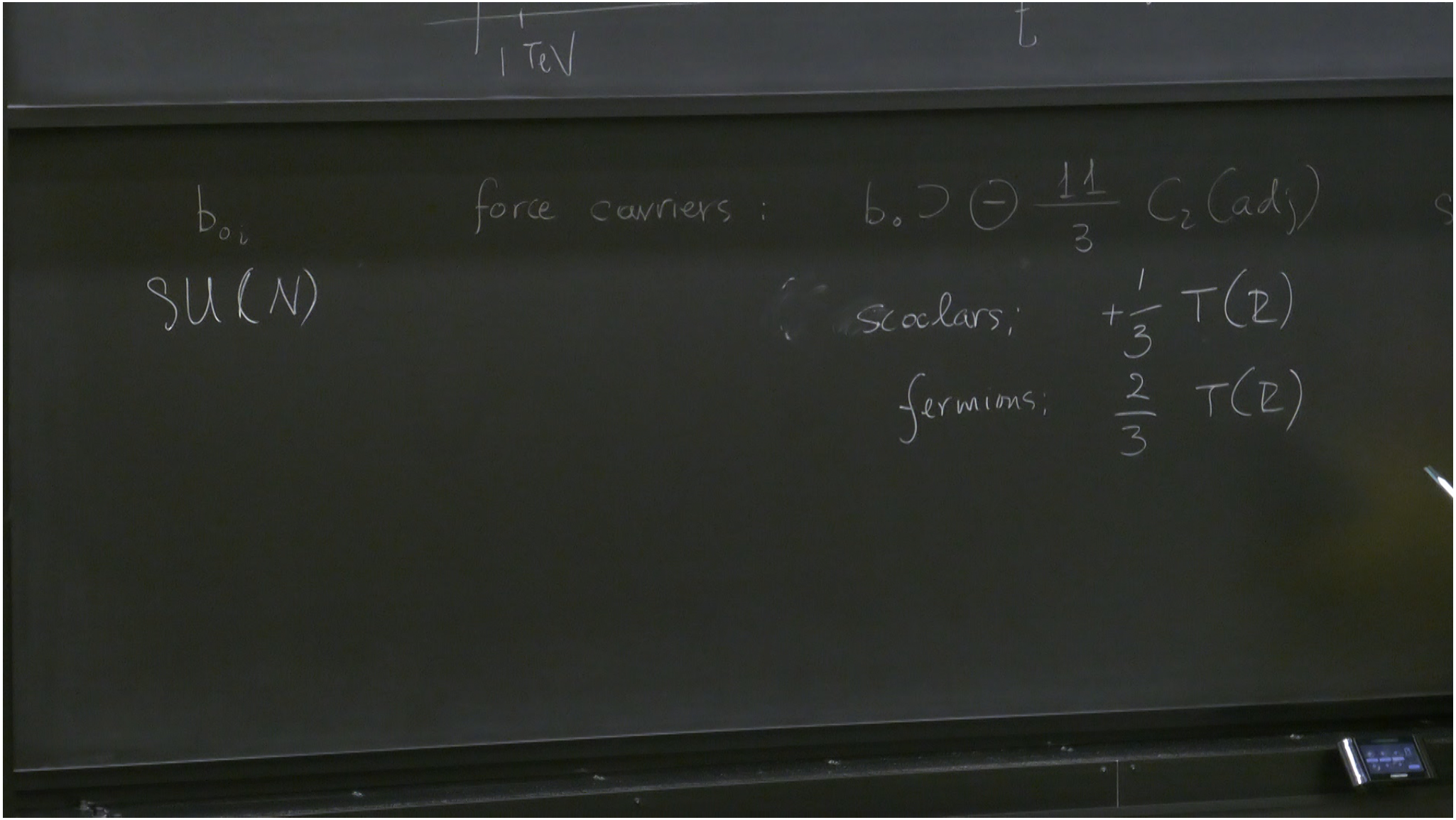
$t = -\ln \mu$, $x_i = \frac{16\pi^2}{g_i^2} = \frac{4\pi}{\alpha_i}$

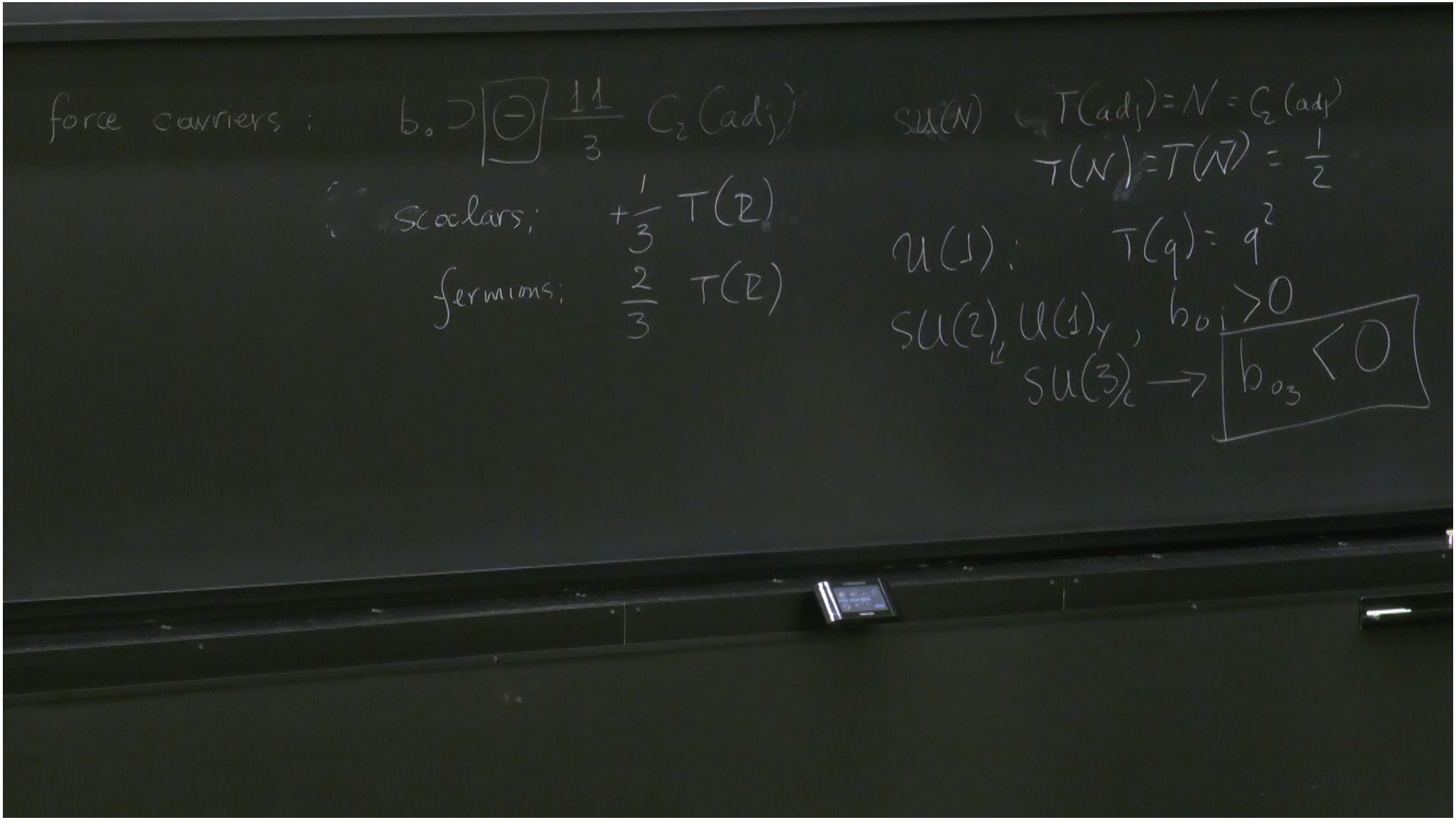
?

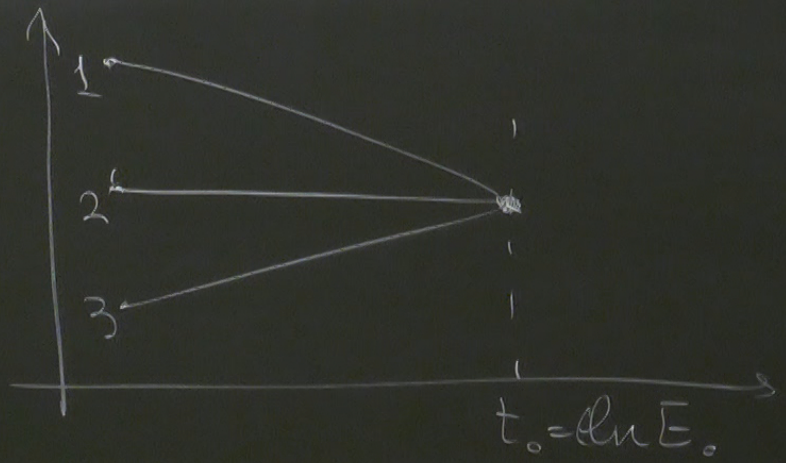
1) $b_{0i} > 0$

2) $b_{0i} < 0$




1 TeV
t
b_0:
force carriers:
$b_0 > \ominus \frac{11}{3} C_2(adj)$
$SU(N)$
scalars; $+\frac{1}{3} T(R)$
fermions; $\frac{2}{3} T(R)$


force carriers : $b_0 \supset \boxed{-} \frac{11}{3} C_2(adj)$
scalars; $+\frac{1}{3} T(R)$
fermions; $\frac{2}{3} T(R)$
$SU(N)$ $T(adj) = N = C_2(adj)$
$T(N) = T(\bar{N}) = \frac{1}{2}$
$U(1)$: $T(q) = q^2$
$SU(2)_L$, $U(1)_Y$, $b_{0i} > 0$
$SU(3)_c \rightarrow \boxed{b_{03} < 0}$



$$x_1(t_0) = x_2(t_0) = x_3(t_0)$$

$$\frac{x_1(0) - x_2(0)}{x_3(0) - x_2(0)} = \frac{b_1 - b_2}{b_3 - b_2}$$

$$t_{unif} = \frac{x_1(0) - x_2(0)}{2(b_1 - b_2)}$$

Georgi, Glashow (1974)

3 - 2 - 1 ⇒ SU(5)