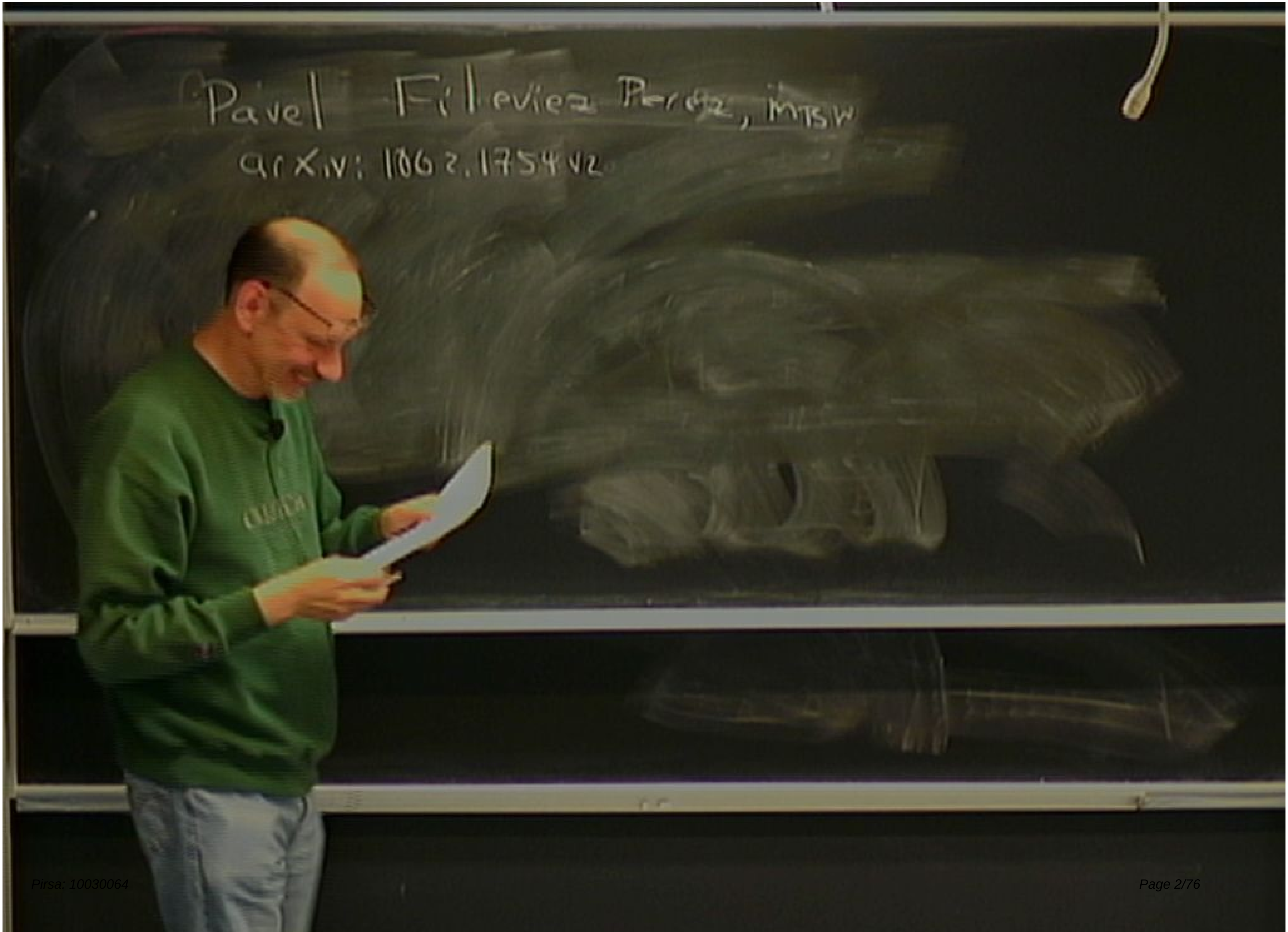
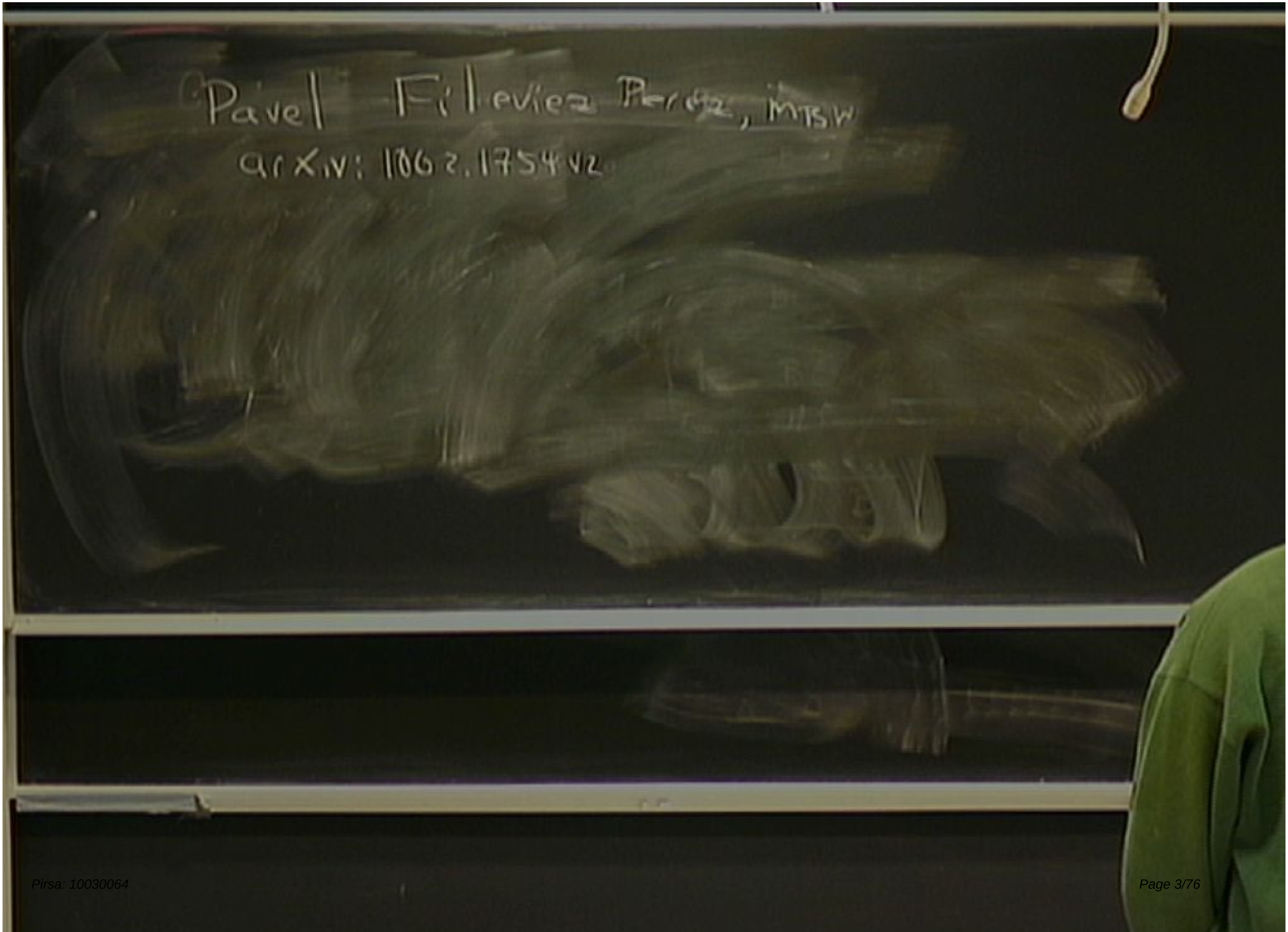
Title: Gauging Baryon and Lepton Number

Date: Mar 19, 2010 02:30 PM

URL: http://pirsa.org/10030064

Abstract: We investigate a simple theory where Baryon number (B) and Lepton number (L) are local gauge symmetries. In this theory B and L are on the same footing and the anomalies are cancelled by adding a single new fermionic generation. There is an interesting realization of the seesaw mechanism for neutrino masses. Furthermore there is a natural suppression of flavour violation in the quark and leptonic sectors since the gauge symmetries and particle content forbid tree level flavor changing neutral currents involving the quarks or charged leptons. Also one finds that the stability of a dark matter candidate is an automatic consequence of the gauge symmetry. Some constraints and signals at the Large Hadron Collider are briefly discussed.


Pavel Fileviez Perez, MTSW
arXiv: 1002.1754 v2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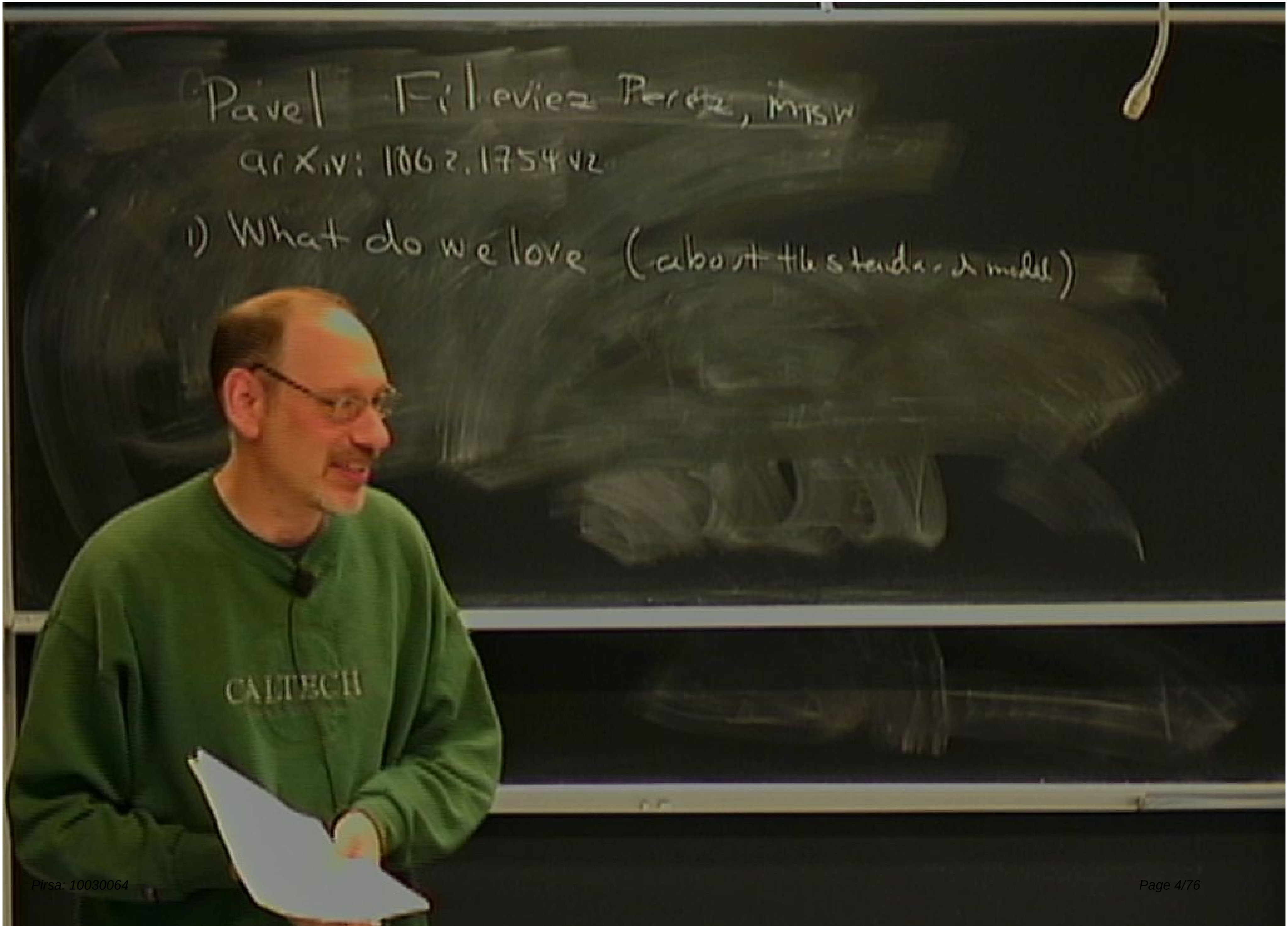
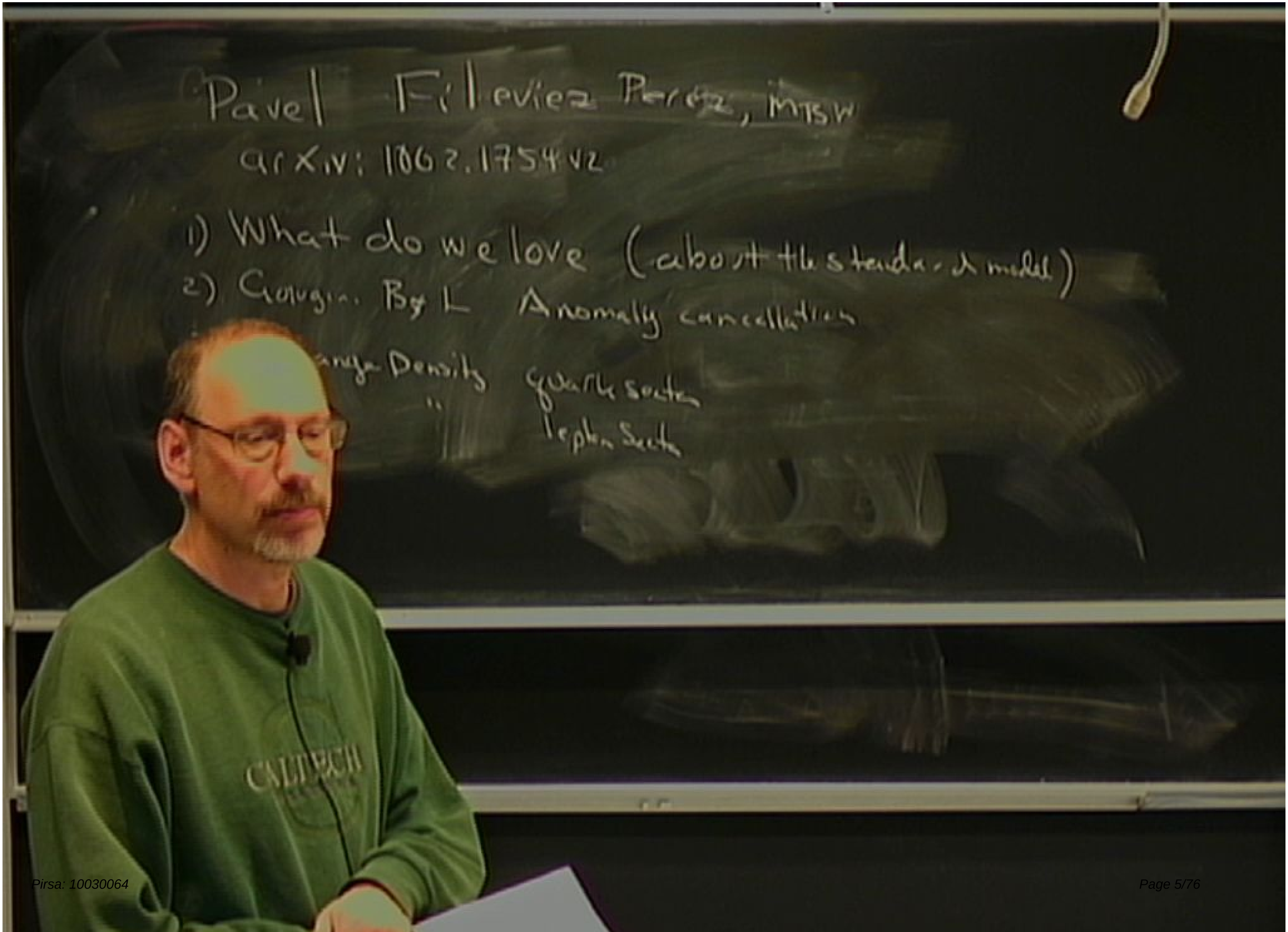
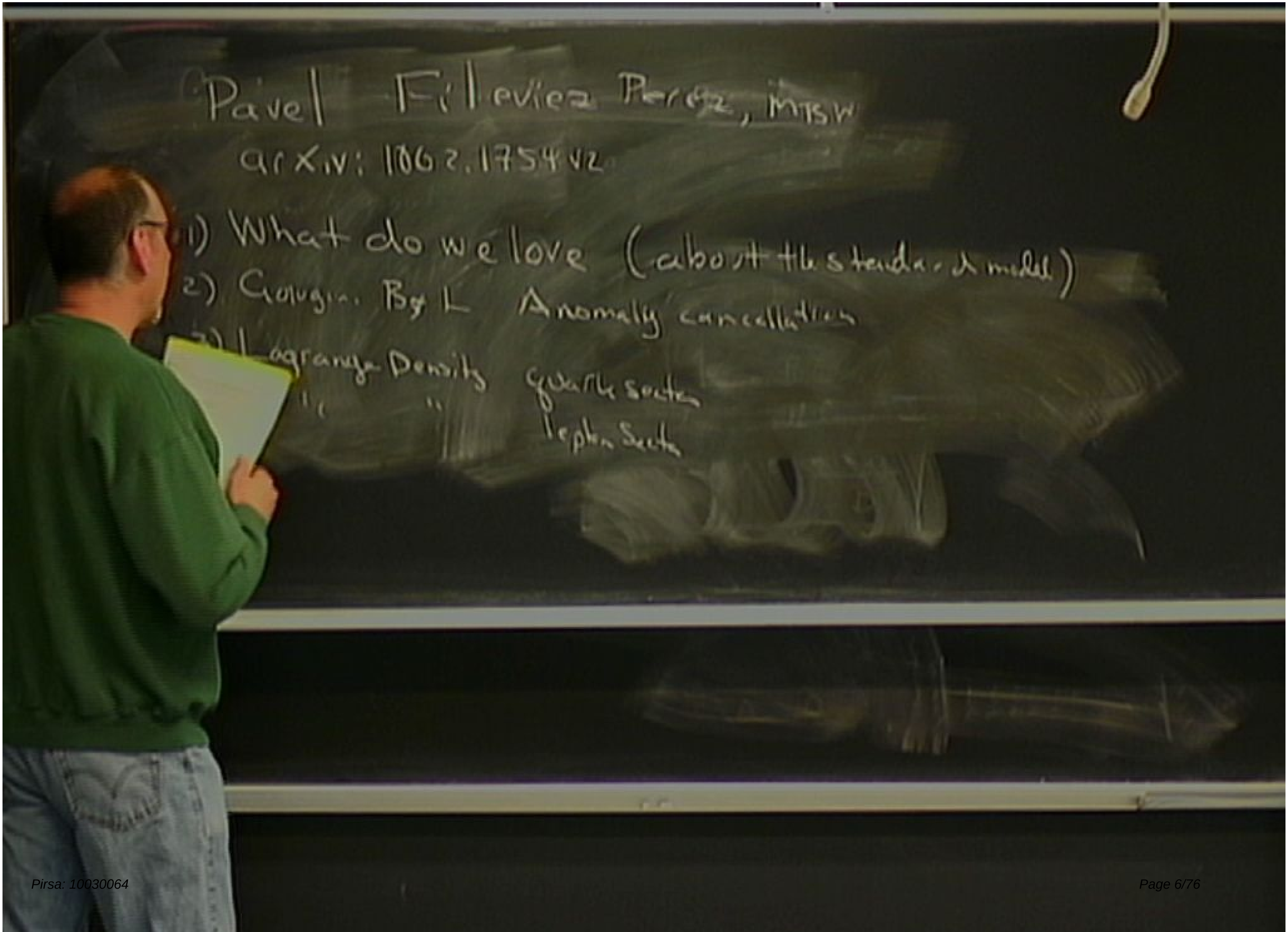
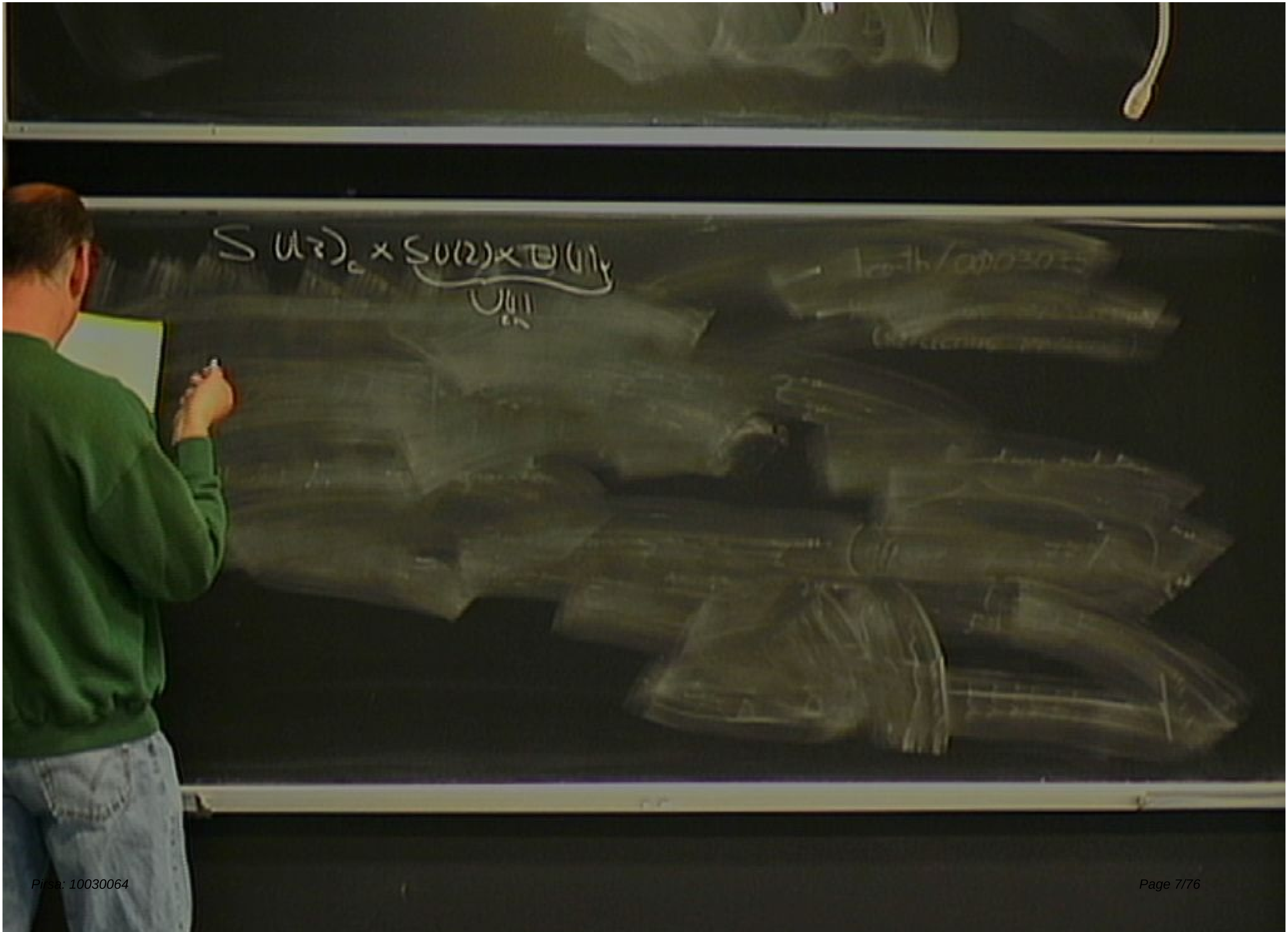
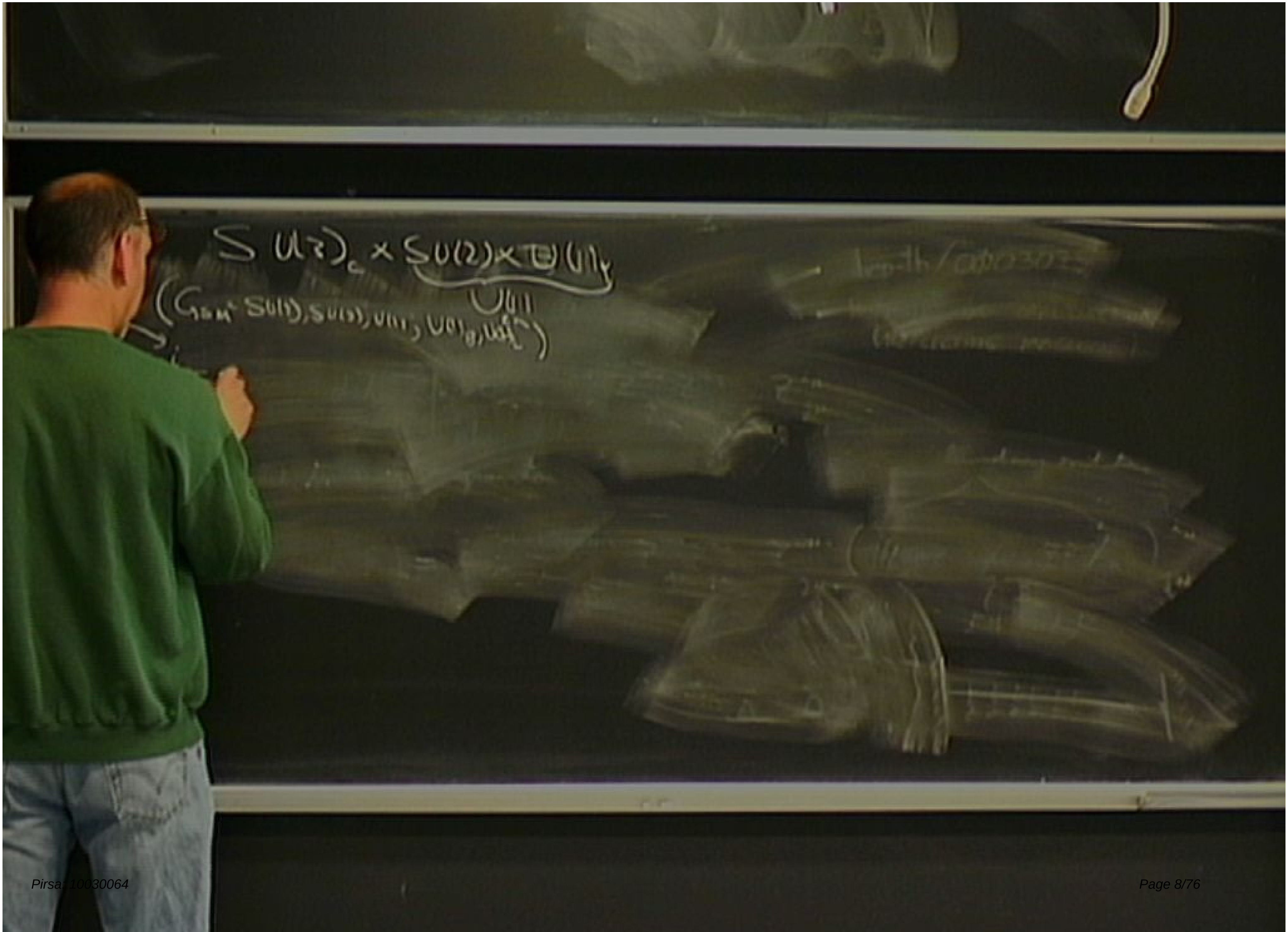
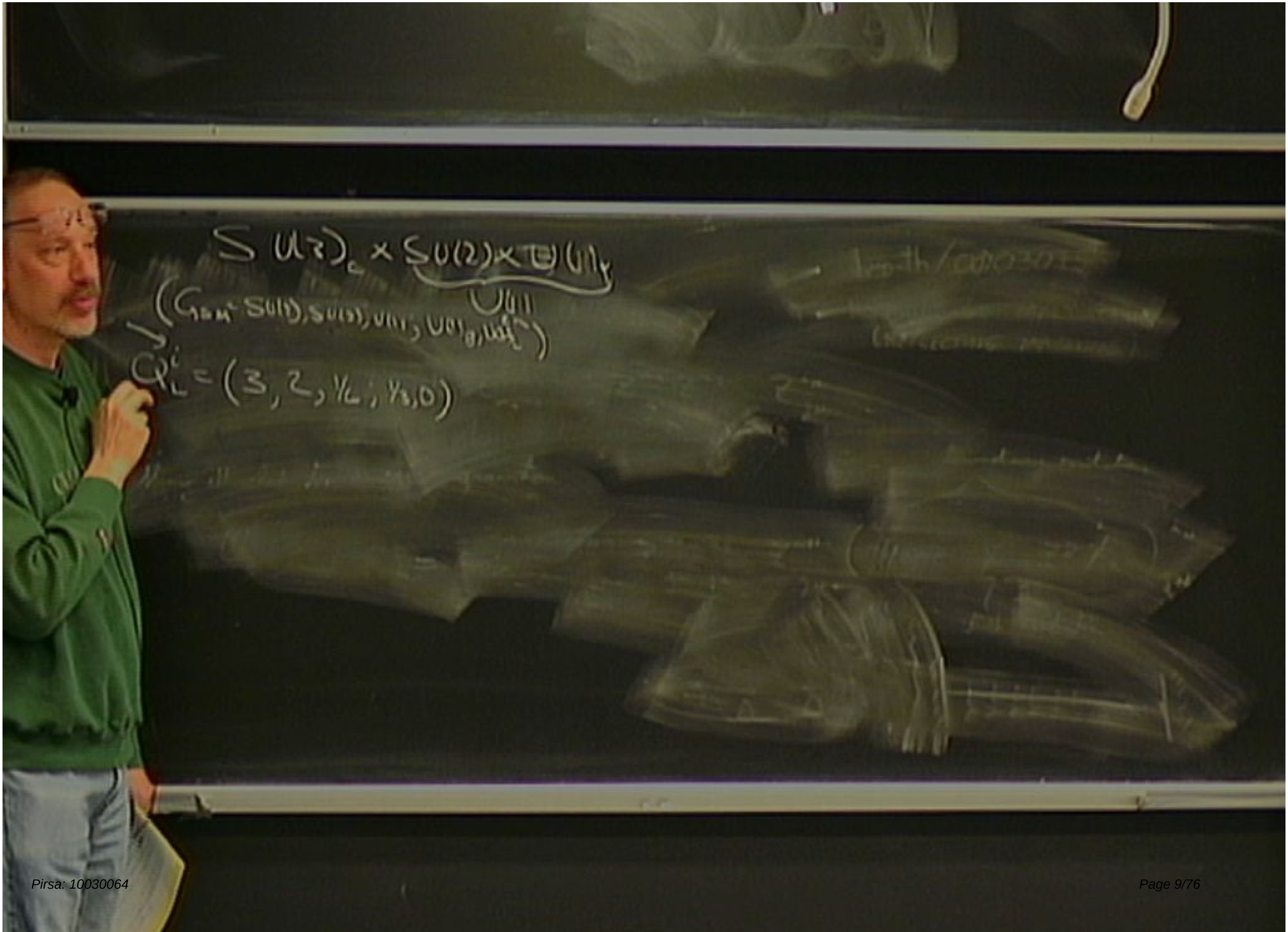

Pavel Fileviez Perez, MTSW
arXiv: 1002.1754 v2
1) What do we love (about the standard model)
CALTECH

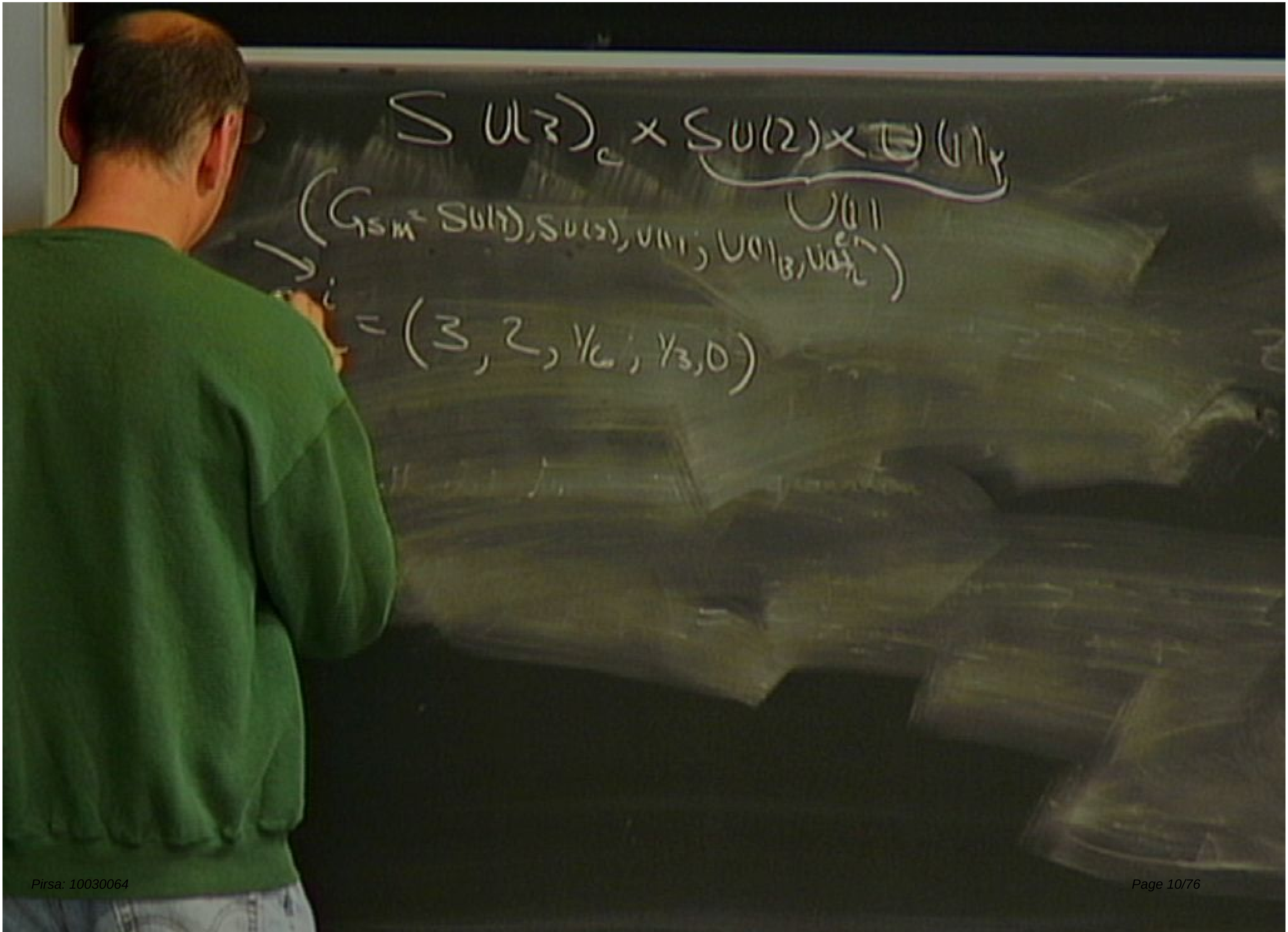

Pavel Fileviez Perez, MTSW
arXiv: 1002.1754 v2
1) What do we love (about the standard model)
2) Gauging B & L Anomaly cancellation
Density quark sector
lepton sector
CALTECH


Pavel Fileviez Perez, MTSW
arXiv: 1002.1754 v2
1) What do we love (about the standard model)
2) Gauging B & L Anomaly cancellation
Lagrange Density quark sector
lepton Sector


SU(3)c × SU(2) × U(1)Y
U(1)em


S U(3)c × SU(2) × U(1)Y
U(1)

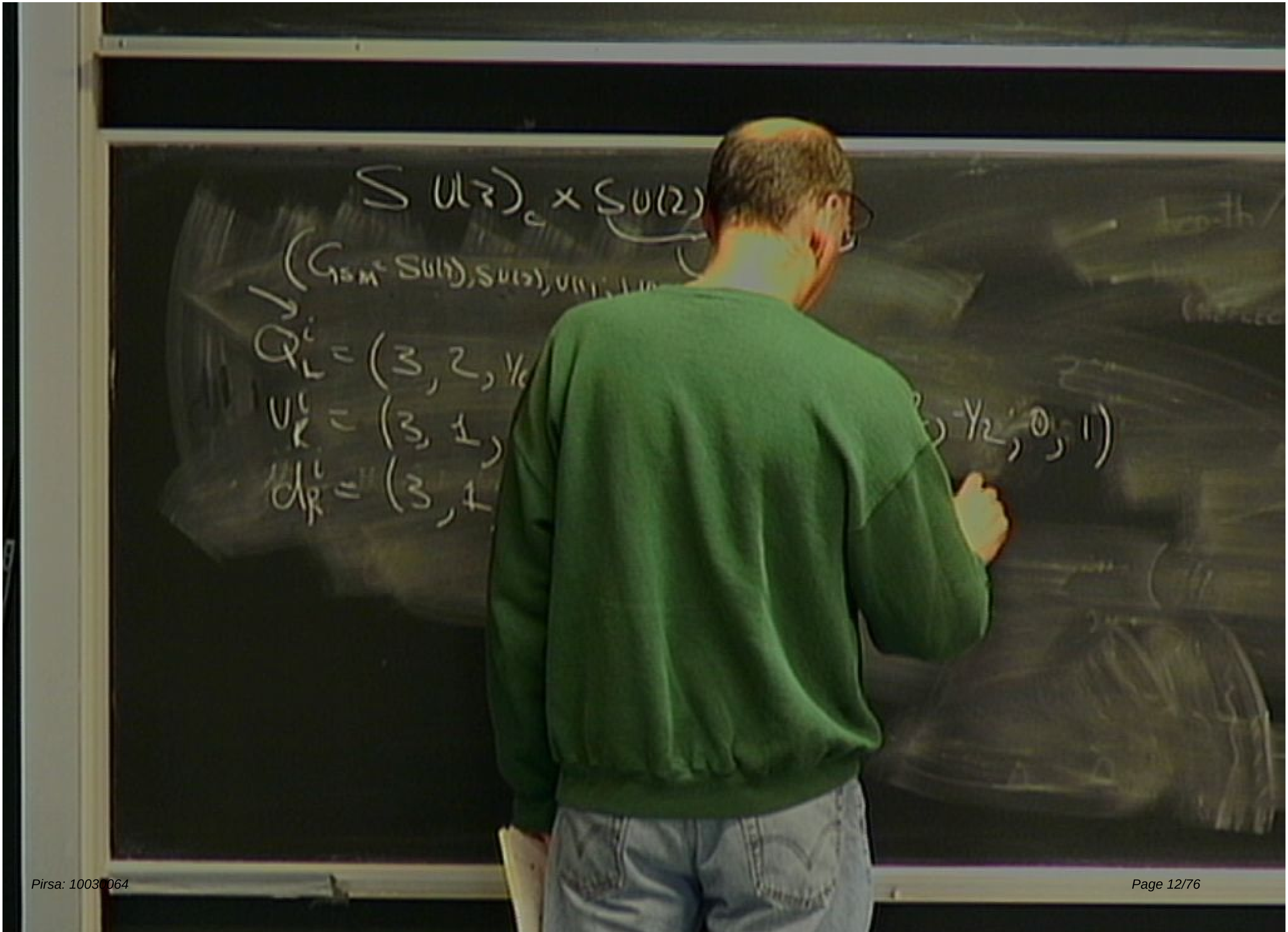

SU(3)c × SU(2) × U(1)Y
U(1)
Q_L^i = (3, 2, 1/6; 1/3, 0)

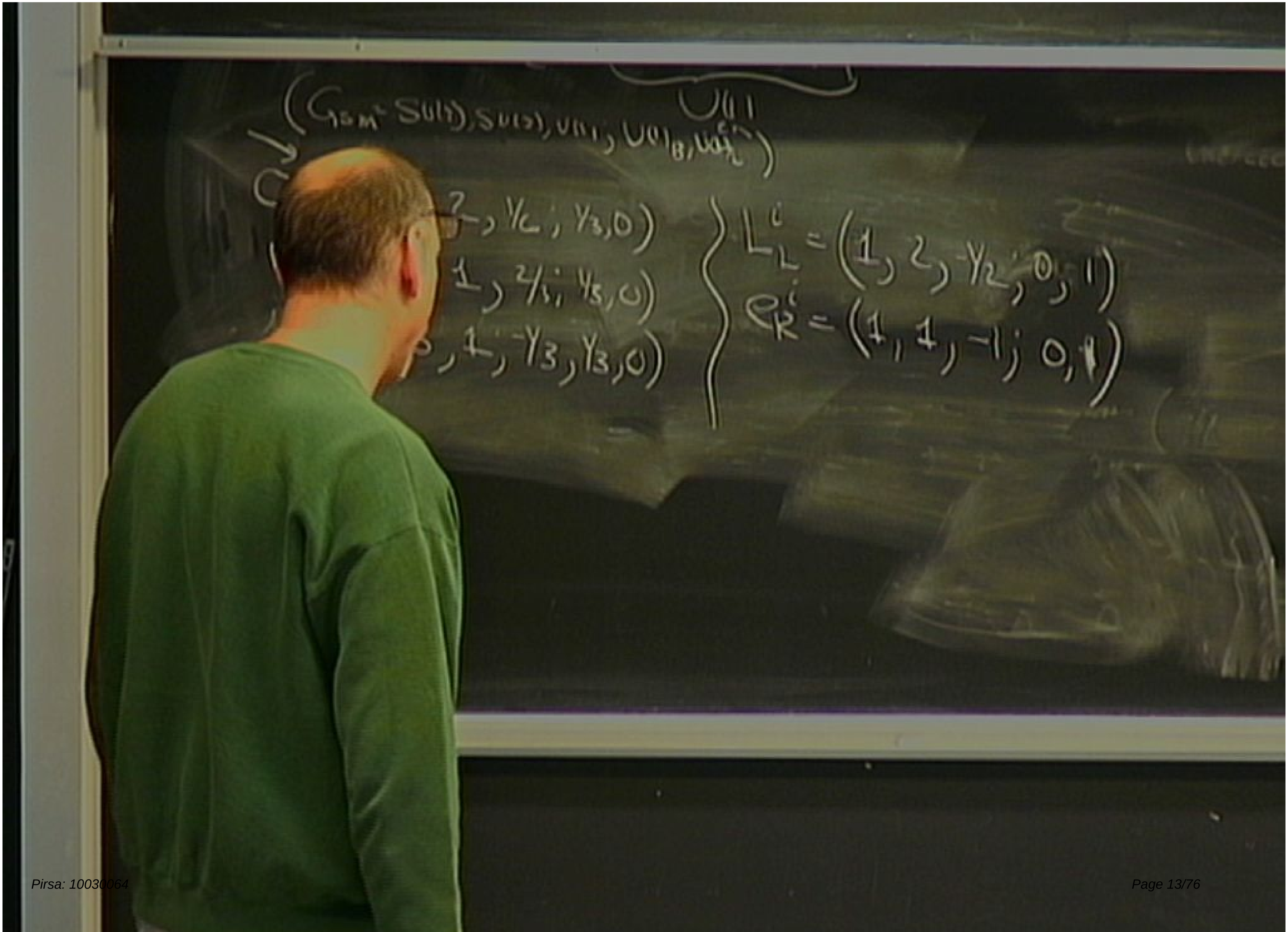

SU(3)c × SU(2) × U(1)Y
U(1)
(GSM = SU(3), SU(2), U(1); U(1)B, U(1)em)
= (3, 2, 1/6; 1/3, 0)

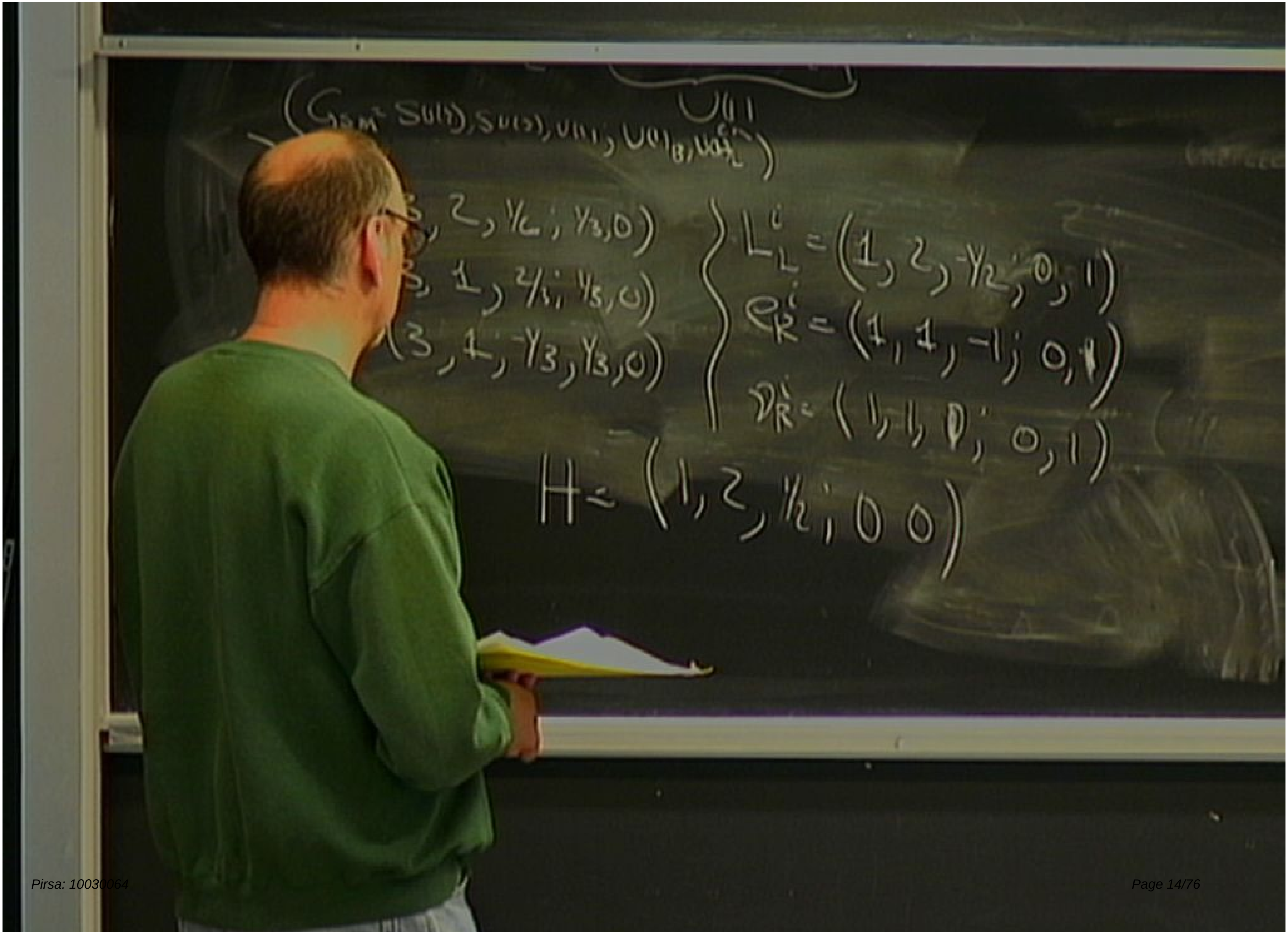
$$SU(3)_c \times \underbrace{SU(2) \times U(1)_Y}_{U(1)}$$

$$\left(G_{SM} = SU(3), SU(2), U(1); U(1)_B, U(1)_L^{e}\right)$$

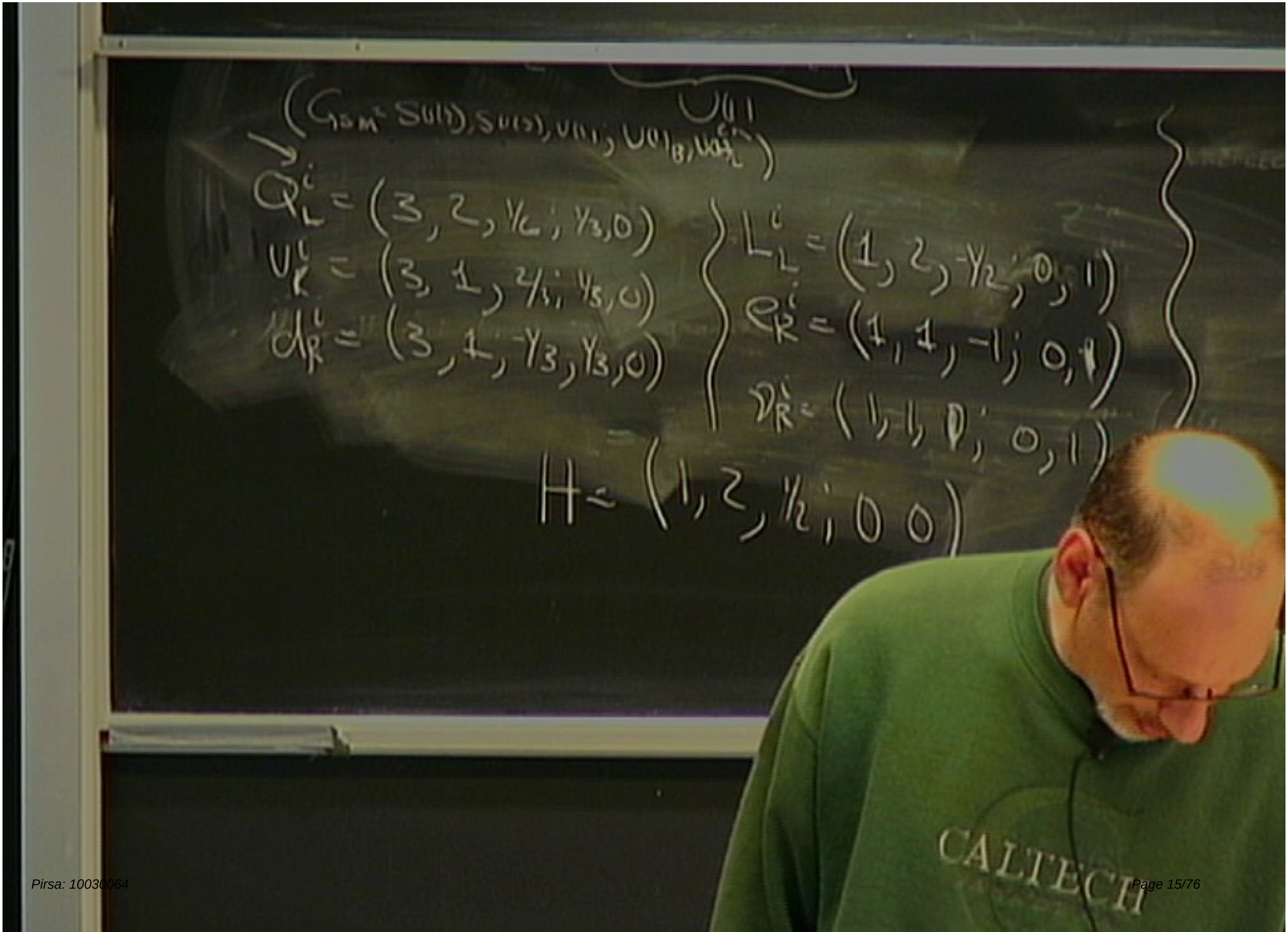
$$Q_L^i = \left(3, 2, 1/6; 1/3, 0\right)$$


S U(3)c × SU(2)
Q = (3, 2,
U = (3, 1,
d = (3, 1
-1/2, 0, 1)


U(1)
L_L^i = (1, 2, -1/2; 0, 1)
e_R^i = (1, 1, -1; 0, 1)



$(G_{SM} = SU(3), SU(2), U(1), U(1)_B, U(1)_L)$
$L_L^i = (1, 2, -1/2; 0, 1)$
$e_R^i = (1, 1, -1; 0, 1)$
$\nu_R^i = (1, 1, 0; 0, 1)$
$H = (1, 2, 1/2; 0\ 0)$


U(1)
(G_SM = SU(3), SU(2), U(1), U(1)_B, U(1)_L)
Q_L^i = (3, 2, 1/6; 1/3, 0)
U_R^i = (3, 1, 2/3; 1/3, 0)
d_R^i = (3, 1, -1/3, 1/3, 0)
L_L^i = (1, 2, -1/2; 0, 1)
e_R^i = (1, 1, -1; 0, 1)
ν_R^i = (1, 1, 0; 0, 1)
H = (1, 2, 1/2; 0 0)
CALTECH

$$\frac{d\,d\,d\,e_R}{\Lambda^2}$$

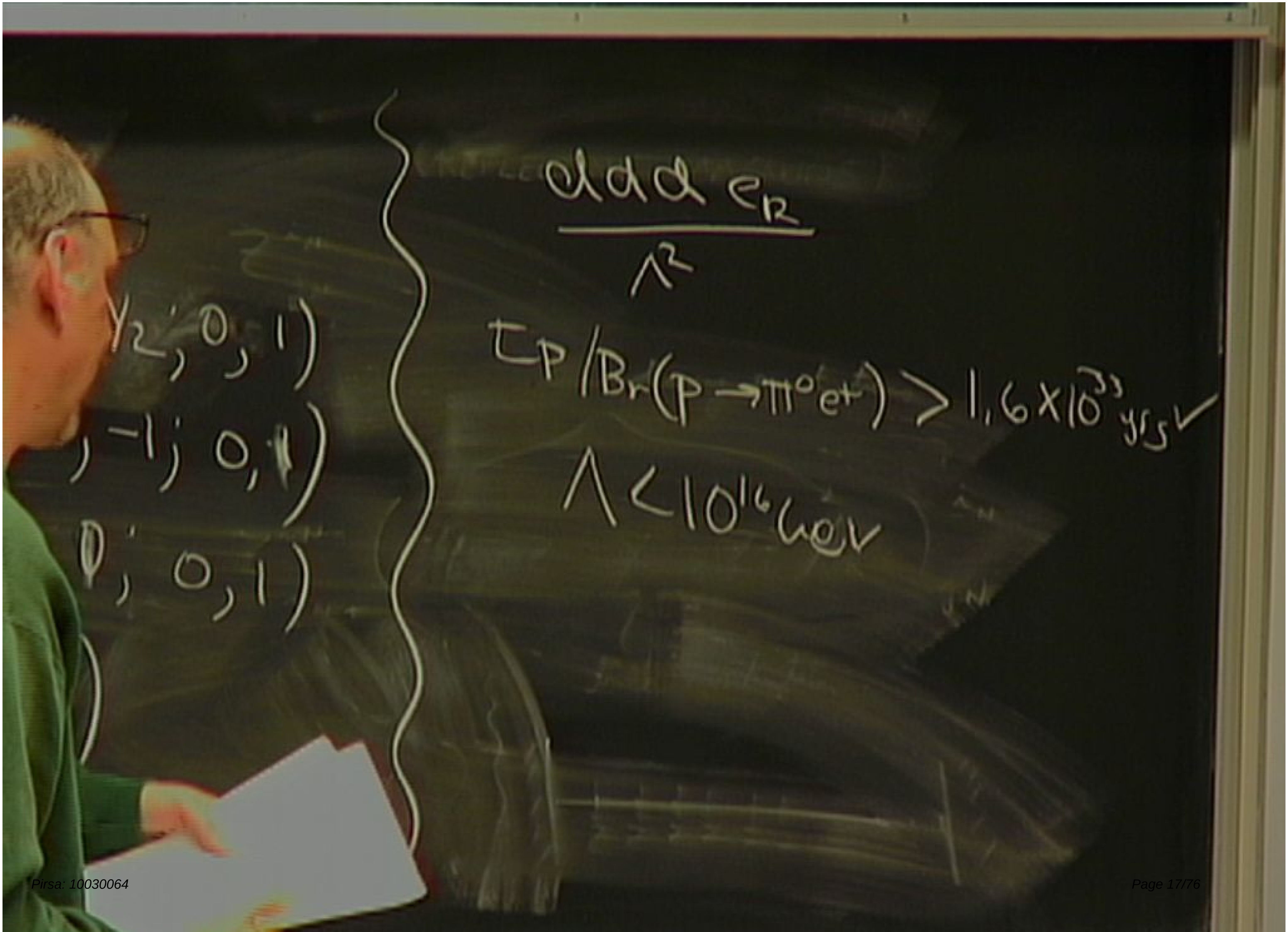
$$\tau_p / Br(p \to \pi^0 e^+) > 1.6 \times 10^{33}\ \text{yrs}$$

$2, -1/2; 0, 1)$

$, 1, -1; 0, 1)$

$1, 0; 0, 1)$

$0)$



$\frac{ddd\, e_R}{\Lambda^2}$
$\tau_p / Br(p \to \pi^0 e^+) > 1.6 \times 10^{33}$ yrs
$\Lambda < 10^{16}$ GeV
$1/2 ; 0, 1)$
$-1 ; 0, 1)$
$0 ; 0, 1)$

$2, -\frac{1}{2}; 0, 1)$

$, 1, -1; 0, 1)$

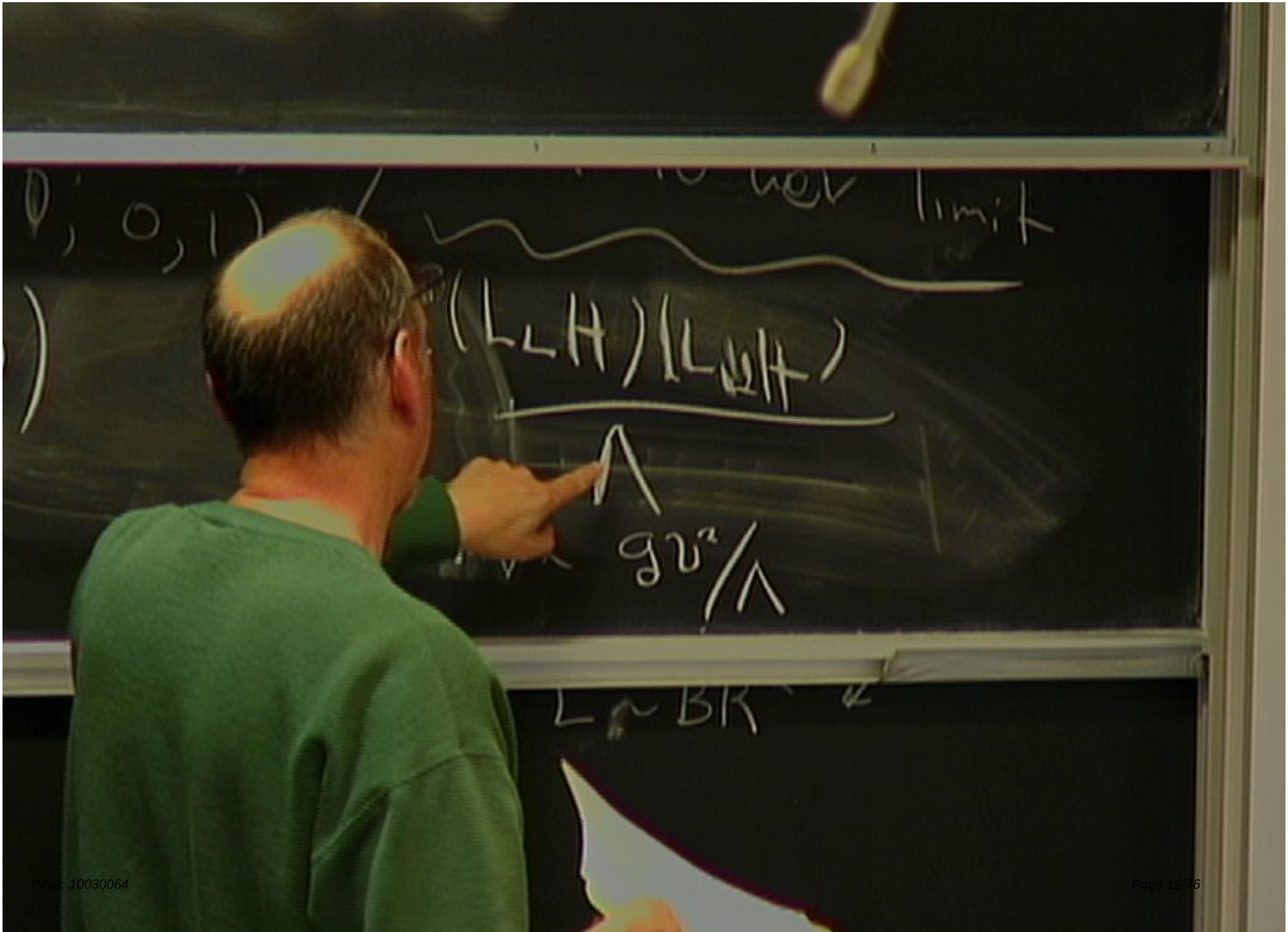
$1, 0; 0, 1)$

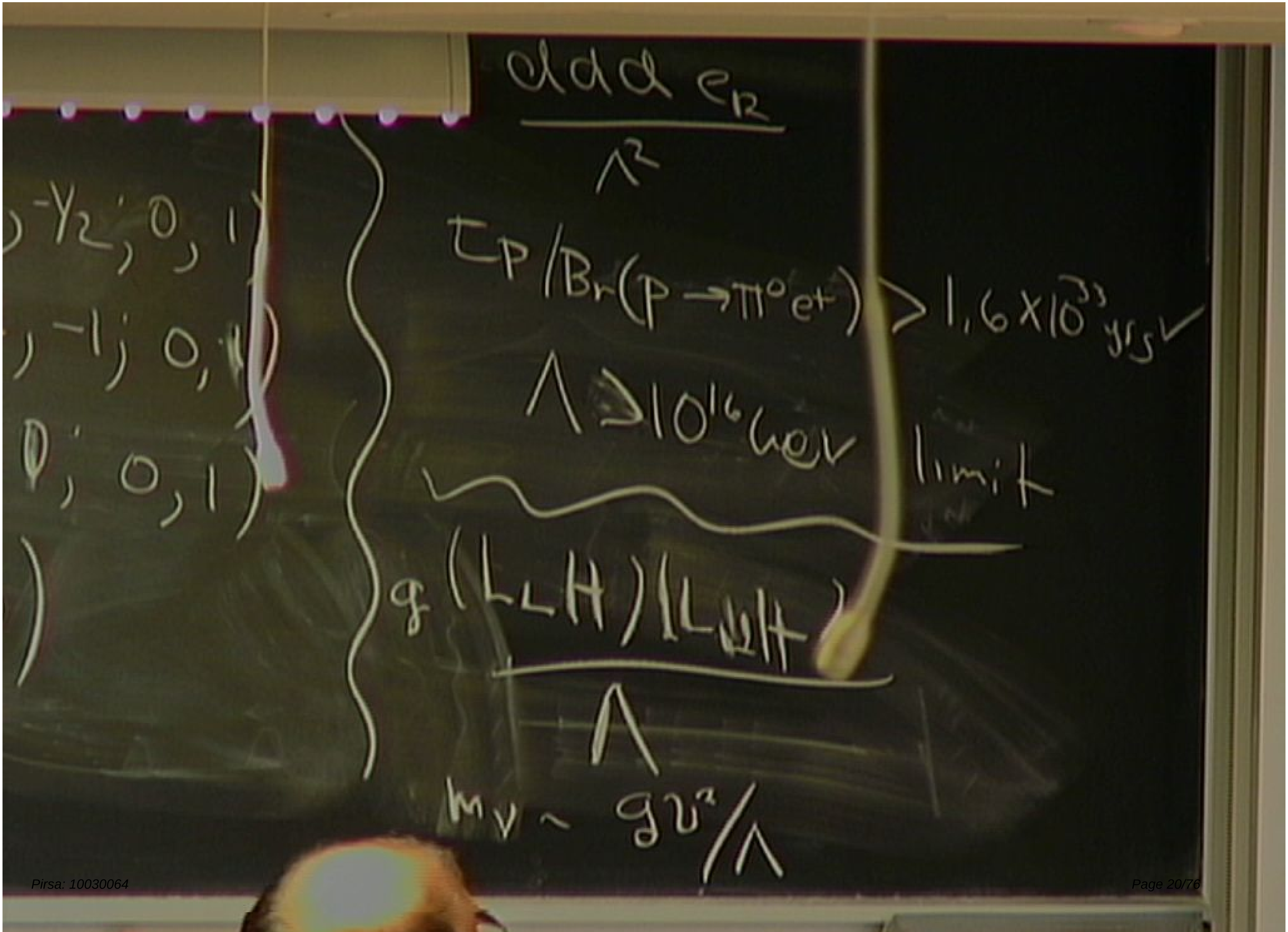
$0)$

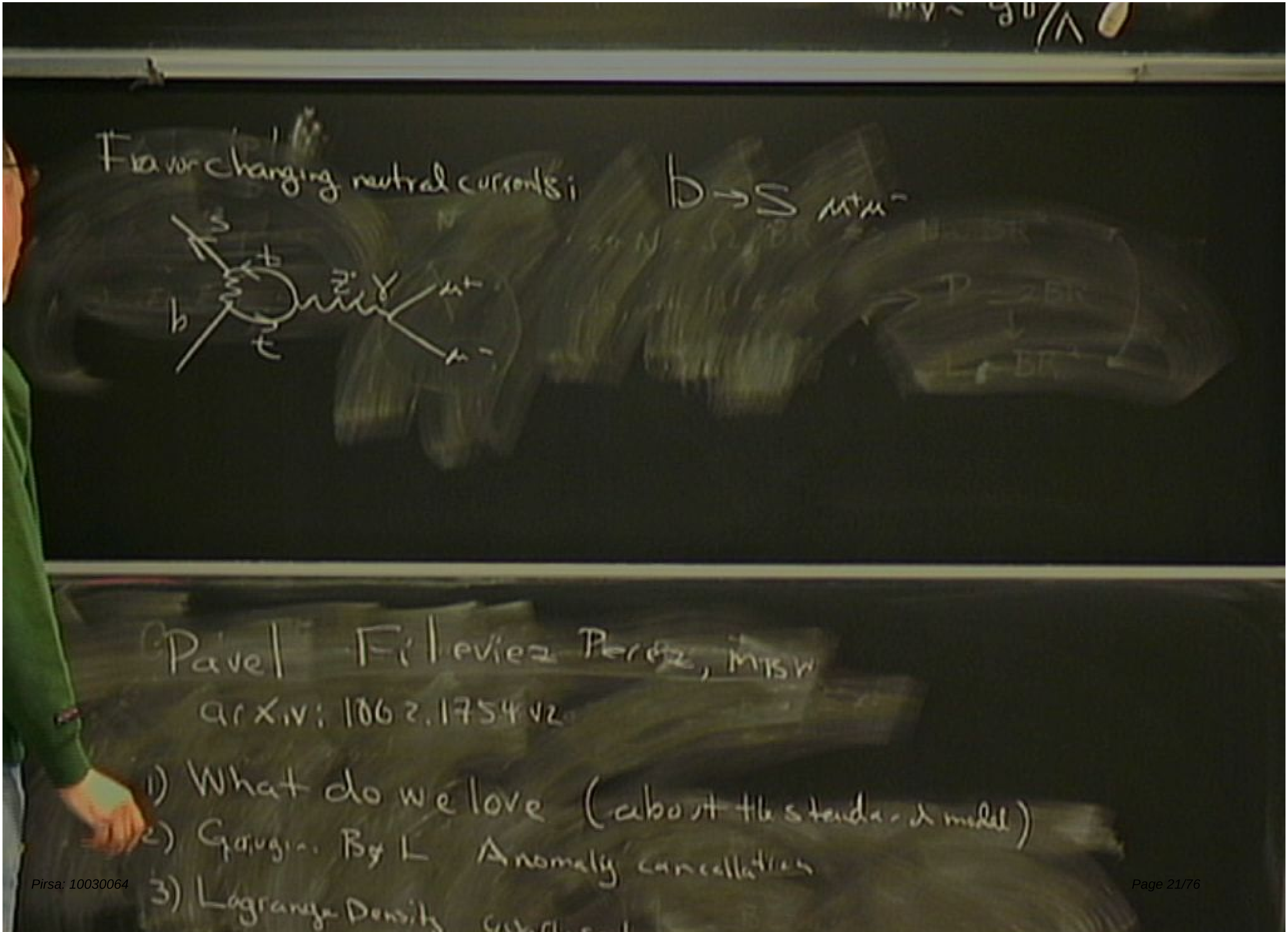
$$\frac{ddd\, e_R}{\Lambda^2}$$

$$\tau_p / B_r(p \to \pi^0 e^+) > 1.6 \times 10^{33}\,\text{yrs} \checkmark$$

$$\Lambda \gtrsim 10^{16}\,\text{GeV} \quad \text{limit}$$


limit
L ~ BR


-1/2 ; 0, 1
-1 ; 0, 1
0 ; 0, 1
add e_R
Λ^2
τ_p / Br(p → π^0 e^+) > 1,6 x 10^33 yrs
Λ > 10^16 GeV
limit
g (L_L H)(L_L H)
Λ
m_ν ~ g v^2/Λ


Flavor changing neutral currents:
b → s μ+μ-
s
b
t
t
Z, γ
μ+
μ-
Pavel Fileviez Perez, MTSW
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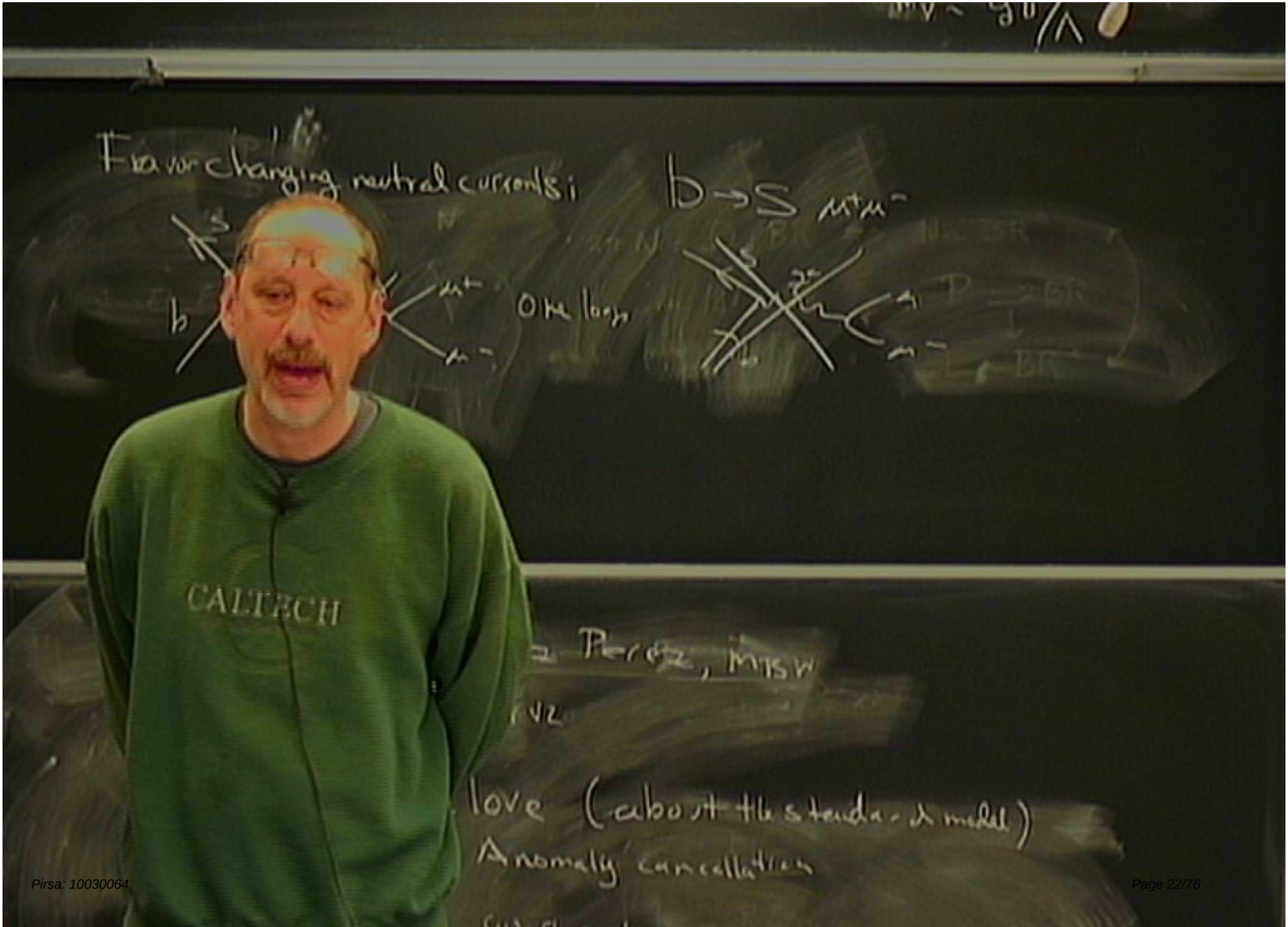
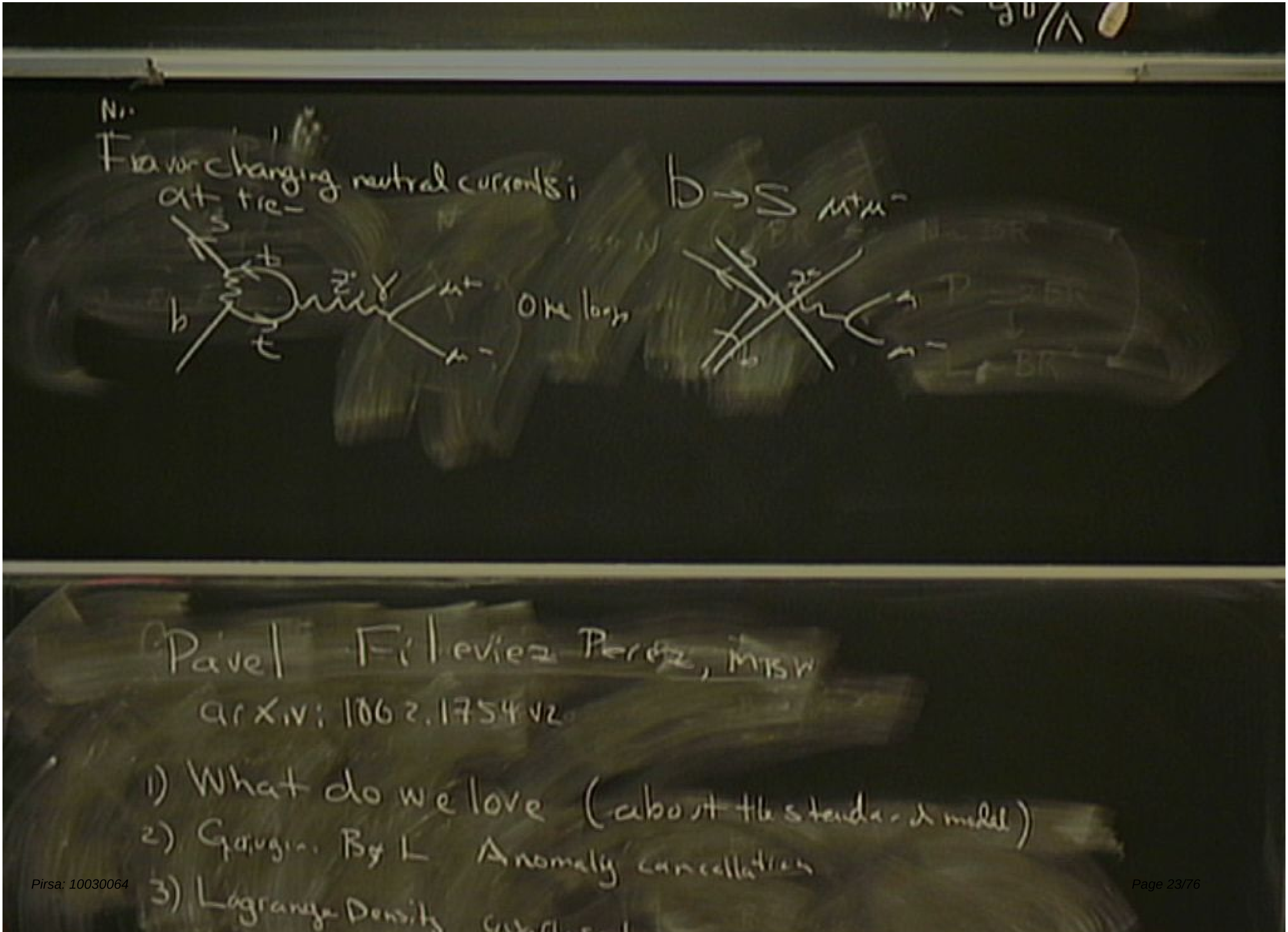
1) What do we love (about the standard model)
2) Gauging B & L Anomaly cancellation
3) Lagrange Density


Flavor changing neutral currents:
b→s μ+μ−
One loop
CALTECH
love (about the standard model)
Anomaly cancellation



Flavor changing neutral currents:
at tree
b → s μ+μ−
One loop
Pavel Fileviez Perez, MBW
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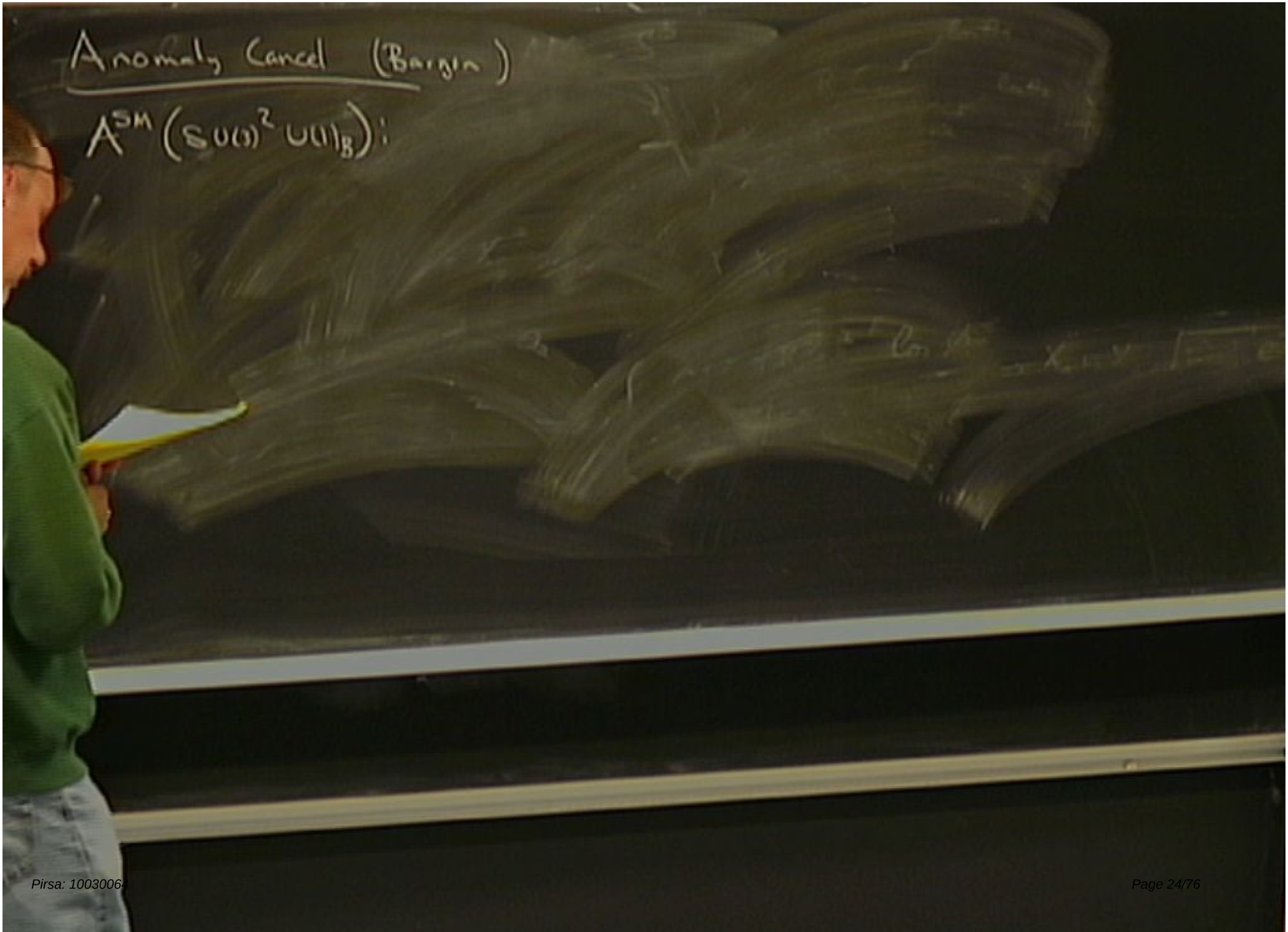
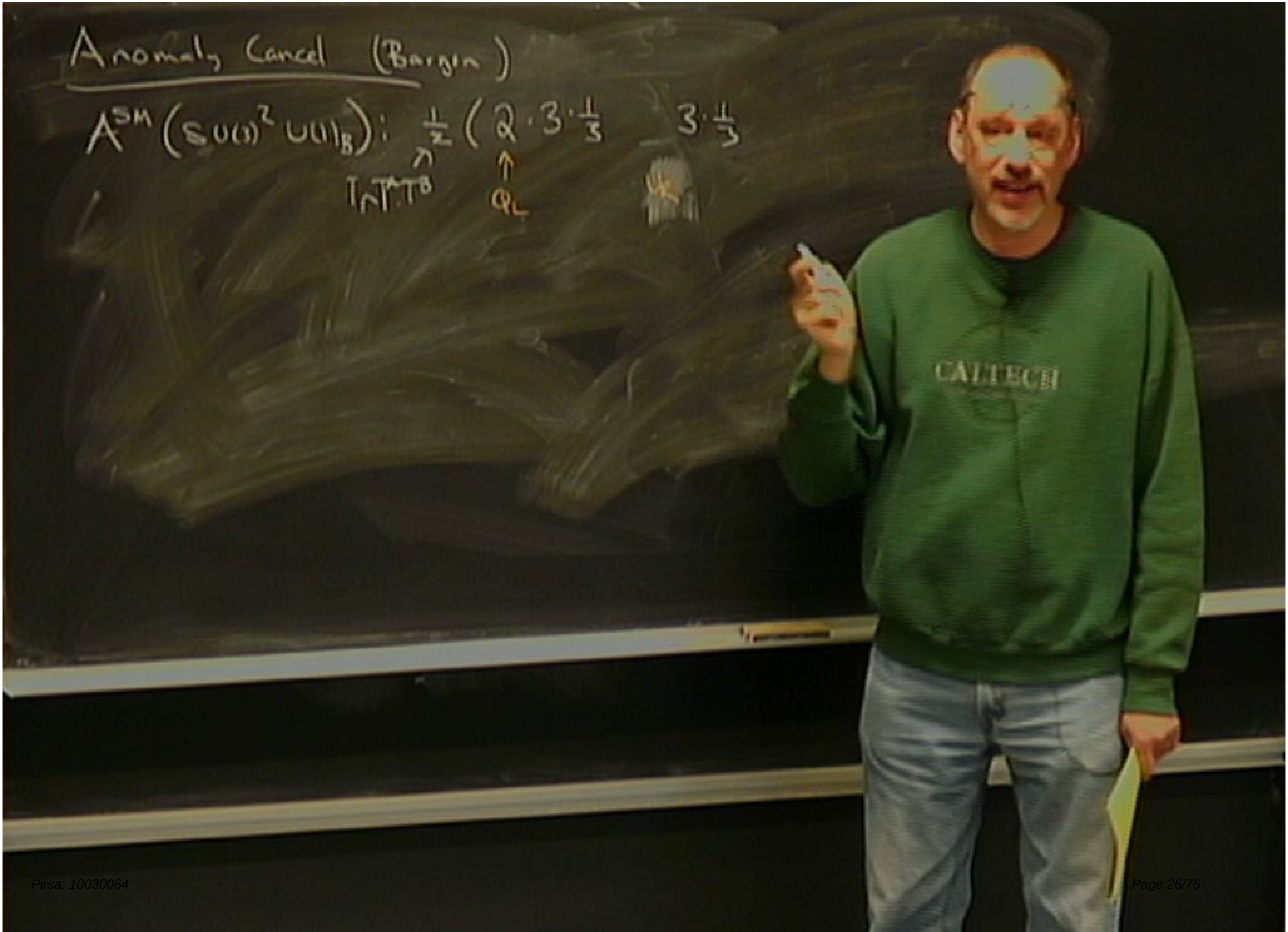
1) What do we love (about the standard model)
2) Gauging B & L Anomaly cancellation
3) Lagrange Density


Anomaly Cancel (Bargin)
A^SM (SU(3)^2 U(1)_B):

Anomaly Cancel (Bargain)

$A^{SM}(SU(3)^2\, U(1)_B)$: $\frac{1}{2}(2 \cdot 3 \cdot \frac{1}{3}$

$\mathrm{Tr}\, T^A T^B$ Q_L u_R


Anomaly Cancel (Baryon)
A^SM (SU(3)^2 U(1)_B): 1/2 (2 · 3 · 1/3   3 · 1/3
Tr T^A T^B
Q_L
CALTECH

Anomaly Cancel (Baryon)

$A^{SM}(SU(3)^2\, U(1)_B)$: $\frac{1}{2}\,(\,2\cdot 3\cdot\frac{1}{3} \quad 3\cdot\frac{1}{3}$

$\uparrow$ $\mathrm{Tr}\,T^A T^B$ $\qquad$ $\uparrow$ Q_L

Anomaly Cancel (Baryon)

$$A^{SM}(SU(3)^2\, U(1)_B):\ \frac{1}{2}\left(2\cdot 3\cdot \frac{1}{3} - 3\cdot\frac{1}{3} - 3\,\frac{1}{3}\right) = 0$$

$\frac{1}{2}$ ↑ $\mathrm{Tr}\,T^A T^B$ — 2 ↑ Q_L — u_R — d_R

Anomaly Cancel (Baryon)

$$A^{SM}(SU(3)^2\, U(1)_B):\ \frac{1}{2}\left(2\cdot 3\cdot \frac{1}{3} - 3\cdot\frac{1}{3} - 3\,\frac{1}{3}\right) = 0$$

$\uparrow T_r T^A T^B$ $\uparrow Q_L$ u_R d_R

$$A^{SM}(SU(2)^2\, U(1)_B) =$$

Anomaly Cancel (Baryon)

$$A^{SM}(SU(3)^2\, U(1)_B):\ \frac{1}{2}\left(2\cdot 3\cdot \frac{1}{3} - 3\cdot\frac{1}{3} - 3\,\frac{1}{3}\right) = 0$$

$\mathrm{Tr}\, T^A T^A T^B$ $\quad Q_L \quad u_R \quad d_R$

$$A^{SM}(SU(2)^2\, U(1)_B) = \frac{1}{2}\Big($$

Q_L

Anomaly Cancel (Baryon)

$$A^{SM}(SU(3)^2\, U(1)_B):\ \frac{1}{2}\left(2\cdot 3\cdot \frac{1}{3} - 3\cdot\frac{1}{3} - 3\,\frac{1}{3}\right) = 0$$

$\mathrm{Tr}\, T^A T^B$ $\qquad Q_L \qquad\qquad d_R$

$$A^{SM}(SU(2)^2\, U(1)_B) = \frac{1}{2}\left(3\cdot 3\cdot 1/3\right) = \boxed{\frac{3}{2}}$$

Q_L $\quad$ colors $\quad$ gen

Anomaly Cancel (Baryon)

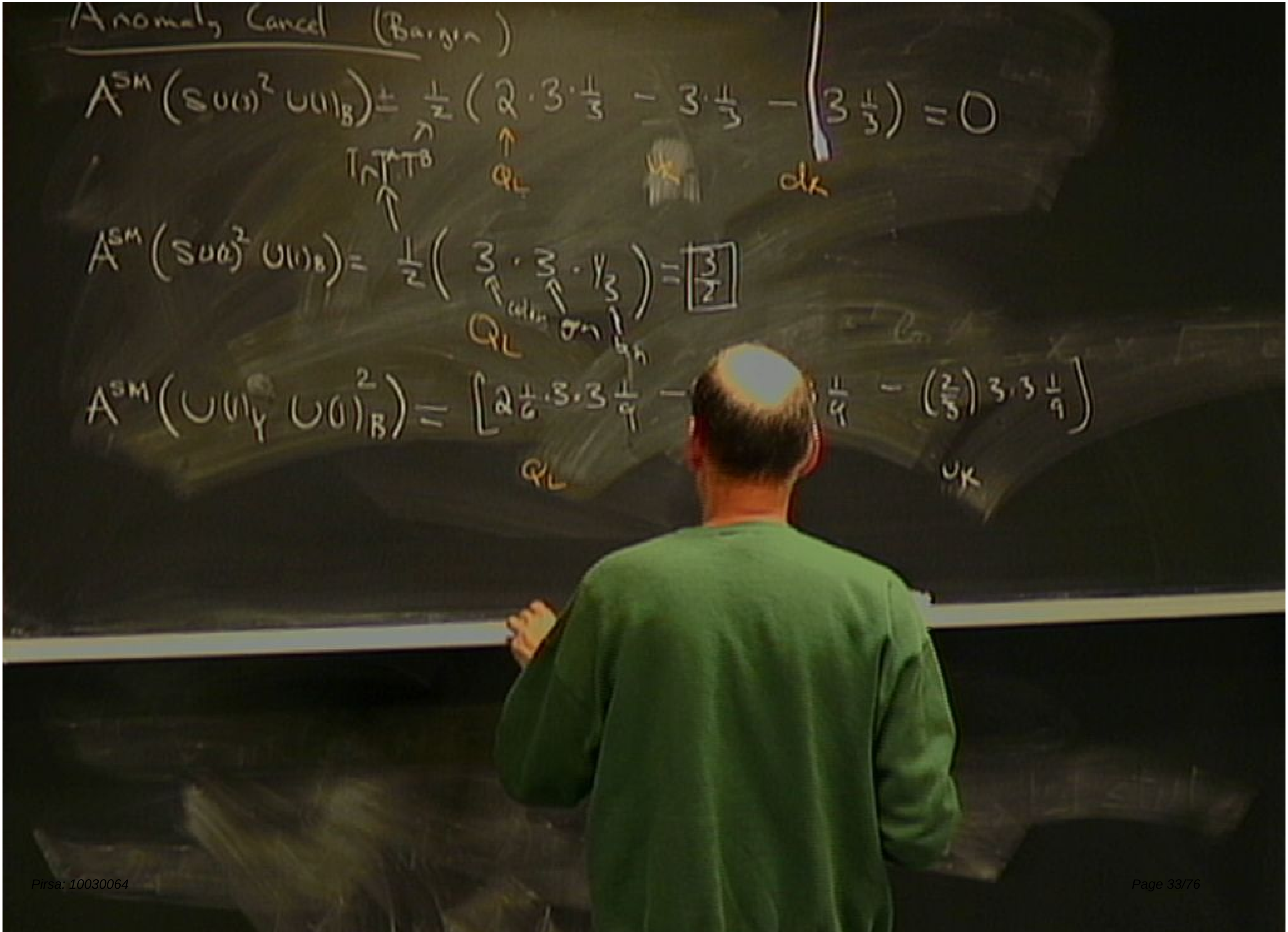
$$A^{SM}(SU(3)^2\, U(1)_B) = \frac{1}{2}\left(2\cdot 3\cdot \frac{1}{3} - 3\cdot\frac{1}{3} - 3\,\frac{1}{3}\right) = 0$$

$\mathrm{Tr}\, T^a T^b T^B$ $\quad Q_L \quad u_R \quad d_R$

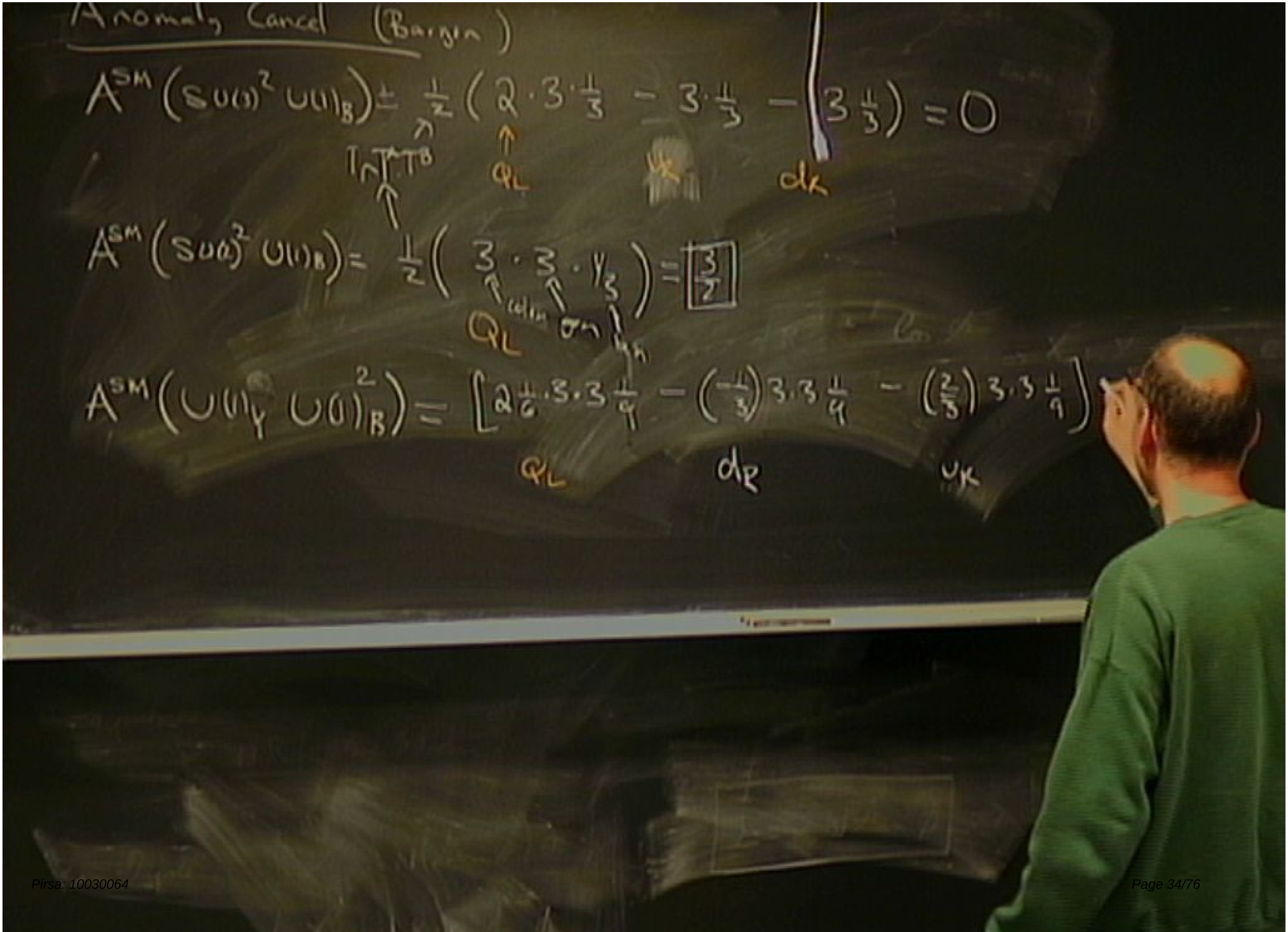
$$A^{SM}(SU(2)^2\, U(1)_B) = \frac{1}{2}\left(3\cdot 3\cdot \frac{1}{3}\right) = \boxed{\frac{3}{2}}$$

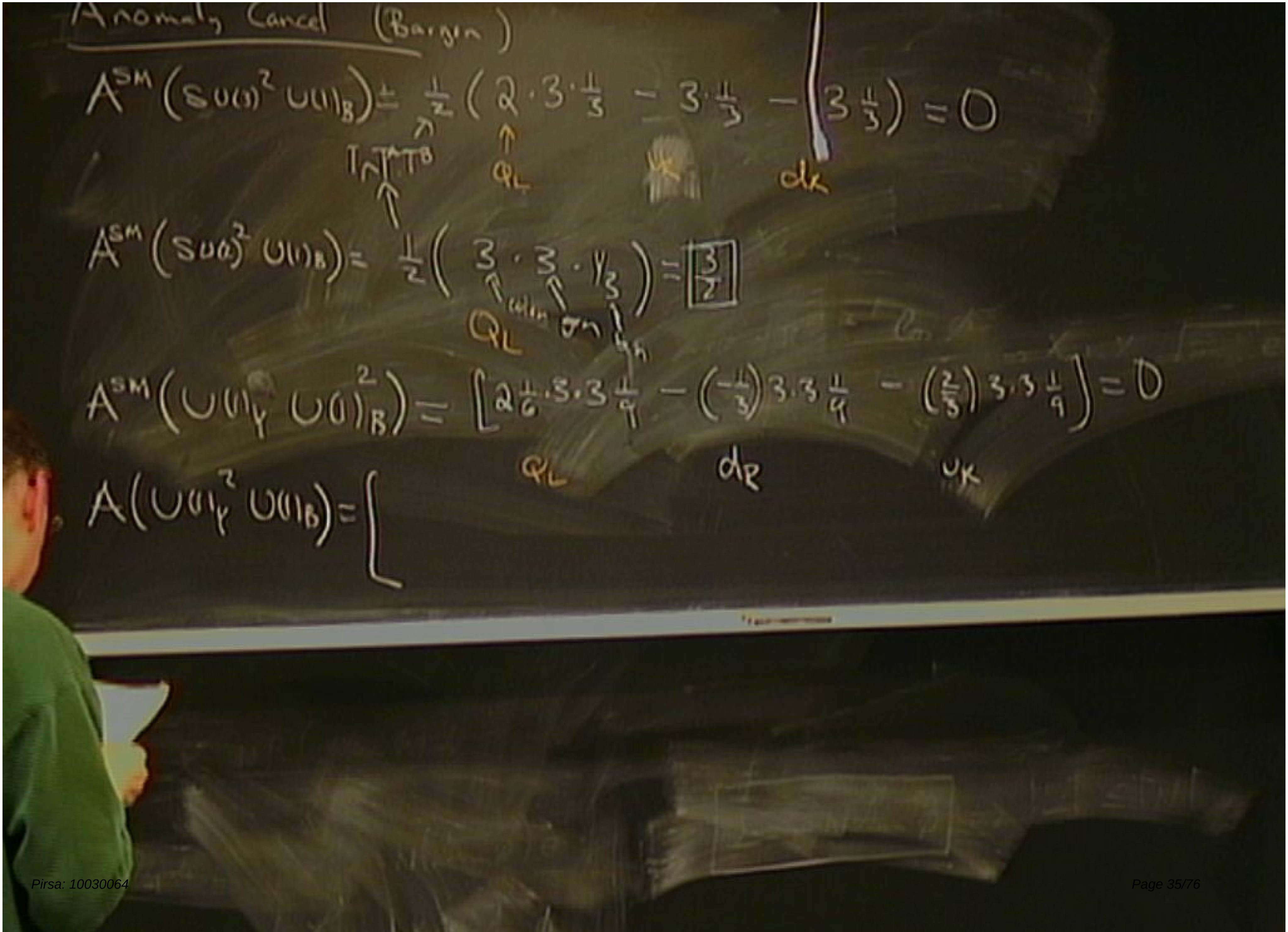
Q_L $\quad$ colors $\quad$ gen $\quad Y_B$

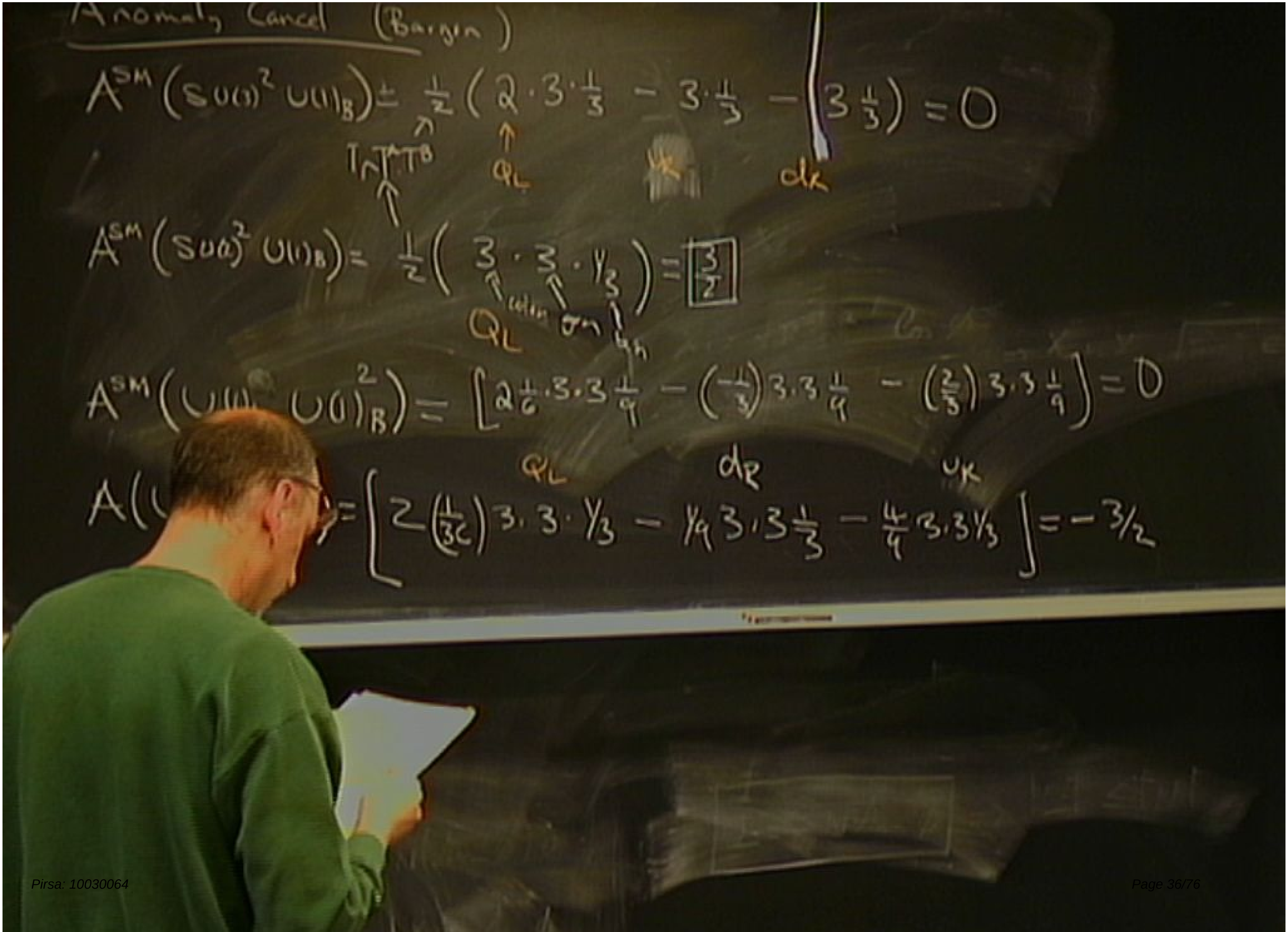
$$A^{SM}(U(1)_Y^2\, U(1)_B) =$$



Anomaly Cancel (Baryon)
A^SM (SU(3)^2 U(1)_B) = 1/2 (2·3·1/3 − 3·1/3 − 3 1/3) = 0
Q_L
d_R
A^SM (SU(2)^2 U(1)_B) = 1/2 (3 · 3 · 1/3) = 3/2
Q_L
A^SM (U(1)_Y^2 U(1)_B) =
Q_L
u_R


Anomaly Cancel (Bargin)
A^SM (SU(3)^2 U(1)_B) = 1/2 (2·3·1/3 − 3·1/3 − 3 1/3) = 0
Q_L
d_R
A^SM (SU(2)^2 U(1)_B) = 1/2 (3 · 3 · 1/3) = 3/2
Q_L
A^SM (U(1)_Y U(1)_B^2) = [2 1/6 ·3·3 1/9 − (−1/3) 3·3 1/9 − (2/3) 3·3 1/9]
Q_L
d_R
u_R


Anomaly Cancel (Baryon)
$A^{SM}(SU(3)^2\,U(1)_B) = \frac{1}{2}\left(2\cdot 3\cdot \frac{1}{3} - 3\cdot\frac{1}{3} - 3\,\frac{1}{3}\right) = 0$
$Tr\,T^a T^a T^B$
Q_L
u_R
d_R
$A^{SM}(SU(2)^2\,U(1)_B) = \frac{1}{2}\left(3\cdot 3\cdot 1/3\right) = \frac{3}{2}$
Q_L
color
gen
q_B
$A^{SM}(U(1)_Y\,U(1)_B^2) = \left[2\frac{1}{6}\cdot 3\cdot 3\,\frac{1}{9} - \left(-\frac{1}{3}\right)3\cdot 3\,\frac{1}{9} - \left(\frac{2}{3}\right)3\cdot 3\,\frac{1}{9}\right] = 0$
Q_L
d_R
u_R
$A(U(1)_Y^2\,U(1)_B) = [$


Anomaly Cancel
A^SM (SU(3)^2 U(1)_B) = 1/2 (2·3·1/3 − 3·1/3 − 3·1/3) = 0
Q_L
d_R
A^SM (SU(2)^2 U(1)_B) = 1/2 (3·3·1/3) = 3/2
Q_L
A^SM (U(1) U(1)_B^2) = [2 1/6 ·3·3 1/9 − (−1/3) 3·3 1/9 − (2/3) 3·3 1/9] = 0
Q_L
d_R
u_R
= −3/2

Anomaly Cancel (Baryon)

$$A^{SM}(SU(3)^2\, U(1)_B) = \tfrac{1}{2}\left(2\cdot 3\cdot \tfrac{1}{3} - 3\cdot\tfrac{1}{3} - 3\,\tfrac{1}{3}\right) = 0$$

$T_A T^A T^B$ $\quad Q_L \quad u_R \quad d_R$

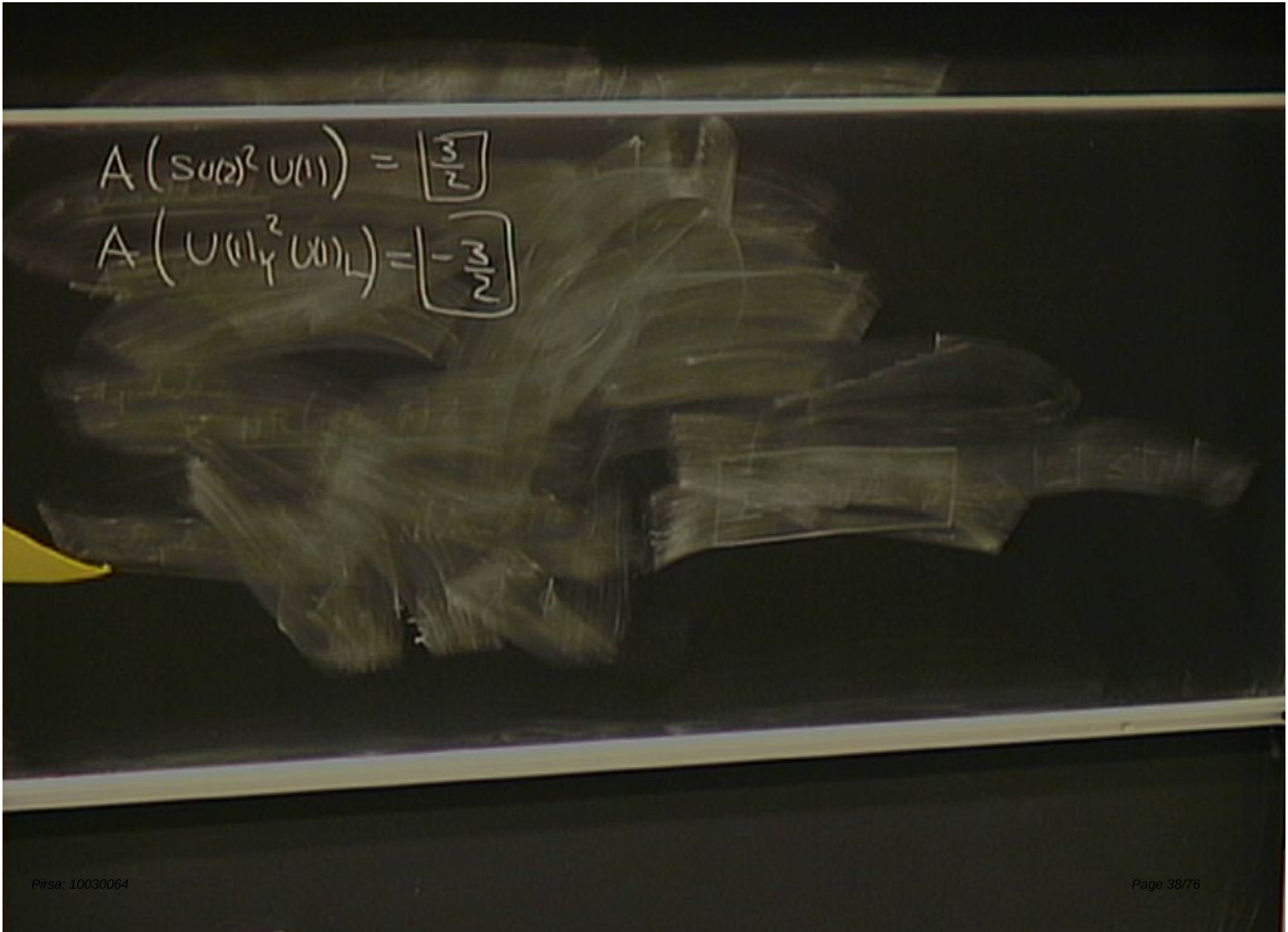
$$A^{SM}(SU(2)^2\, U(1)_B) = \tfrac{1}{2}\left(3\cdot 3\cdot \tfrac{1}{3}\right) = \boxed{\tfrac{3}{2}}$$

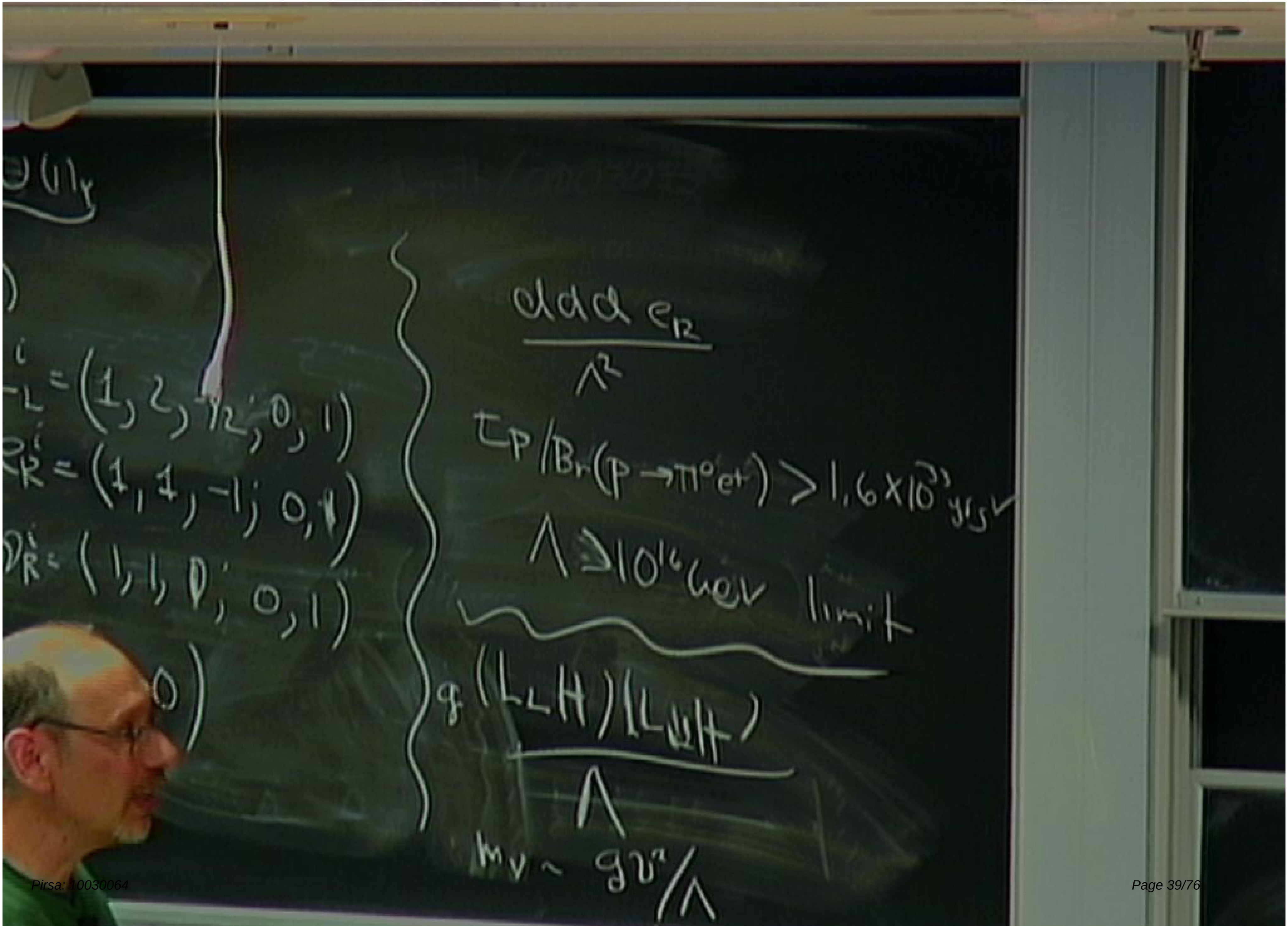
Q_L color gen B_n

$$A^{SM}(U(1)_Y\, U(1)_B^2) = \left[2\tfrac{1}{6}\cdot 3\cdot 3\,\tfrac{1}{9} - \left(-\tfrac{1}{3}\right)3\cdot 3\,\tfrac{1}{9} - \left(\tfrac{2}{3}\right)3\cdot 3\,\tfrac{1}{9}\right] = 0$$

$Q_L \quad d_R \quad u_R$

$$A(U(1)_Y^2\, U(1)_B) = \left[2\left(\tfrac{1}{36}\right)3\cdot 3\cdot \tfrac{1}{3} - \tfrac{1}{9}\,3\cdot 3\,\tfrac{1}{3} - \tfrac{4}{9}\,3\cdot 3\,\tfrac{1}{3}\right] = \boxed{-3/2}$$


$A\left(SU(2)^2\,U(1)\right) = \frac{3}{2}$
$A\left(U(1)_Y^2\,U(1)_L\right) = -\frac{3}{2}$


ddd e_R / Λ^2
τp / Br(p → π^0 e^+) > 1,6 × 10^33 yrs
Λ ≳ 10^16 GeV limit
g (L_L H)(L_L H) / Λ
m_ν ~ g v^2 / Λ

$L = (1, 2, -\frac{1}{2}; 0, 1)$

$R = (1, 1, -1; 0, 1)$

$R = (1, 1, 0; 0, 1)$

$\frac{1}{2}; 0\ 0)$

Q_L'

u_L'

d

L

e

ν

$(1)_Y$

$_L = (1, 2, -1/2; 0, 1)$

$_R = (1, 1, -1; 0, 1)$

$_R = (1, 1, 0; 0, 1)$

$1/2; 0\ 0)$

$Q'_R = ($

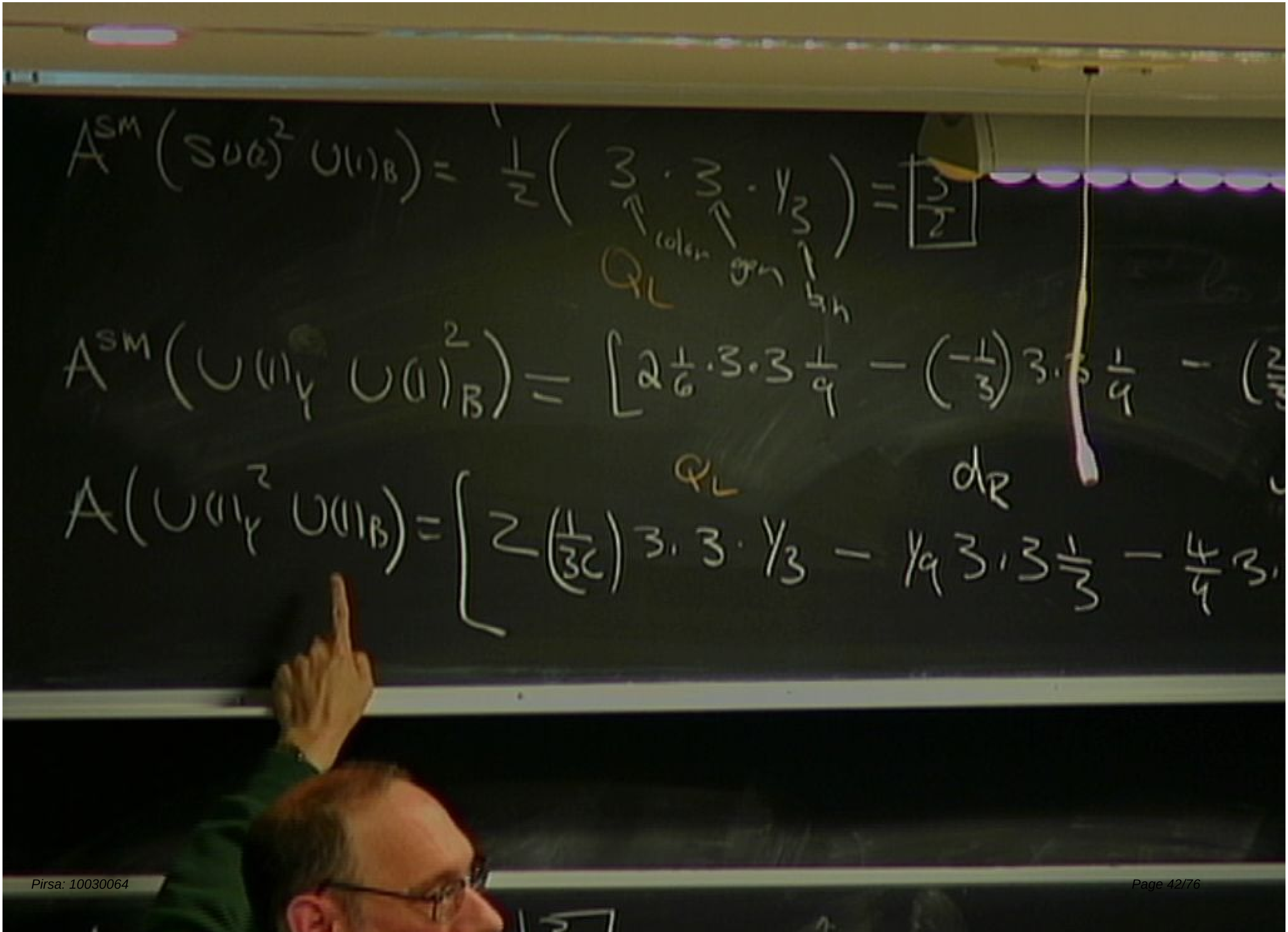
$U'_L =$

$d'_L =$

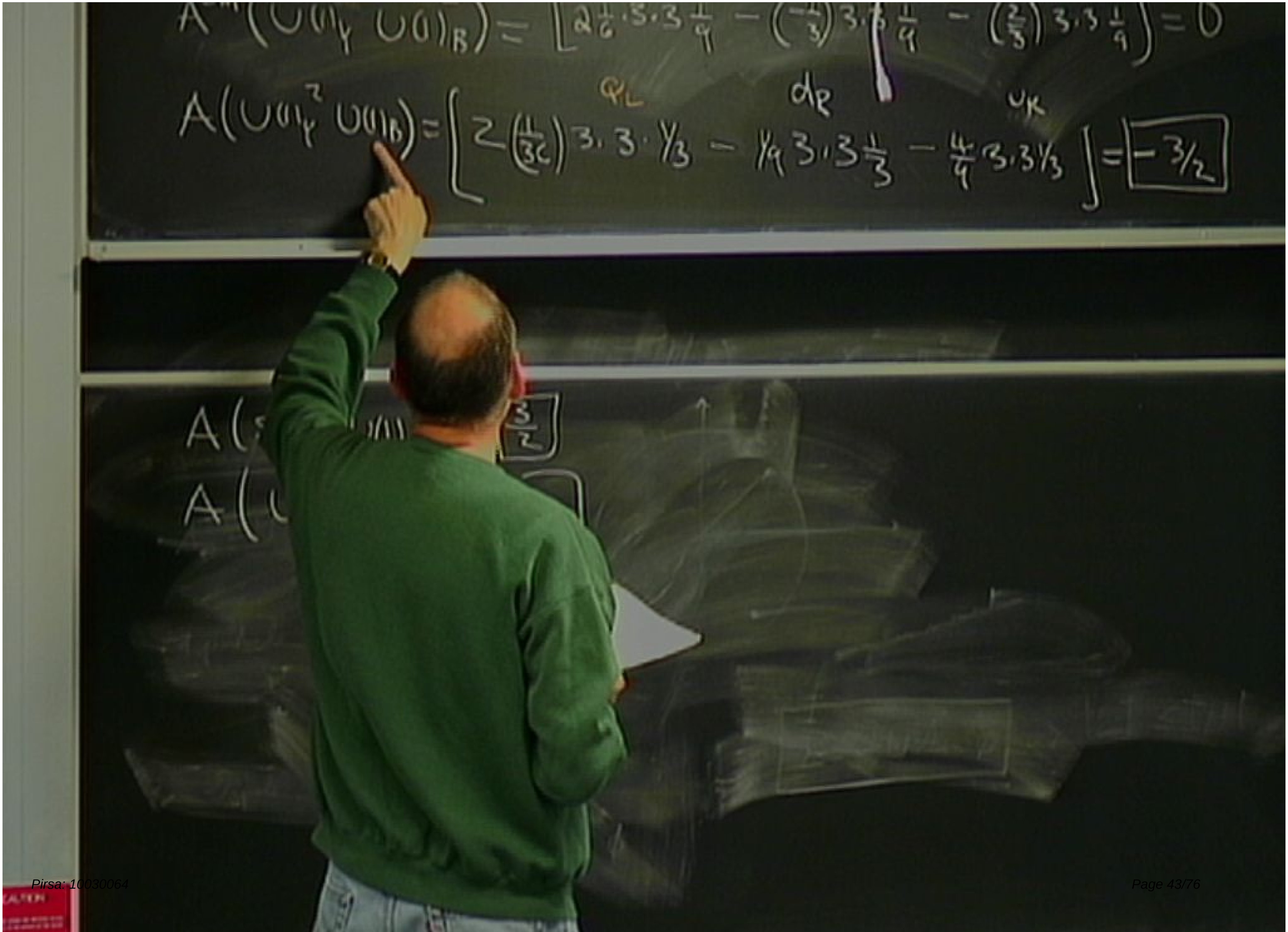
$L'_R =$

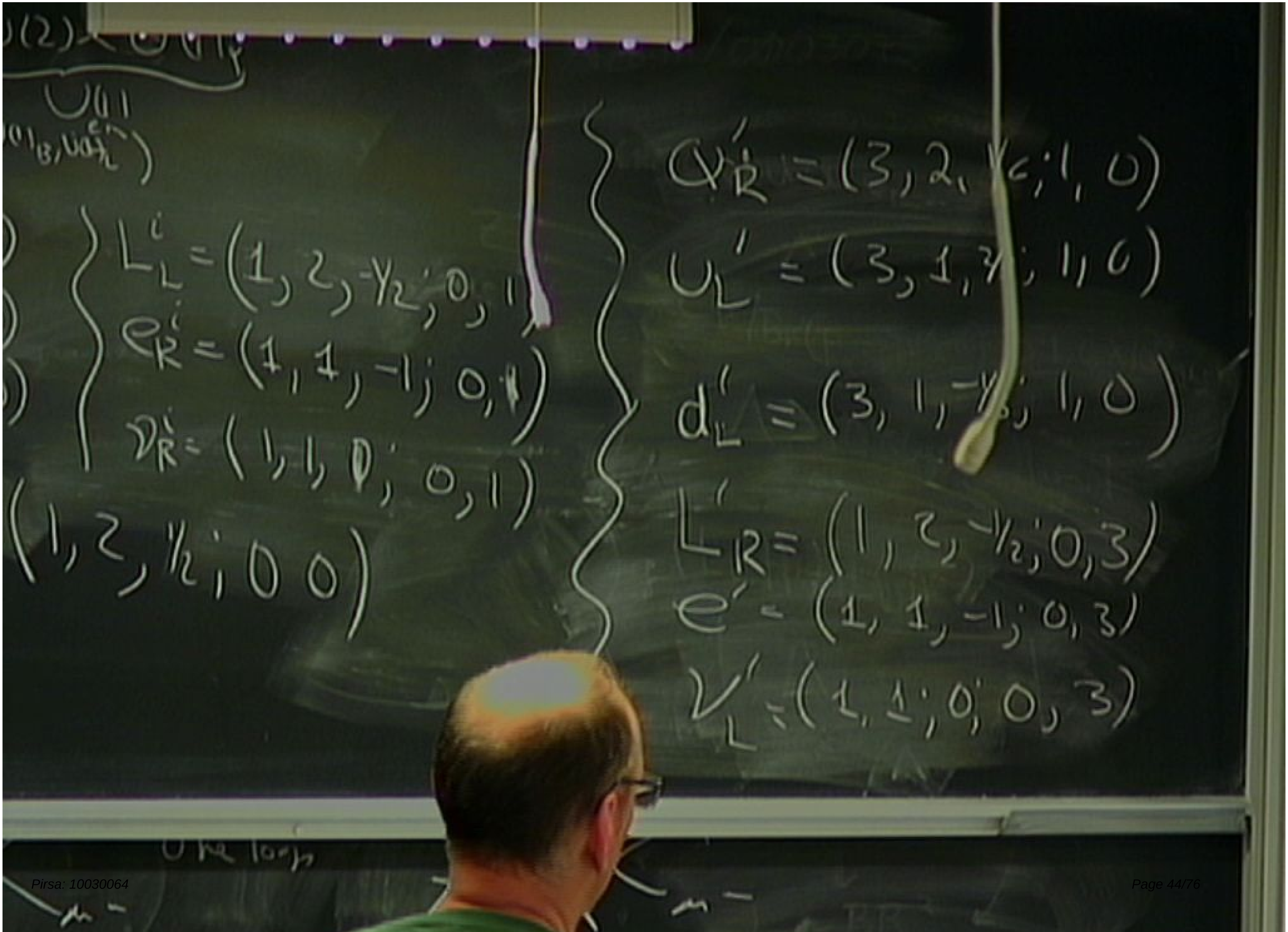
$e' =$

$\nu' =$



A^SM (SU(2)^2 U(1)_B) = 1/2 (3 · 3 · 1/3) = 3/2
color
gen
QL
A^SM (U(1)_Y U(1)_B^2) = [2 1/6 · 3 · 3 1/9 − (−1/3) 3 · 3 1/9 − (
QL
dR
A(U(1)_Y^2 U(1)_B) = [2 (1/(3c)) 3 · 3 · 1/3 − 1/9 3 · 3 1/3 − 4/9 3




U(1)
Q'R = (3, 2,
L'L = (1, 2, -1/2; 0, 1
u'L = (3, 1,
e'R = (1, 1, -1; 0,
νR = (1, 1, 0; 0, 1)
d'L = (3, 1,
(1, 2, 1/2; 0 0)
L'R = (1, 2, -1/2; 0, 3)
e' = (1, 1, -1; 0, 3)
ν'L = (1, 1; 0; 0, 3)

$$A^{SM}\left(SU(2)^2\, U(1)_B\right) = \frac{1}{2}\left(3 \cdot 3 \cdot 1/3\right) = \boxed{\frac{3}{2}}$$

colors, gen, Q_L

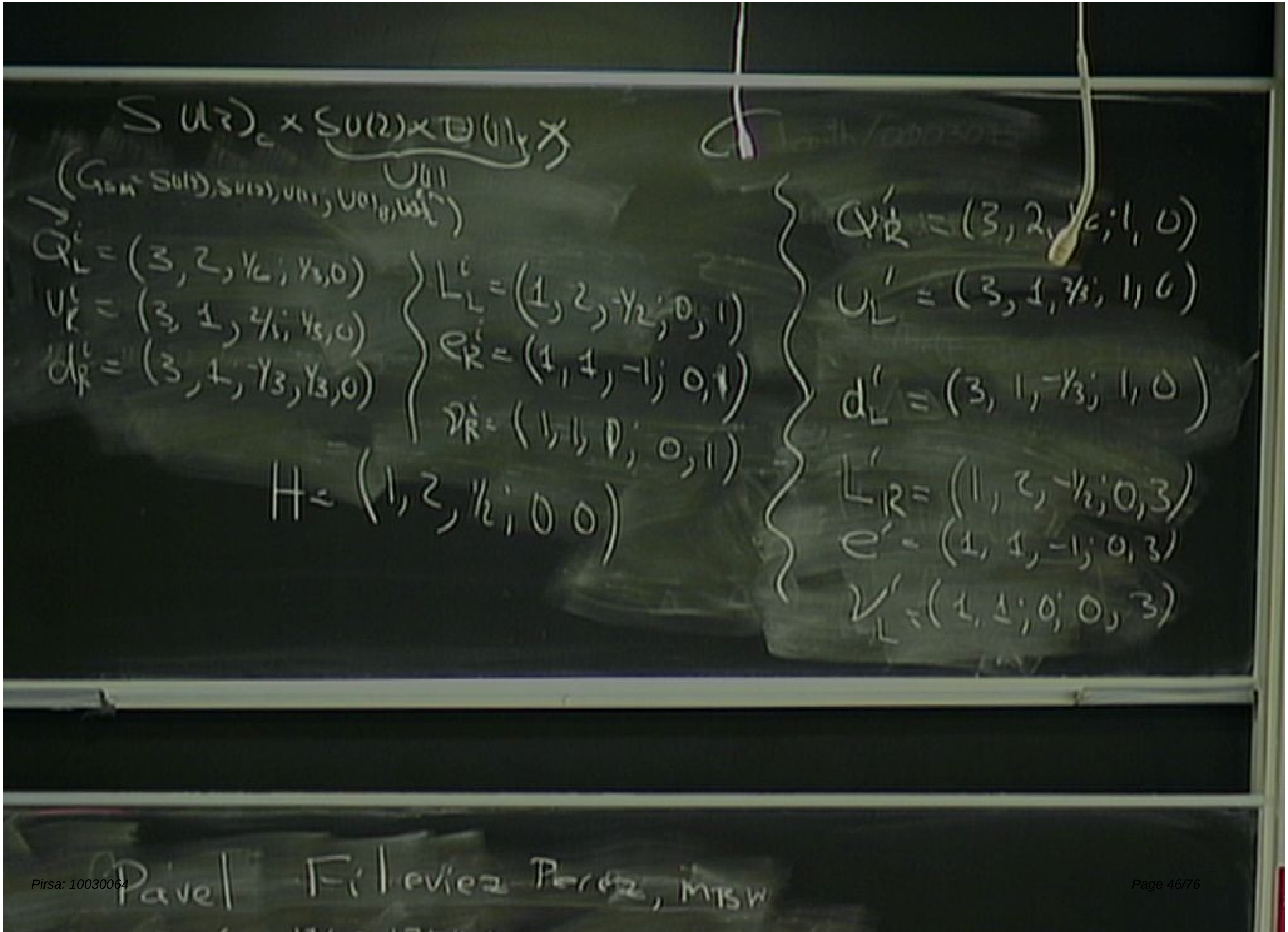
$$A^{SM}\left(U(1)_Y^2\, U(1)_B\right) = \left[2\,\tfrac{1}{6}\cdot 3\cdot 3\,\tfrac{1}{4} - \left(-\tfrac{1}{3}\right) 3\cdot 3\,\tfrac{1}{4} - \left(\tfrac{2}{3}\right) 3\cdot 3\,\tfrac{1}{4}\right] = 0$$

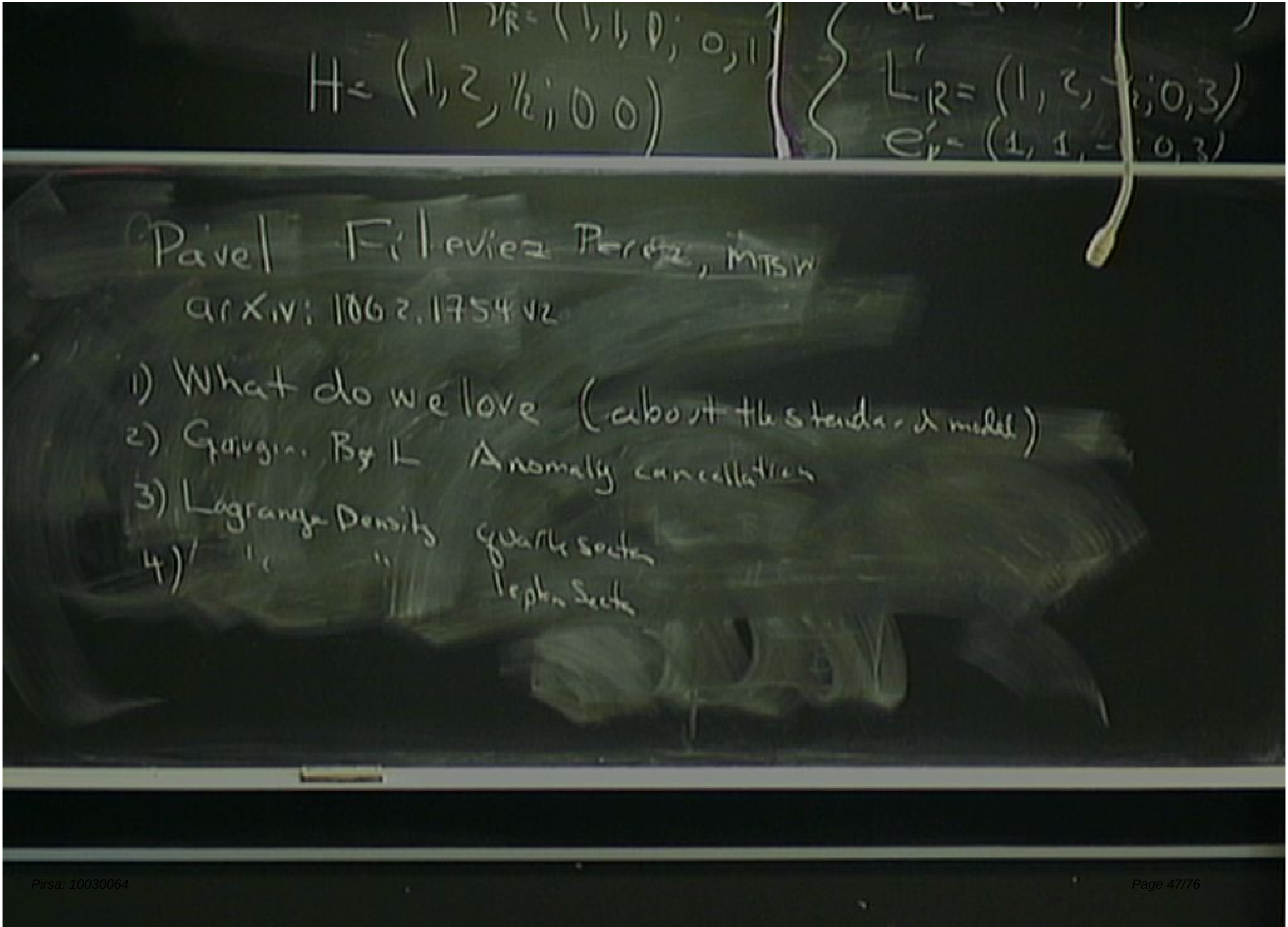
Q_L d_R u_R

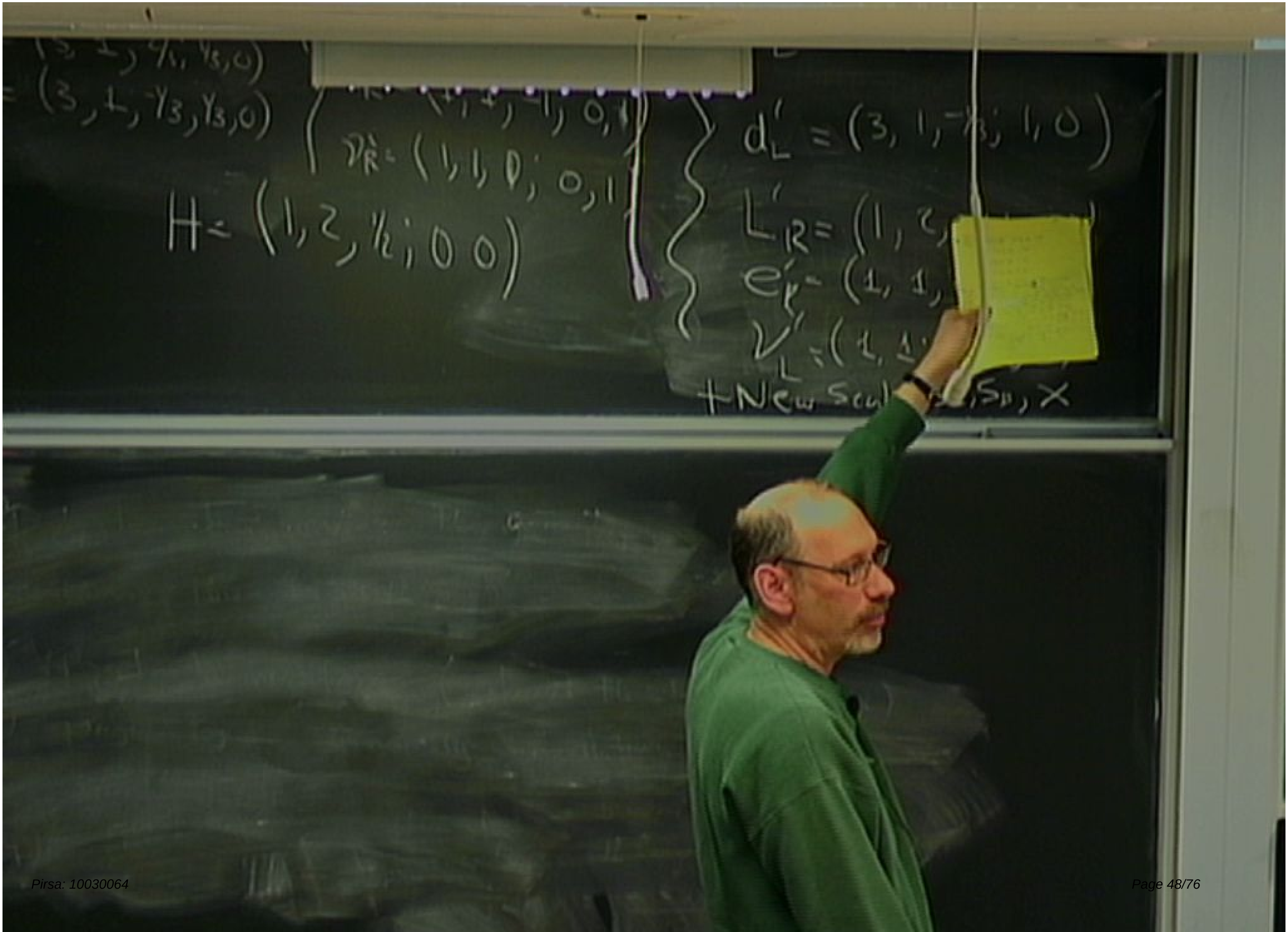
$$A\left(U(1)_Y^2\, U(1)_B\right) = \left[2\left(\tfrac{1}{36}\right) 3\cdot 3 \cdot 1/3 - 1/9\; 3\cdot 3\,\tfrac{1}{3} - \tfrac{4}{9}\, 3\cdot 3\, 1/3\right] = \boxed{-3/2}$$

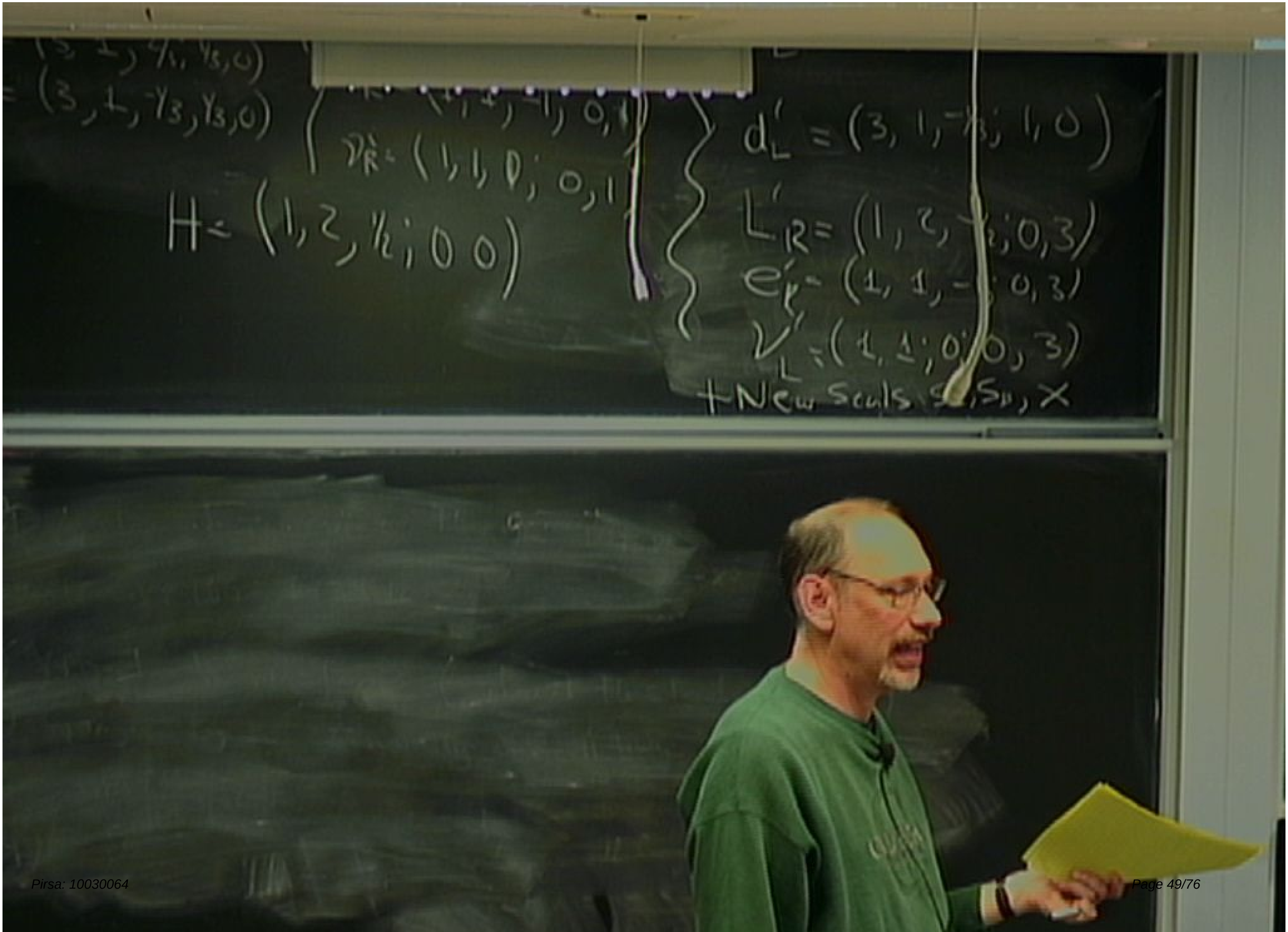
$$A\left(SU(2)^2\, U(1)\right) = \boxed{\frac{3}{2}}$$

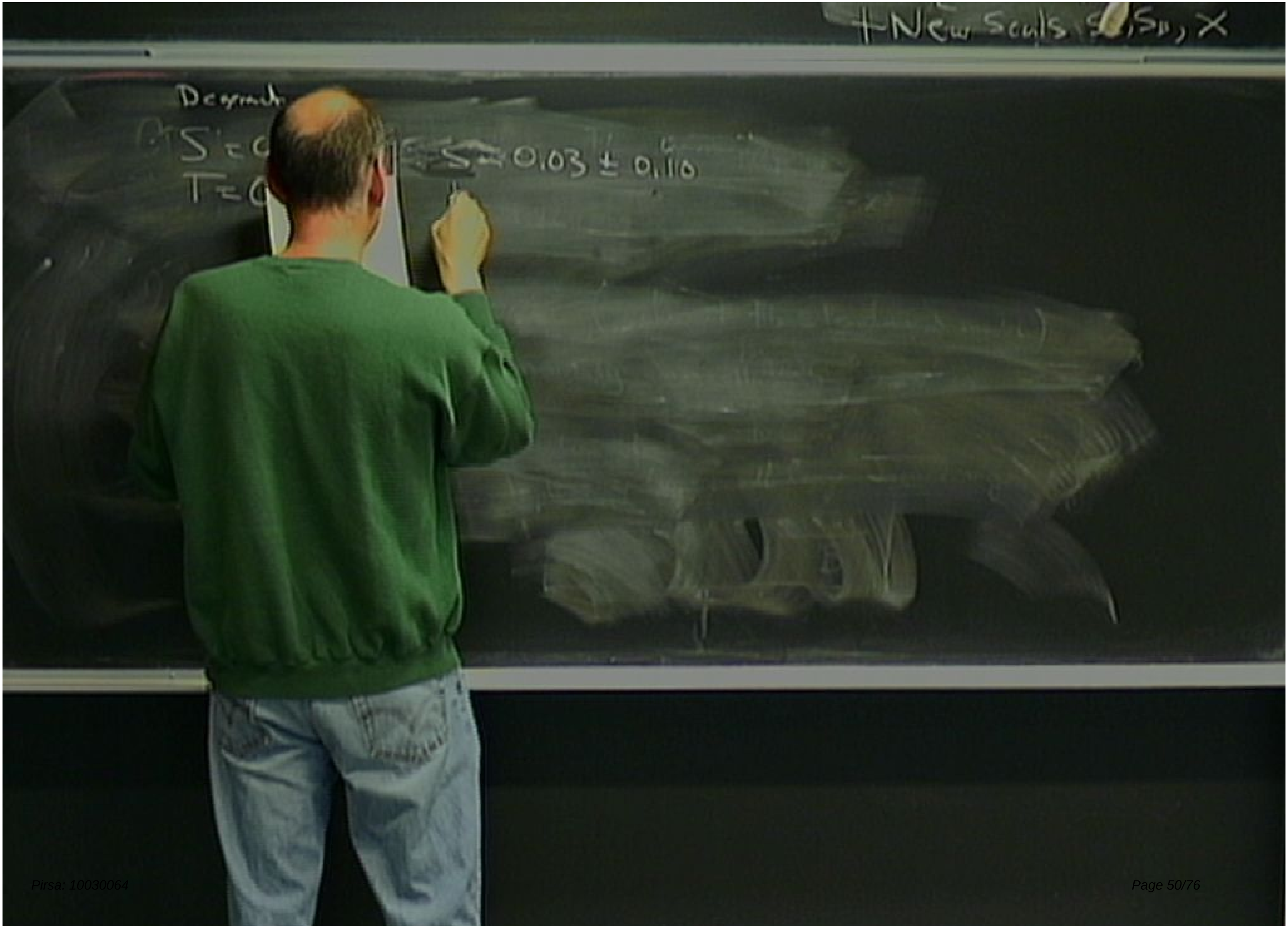
$$A\left(U(1)_Y^2\, U(1)_L\right) = \boxed{-\frac{3}{2}}$$

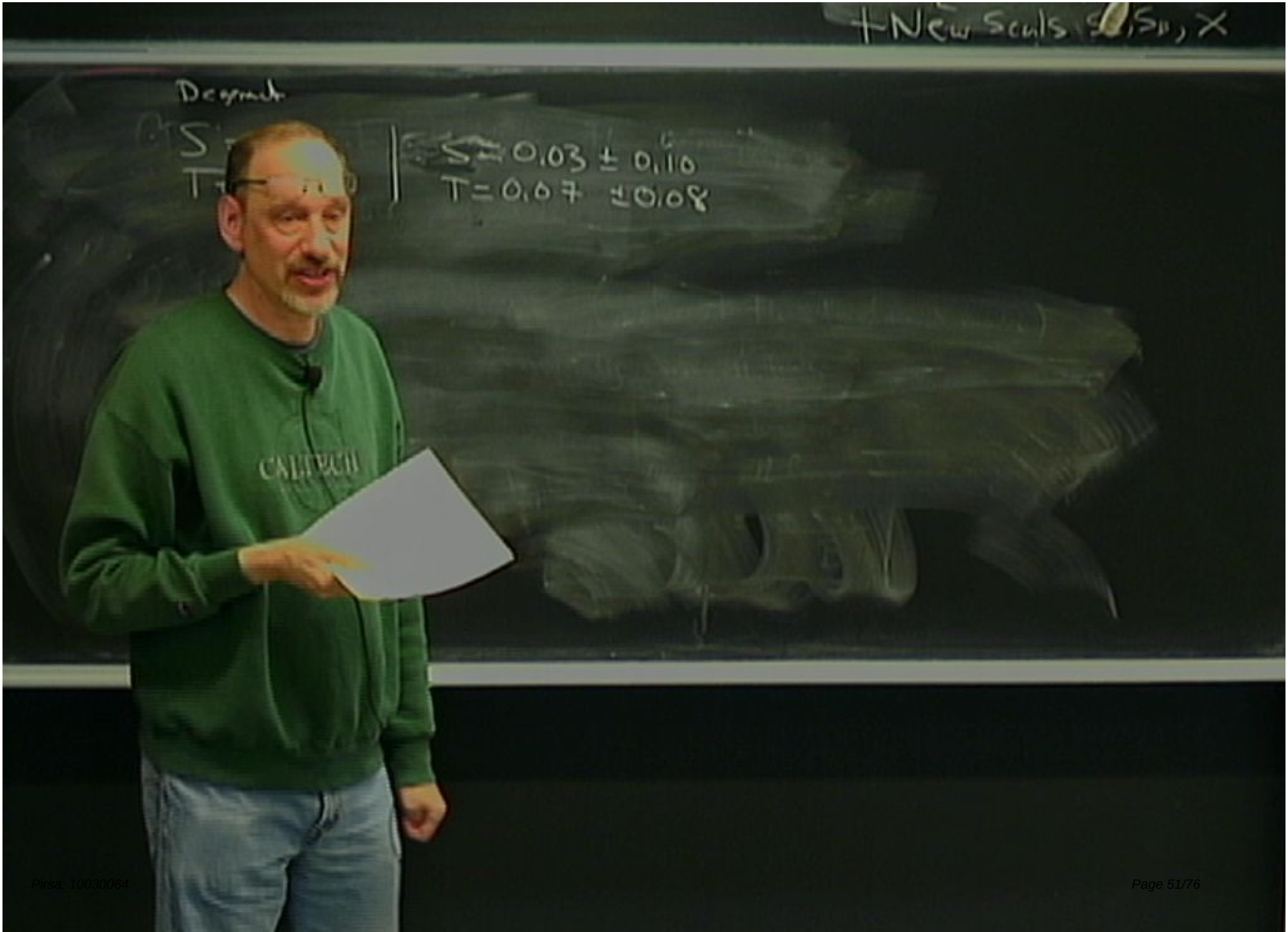

SU(3)_C × SU(2) × U(1)_Y × ...
U(1)
Q_L^i = (3, 2, 1/6; 1/3, 0)
u_R^i = (3, 1, 2/3; 1/3, 0)
d_R^i = (3, 1, -1/3, 1/3, 0)
L_L^i = (1, 2, -1/2; 0, 1)
e_R^i = (1, 1, -1; 0, 1)
ν_R^i = (1, 1, 0; 0, 1)
H = (1, 2, 1/2; 0 0)
Q_R' = (3, 2, 1/6; 1, 0)
u_L' = (3, 1, 2/3; 1, 0)
d_L' = (3, 1, -1/3; 1, 0)
L_R' = (1, 2, -1/2; 0, 3)
e' = (1, 1, -1; 0, 3)
ν_L' = (1, 1; 0; 0, 3)
Pavel Fileviez Perez, MTSW

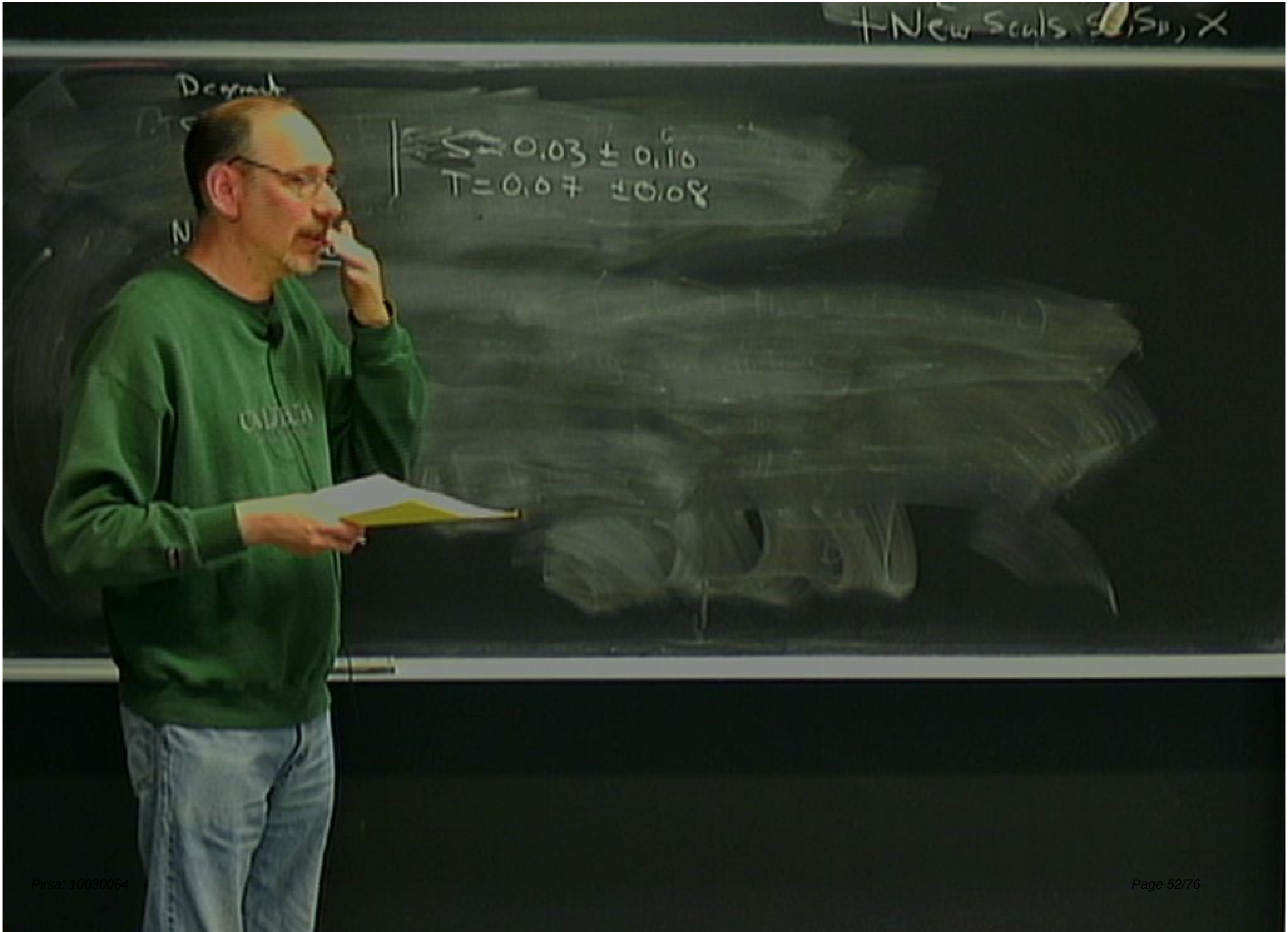

H = (1, 2, ½; 0 0)
Pavel Fileviez Perez, MTSW
arXiv: 1002.1754 v2
1) What do we love (about the standard model)
2) Gauging B & L Anomaly cancellation
3) Lagrange Density quark sector
4) " " lepton sector

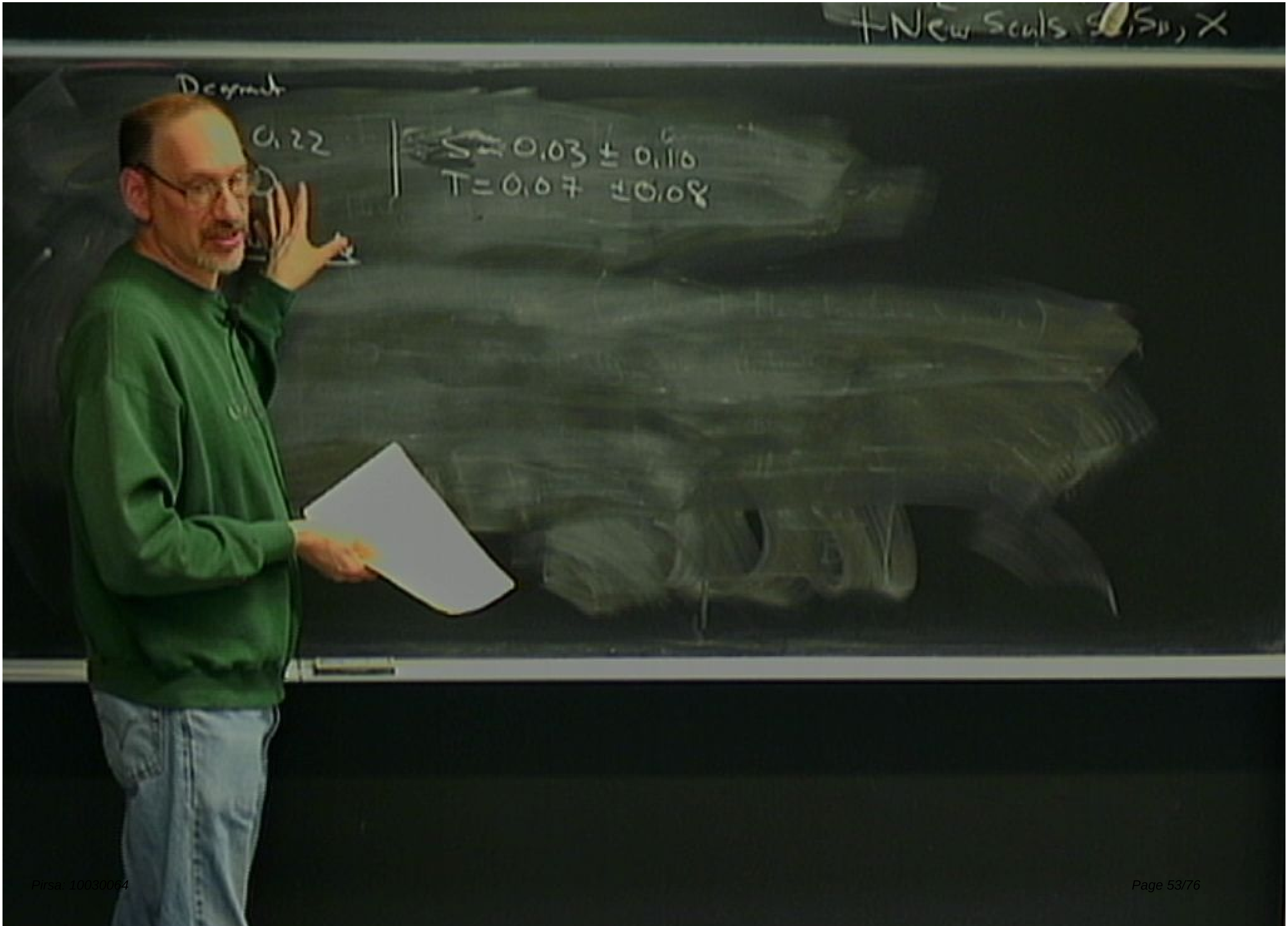

H = (1, 2, ½; 0 0)
d'L = (3, 1, -⅓; 1, 0)

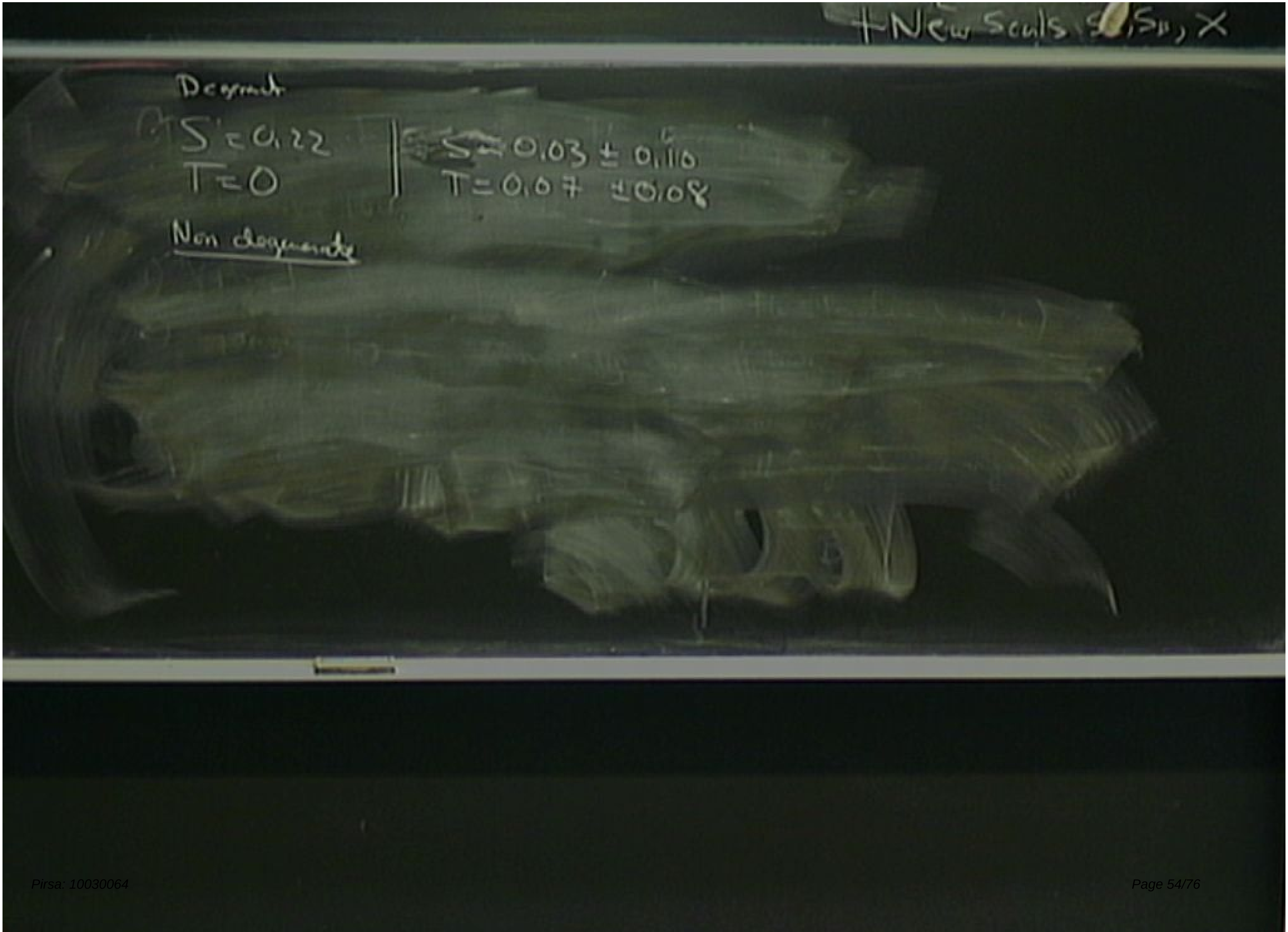

H = (1, 2, ½; 0 0)
d'_L = (3, 1, -⅓; 1, 0)
ν'_L = (1, 1; 0; 0, 3)

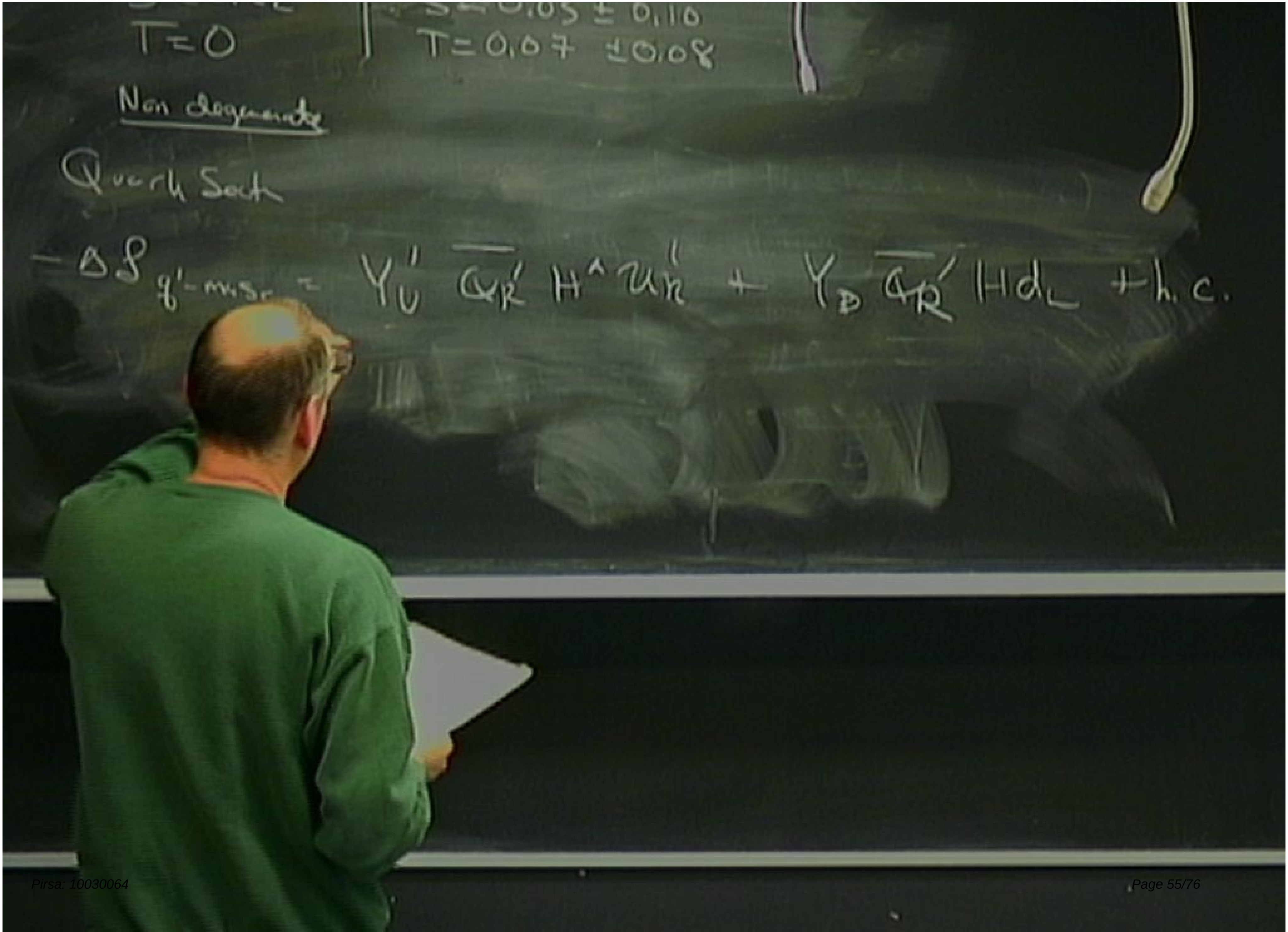


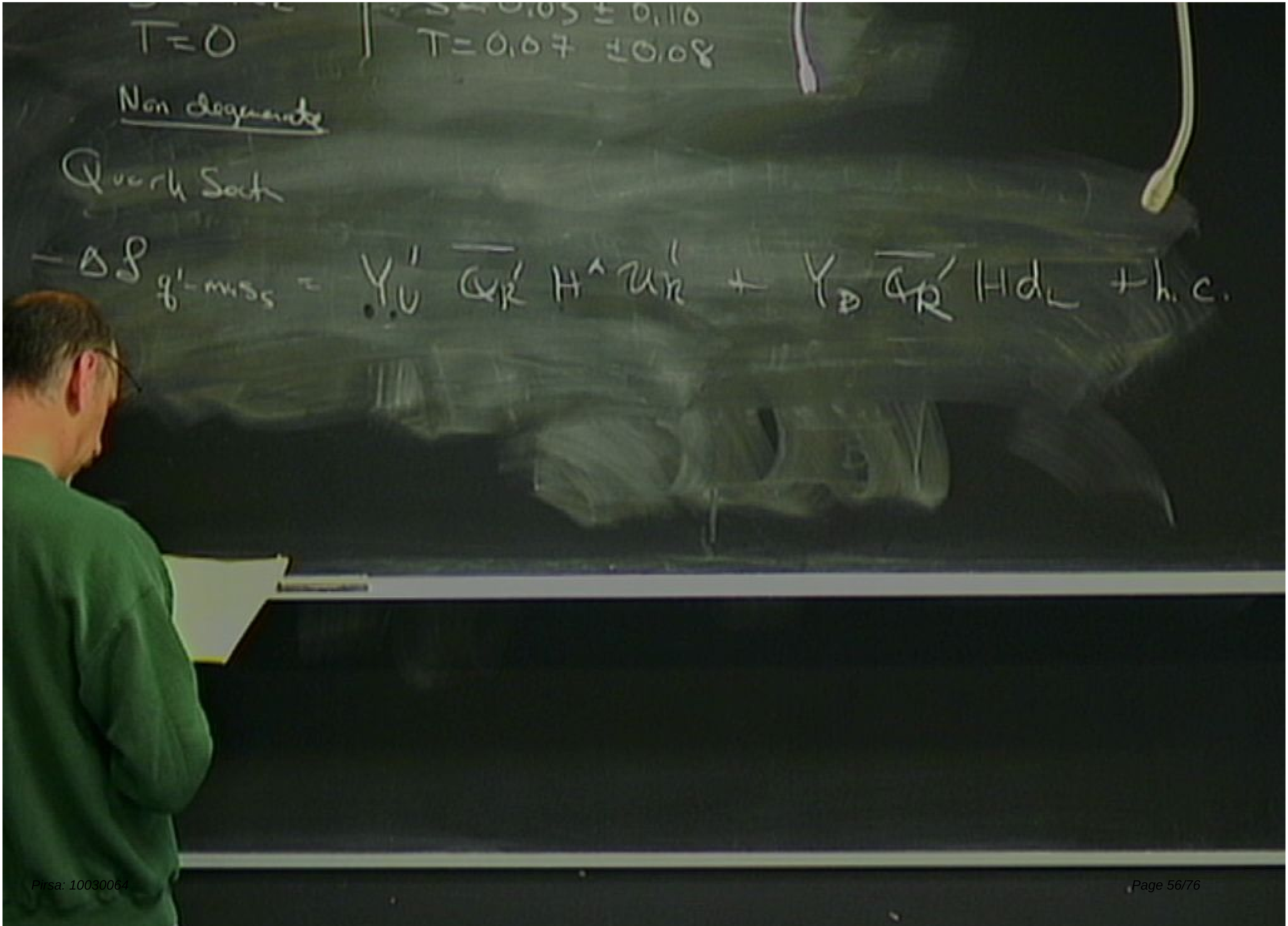

S = 0.03 ± 0.10
T = 0.07 ± 0.08
CALTECH

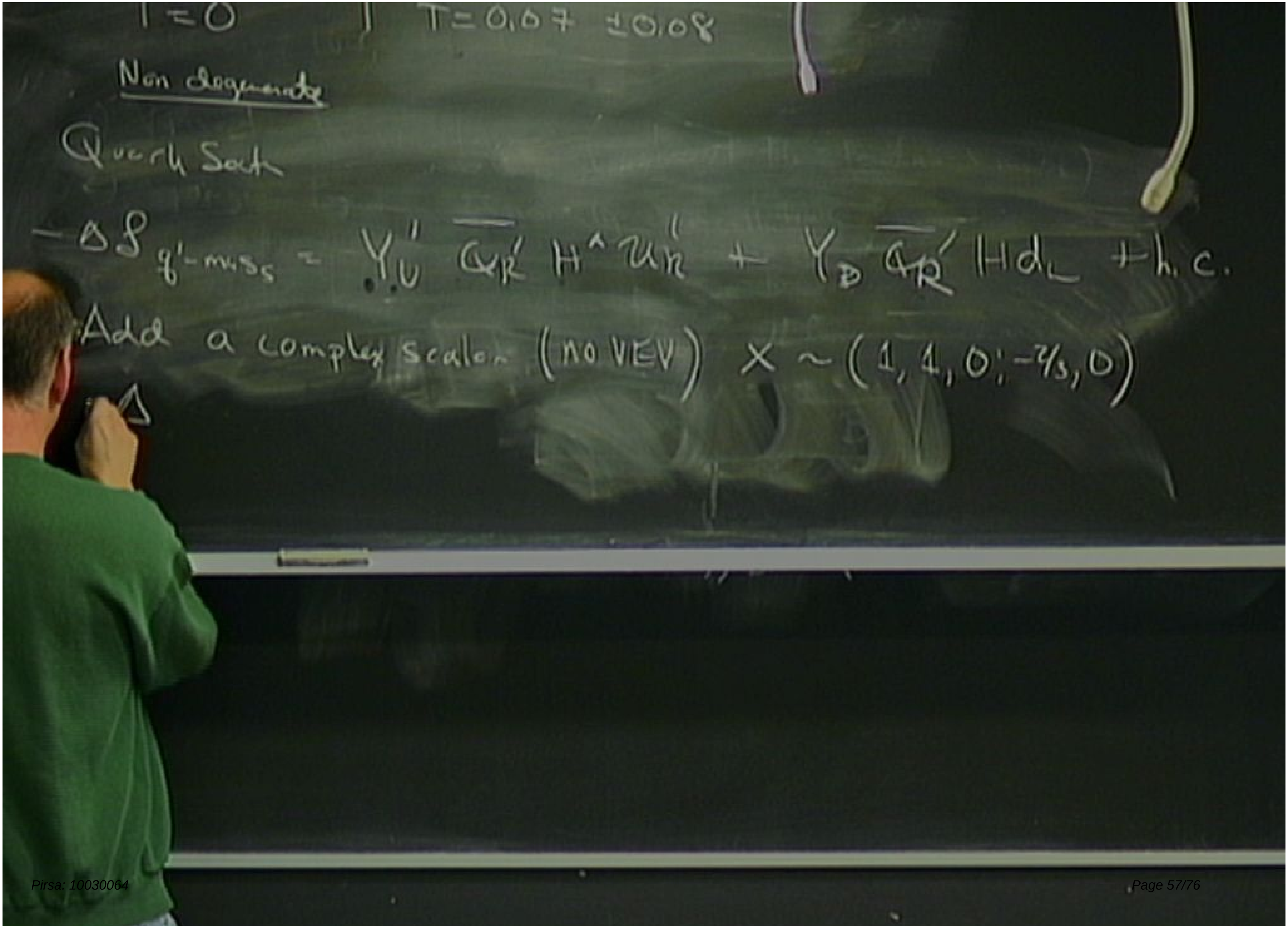

S = 0.03 ± 0.10
T = 0.07 ± 0.08

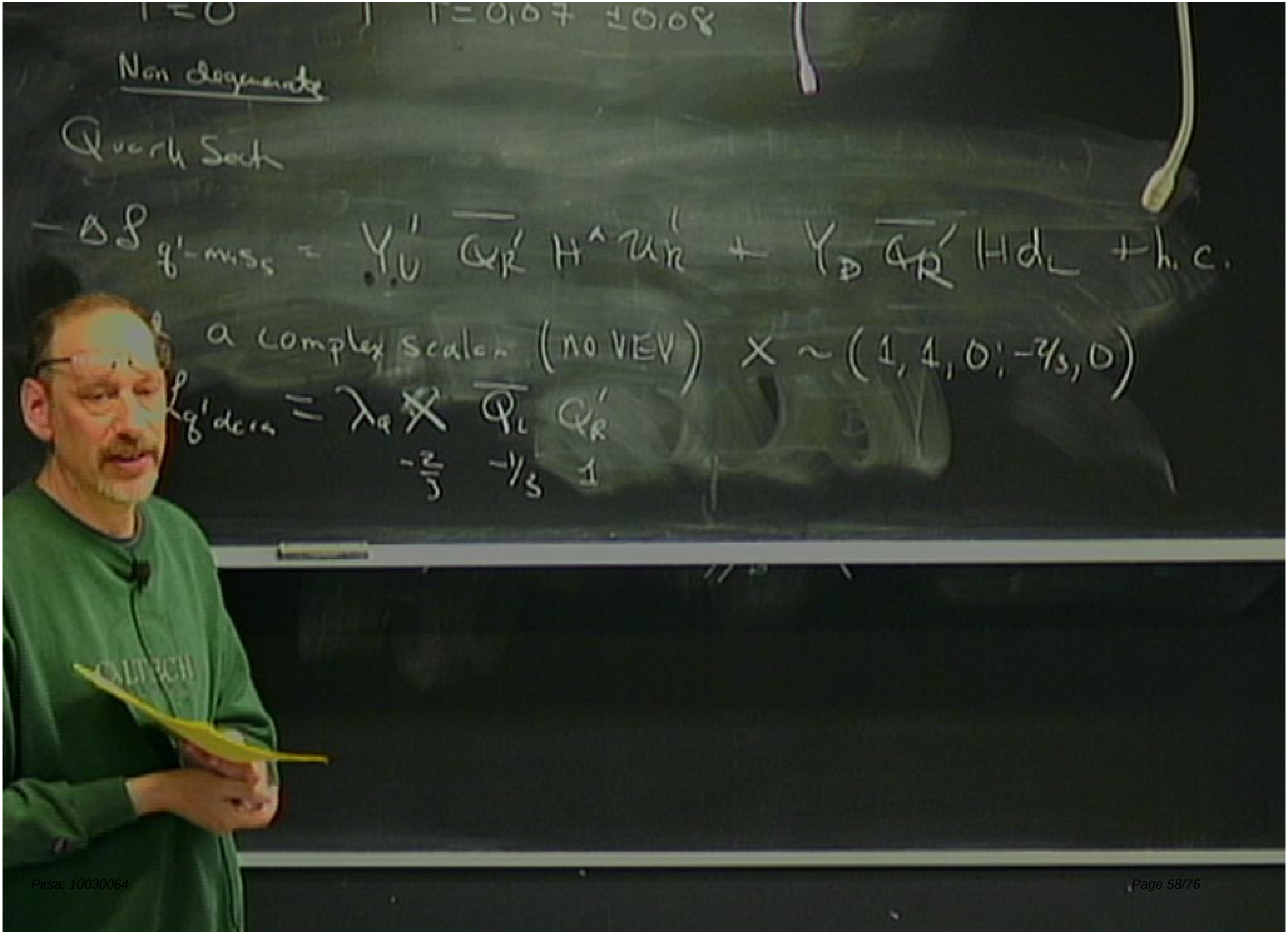

0.22
S = 0.03 ± 0.10
T = 0.07 ± 0.08

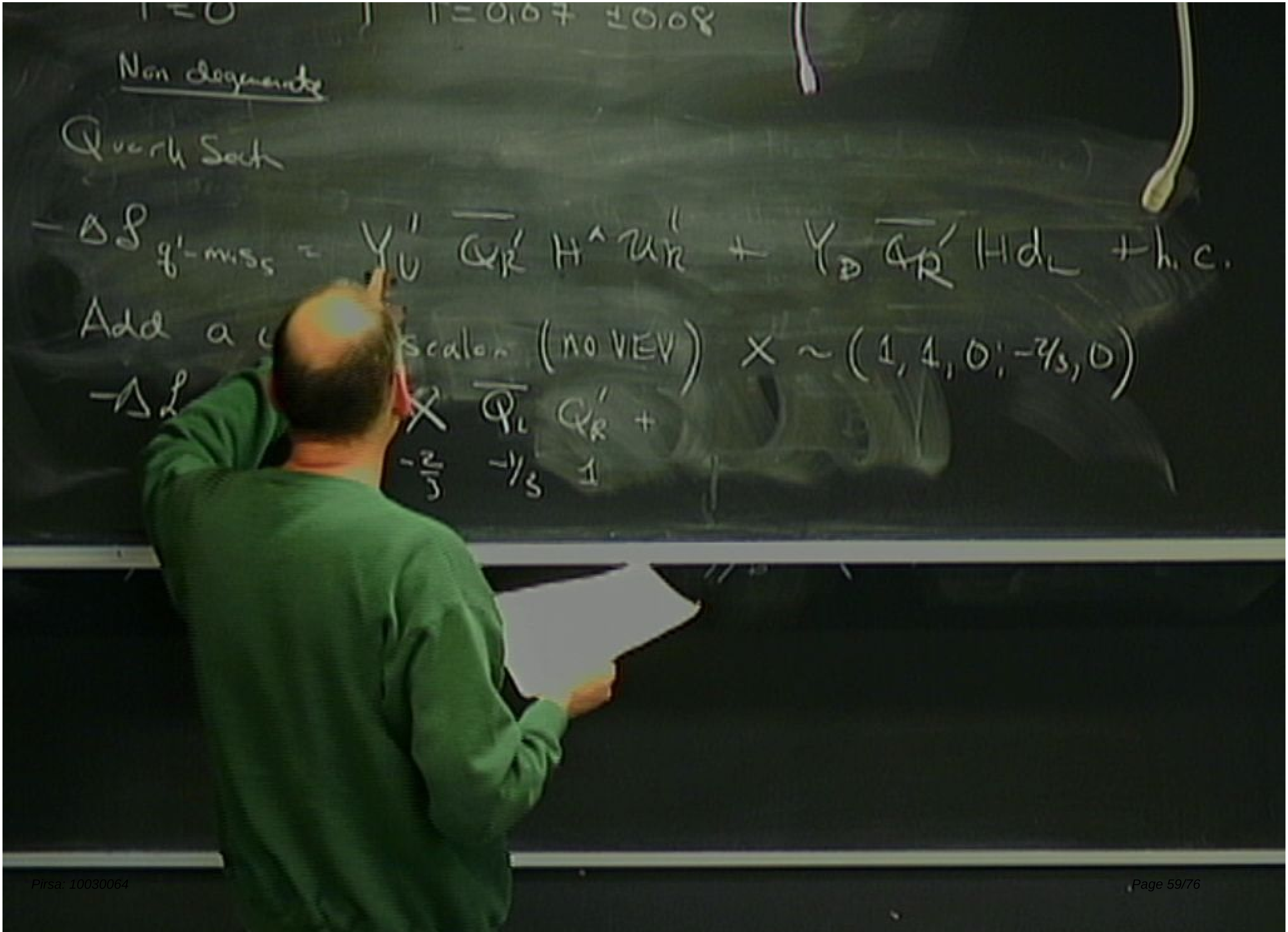

+ New Scals S, S∥, X
Degenerate
S = 0.22
T = 0
S = 0.03 ± 0.10
T = 0.07 ± 0.08
Non degenerate

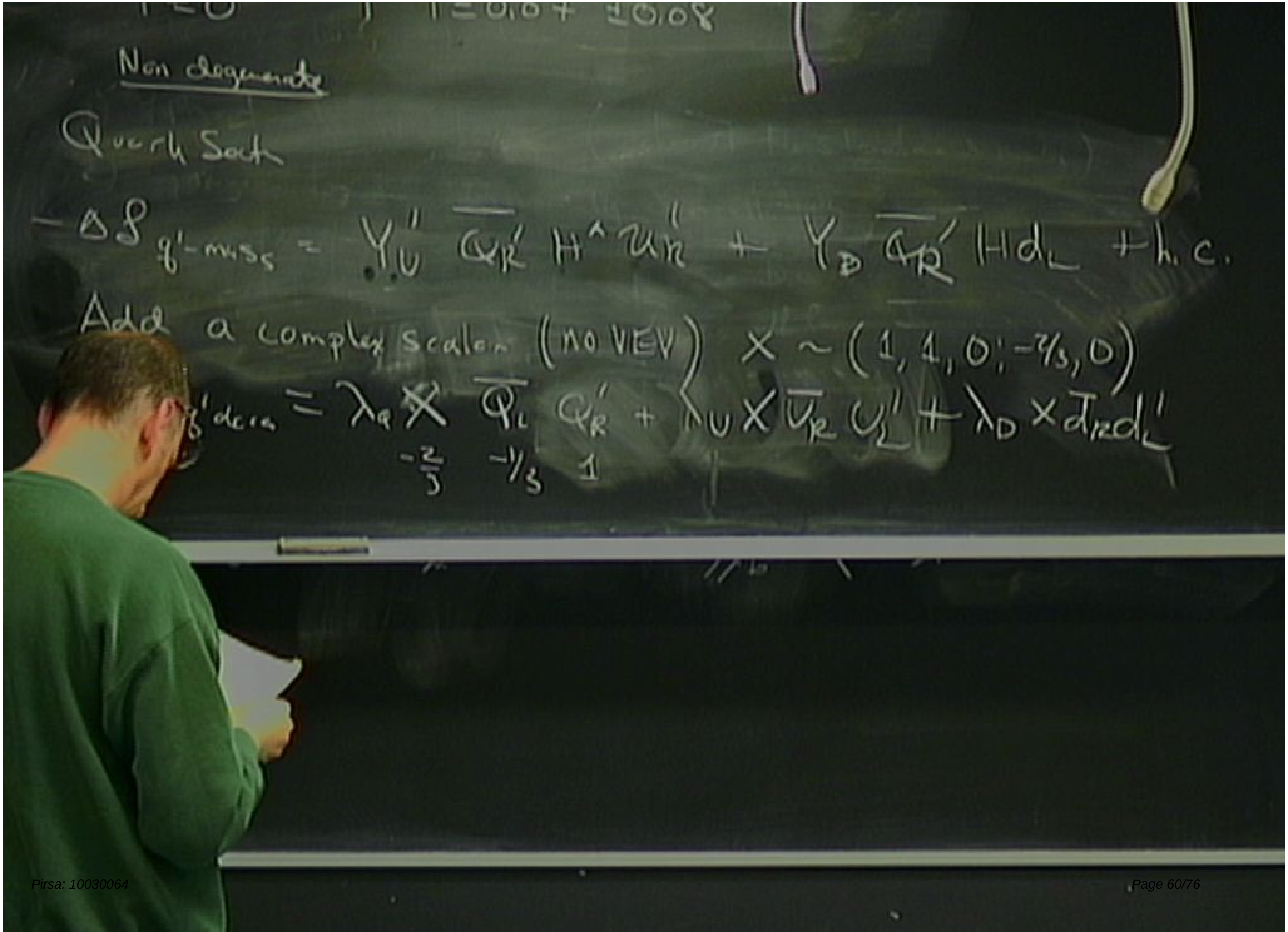

T=0
T=0.07 ±0.08
Non degenerate
Quark Sect

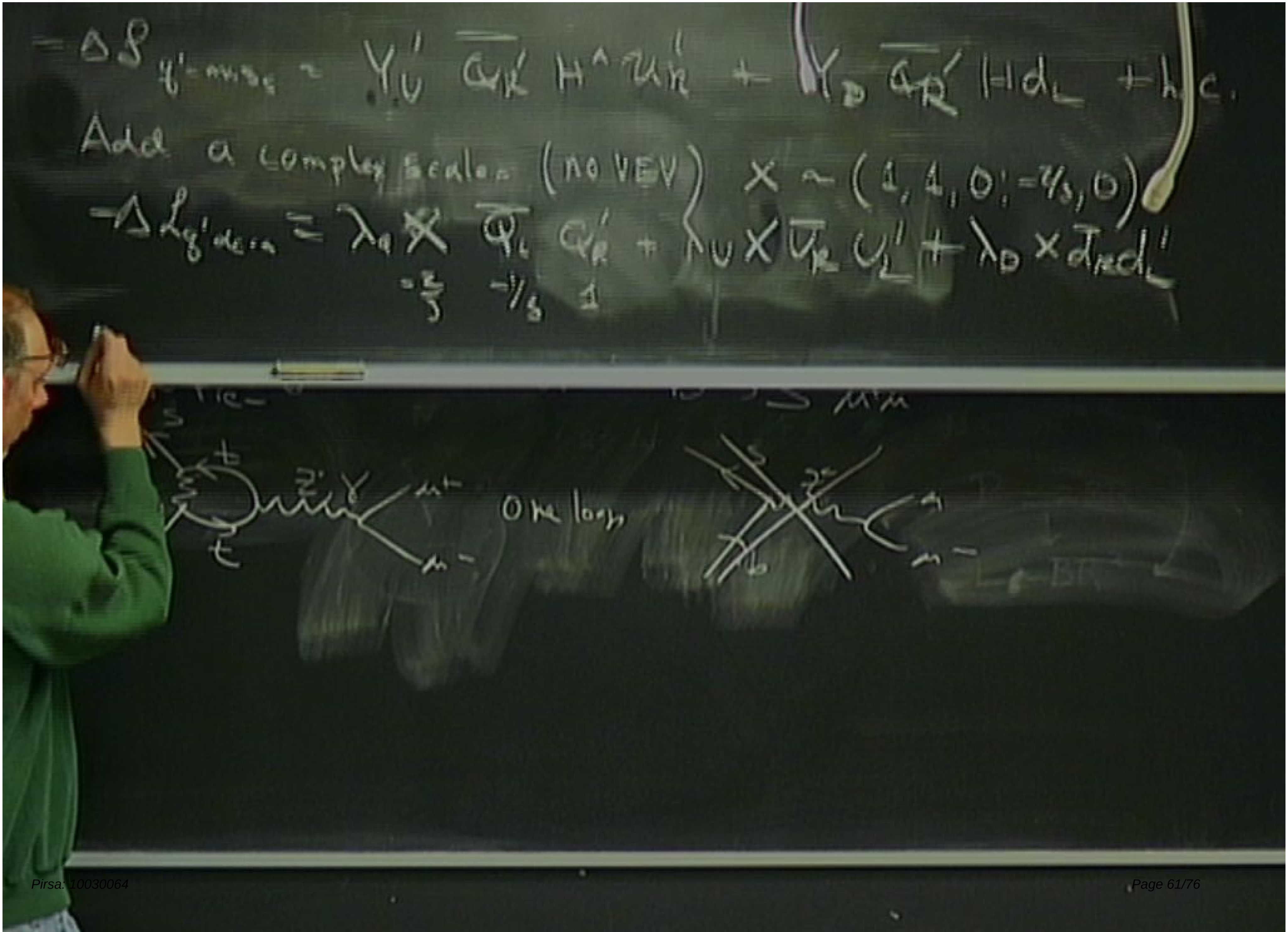

T=0
T=0.07 ±0.08
Non degenerate
Quark Sector
$-\Delta\mathcal{L}_{q'\text{-mass}} = Y_U' \overline{Q_R'} H^{*} u_R' + Y_D \overline{Q_R'} H d_L + h.c.$


T=0 | T=0.07 ±0.08
Non degenerate
Quark Sect
−ΔL q'-mass = Y'U Q̄'R H^ u'R + YD Q̄'R H dL + h.c.
Add a complex scalar (no VEV) X ~ (1, 1, 0; -4/3, 0)
Δ


Non degenerate
Quark Sect
$-\Delta\mathcal{L}_{q'\text{-mass}} = Y_U' \overline{Q_R'} H^\dagger u_R' + Y_D \overline{Q_R'} H d_L + h.c.$
a complex scalar (no VEV) $X \sim (1, 1, 0; -2/3, 0)$
$\mathcal{L}_{q'\text{decay}} = \lambda_q X \overline{Q_L} Q_R'$
$-\frac{2}{3}$ $-1/3$ 1


Non degenerate
Quark Sect
+ h.c.
Add a
scalar (no VEV)


Non degenerate
Quark Sect
-ΔL q'-mass = Y'U Q̄'R H* u'R + YD Q̄'R H dL + h.c.
Add a complex scalar (no VEV) X ~ (1, 1, 0; -2/3, 0)
-2/3 -1/3 1


−ΔL q'-mass = Y'U Q̄'R H^ u'R + YD Q̄'R H dL + h.c.
Add a complex scalar (no VEV) X ~ (1, 1, 0; -1/3, 0)
−ΔL q'-decay = λQ X Q̄L Q'R + λU X ŪR U'L + λD X d̄R d'L
-2/3 -1/3 1
One loop

$H = (1, 2, 1/2; 0\ 0)$ ... $L_R = (1, 2, \ldots)$, $e_R' = (1, 1, \ldots)$

Degenerate

$S = 0.22$ | $S = 0.03 \pm 0.10$

$T = 0$ | $T = 0.07 \pm 0.08$

Non degenerate

Quark Sector

$$-\Delta \mathcal{L}_{q'\text{-mass}} = Y_U' \, \overline{Q_R'} \, \tilde{H} \, u_R' + Y_D \, \overline{Q_R'} \, H \, d_L + h.c.$$

Add a complex scalar (no VEV) $X \sim (1, 1, 0; -2/3, 0)$

$$-\Delta \mathcal{L}_{q'\text{decay}} = \lambda_Q X \, \overline{Q_L} \, Q_R' + \lambda_U X \, \overline{U_R} \, U_L' + \lambda_D X \, \overline{d_R} \, d_L'$$

$-\frac{2}{3}$ $\quad -1/3$ $\quad 1$

A

$$u' d' \to \bar{X} u d$$

$$(q'_R, u'_L, d'_L) \to e^{i\alpha} (q'_R, u'_R, d'_R)$$

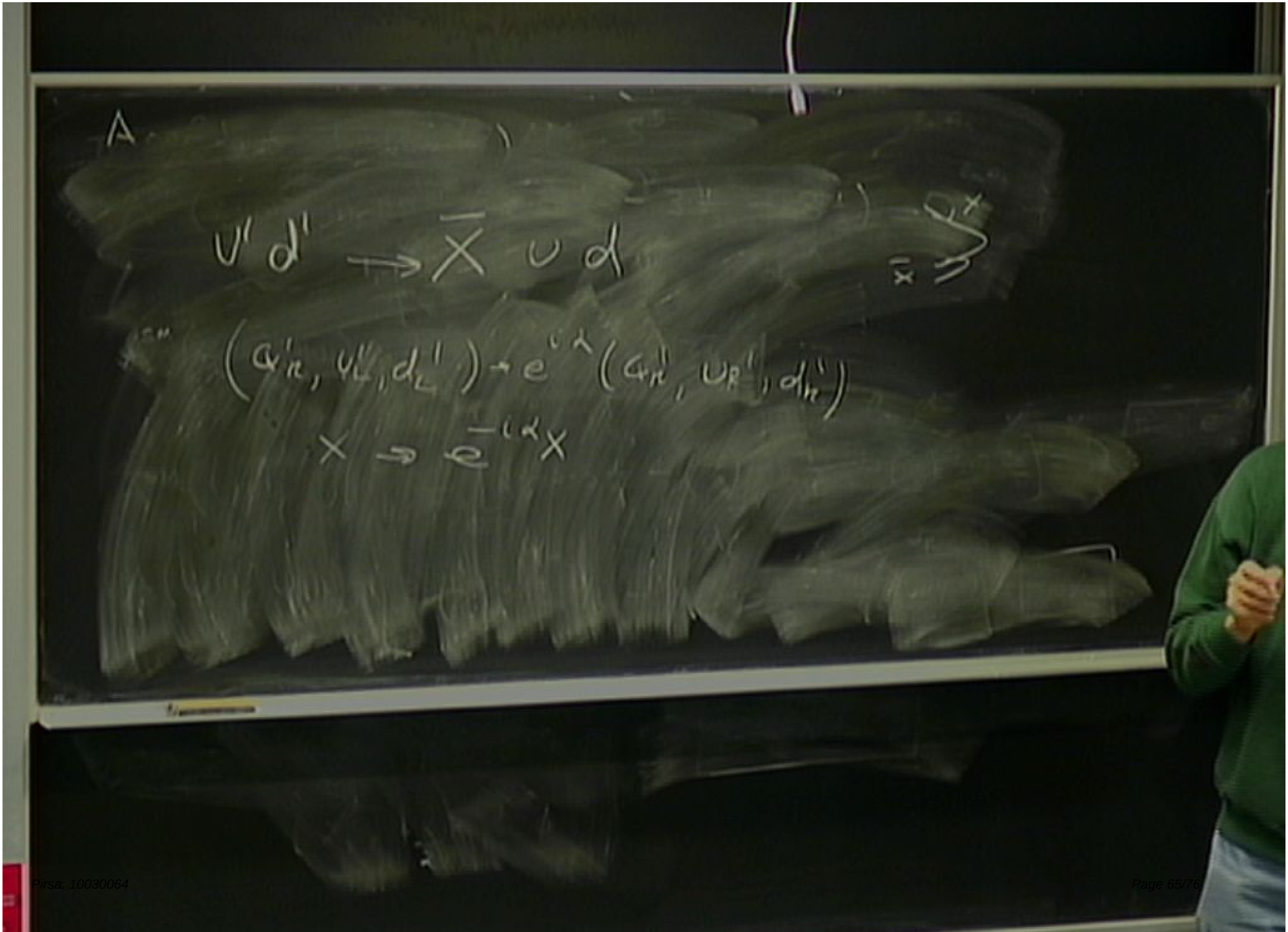
$$X \to e^{-i\alpha} X$$

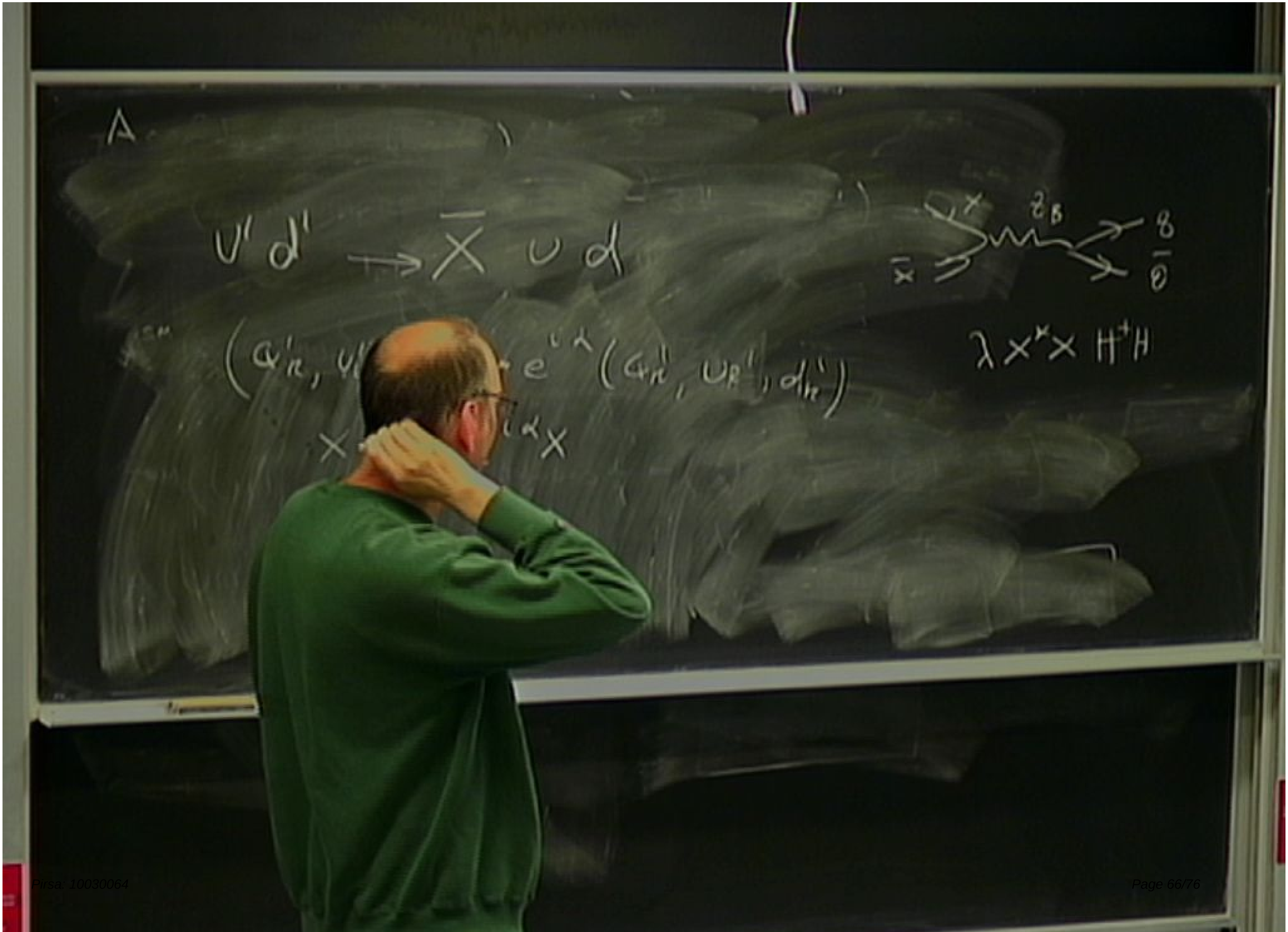
A

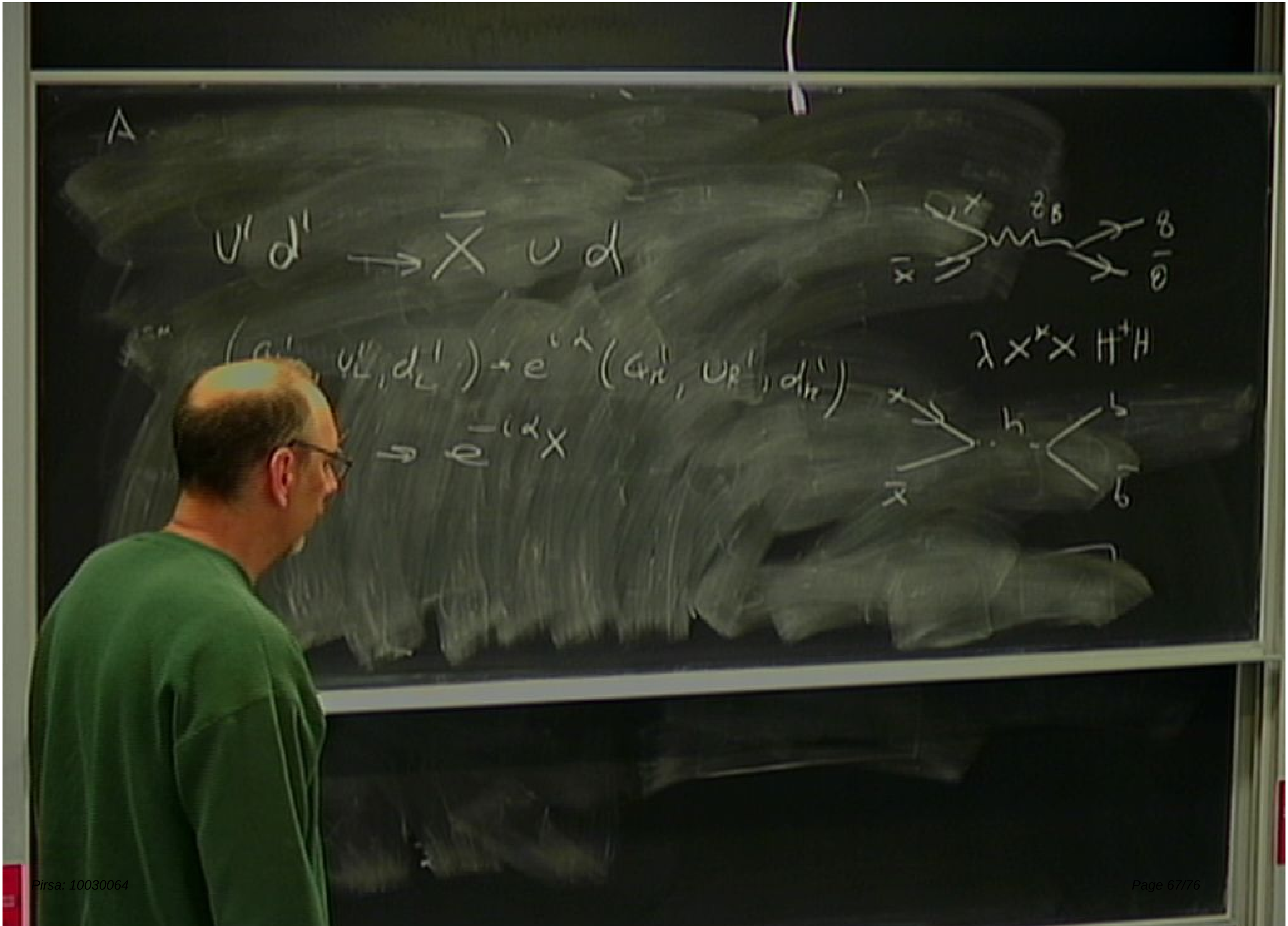
$$u' d' \to \bar{X}\, u\, d$$

$$(q_L', u_L', d_L') \to e^{i\alpha}(q_R', u_R', d_R')$$

$$X \to e^{-i\alpha} X$$

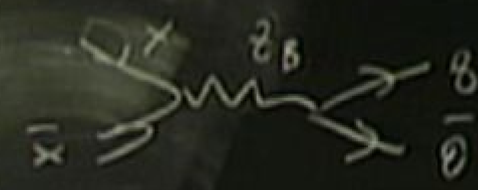

u'd' → X̄ u d
(Q'_L, u'_L, d'_L) → e^{iα} (Q_R', u_R', d_R')
X → e^{-iα} X


u'd' → X̄ u d
λ X*X H†H


A
u' d' → X̄ u d
λ X*X H†H
→ e^{-iα} X

A

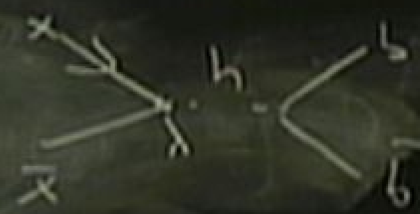
$$u' d' \rightarrow \bar{X} u d$$

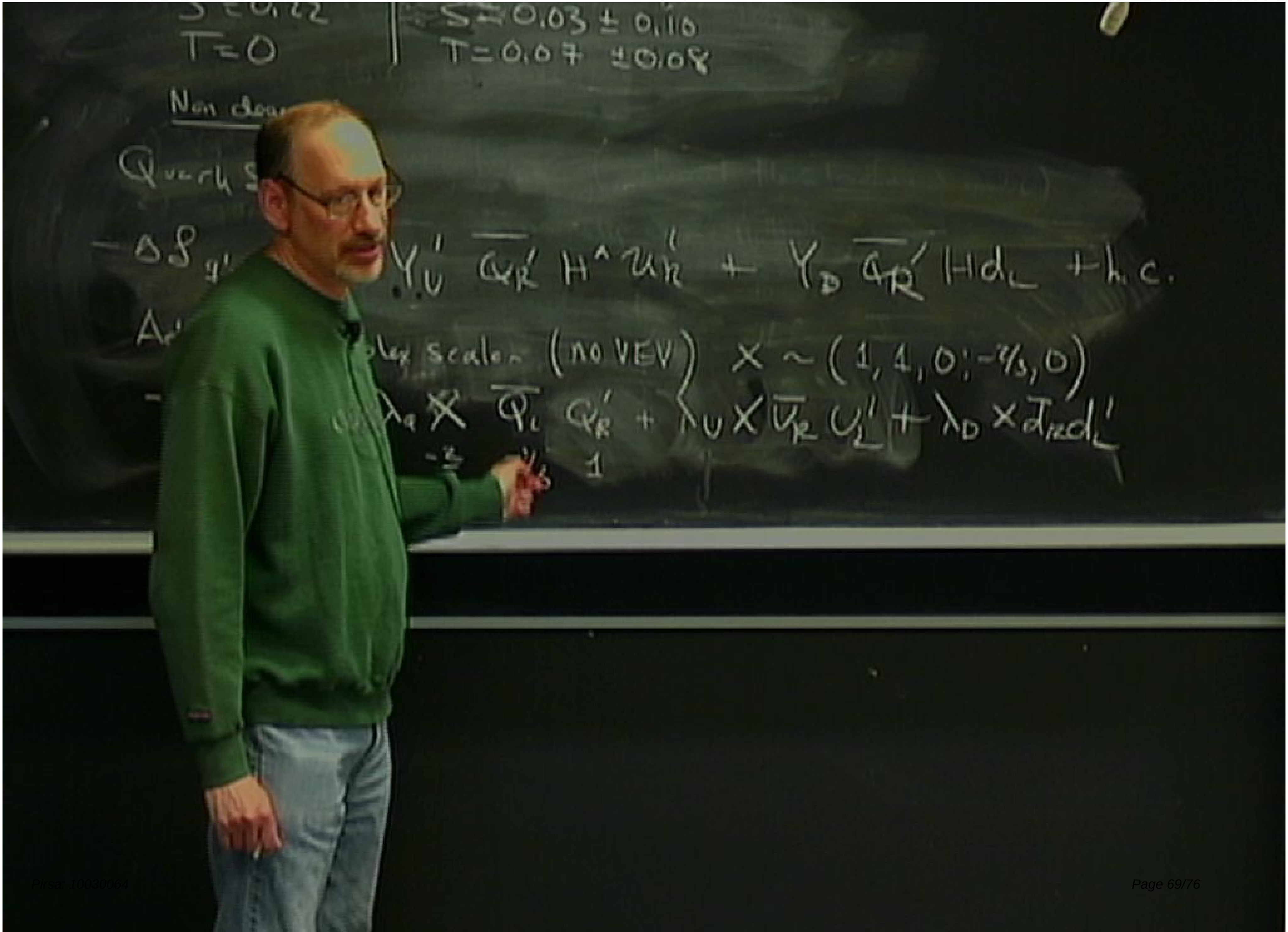


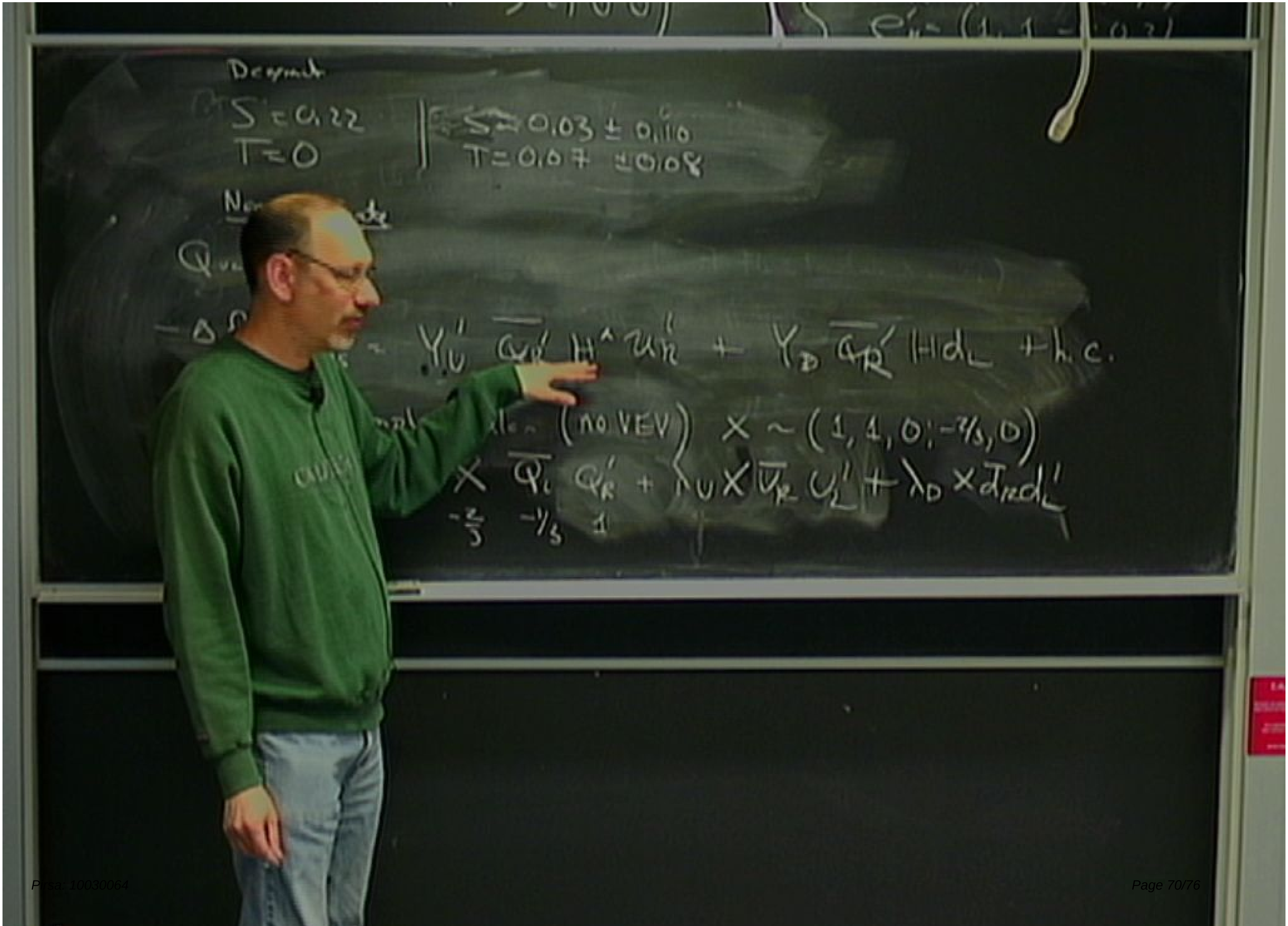
$$(Q'_R, u'_L, d'_L) \rightarrow e^{i\alpha}(Q'_R, u'_R, d'_R)$$

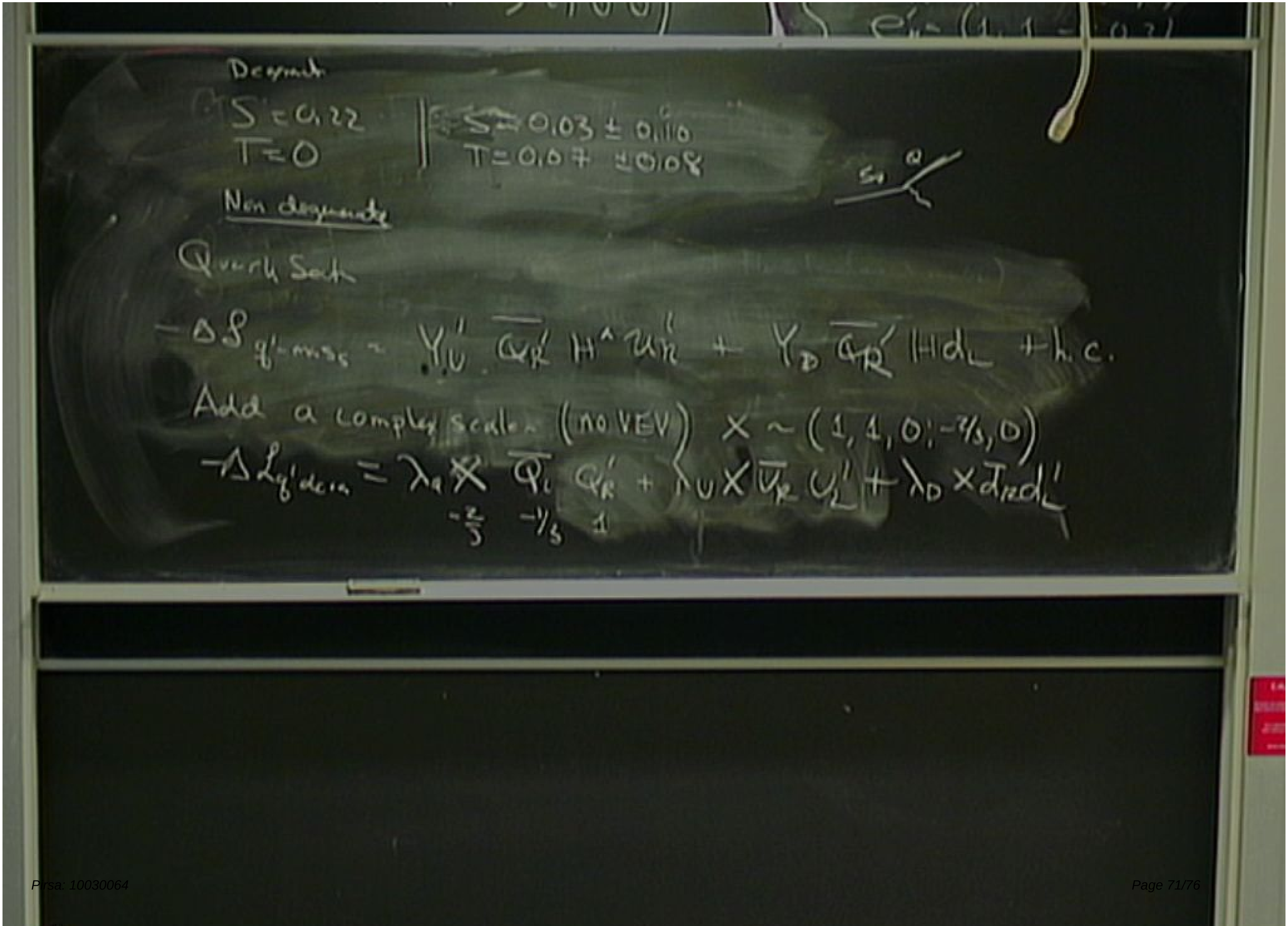
$$X \rightarrow e^{-i\alpha} X$$

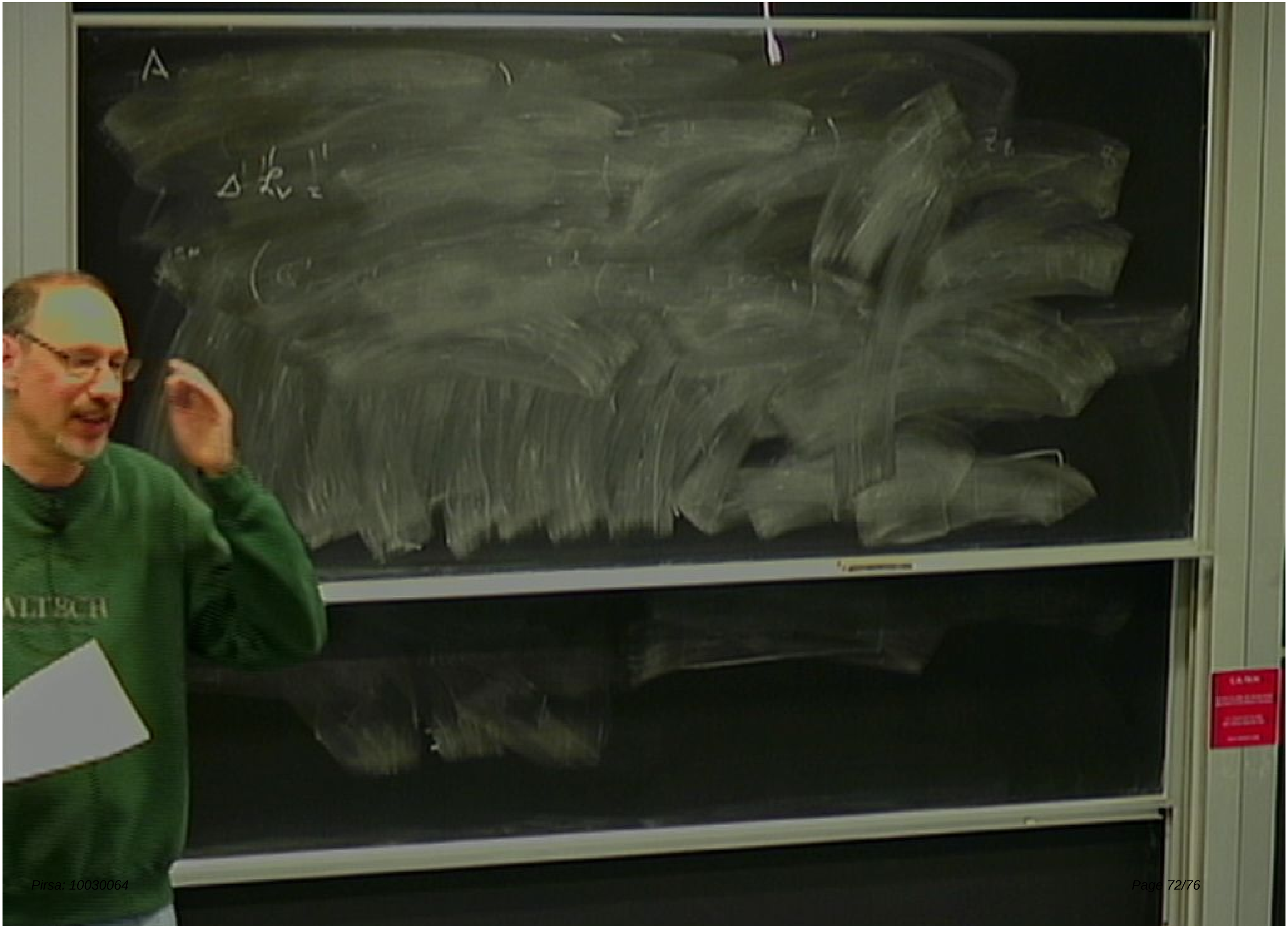
$$\lambda X^* X H^\dagger H$$




T=O
S=0.03 ± 0.10
T=0.07 ±0.08
(no VEV)
+h.c.


S = 0.22
T = 0
S = 0.03 ± 0.10
T = 0.07 ± 0.08
+ h.c.
(no VEV)

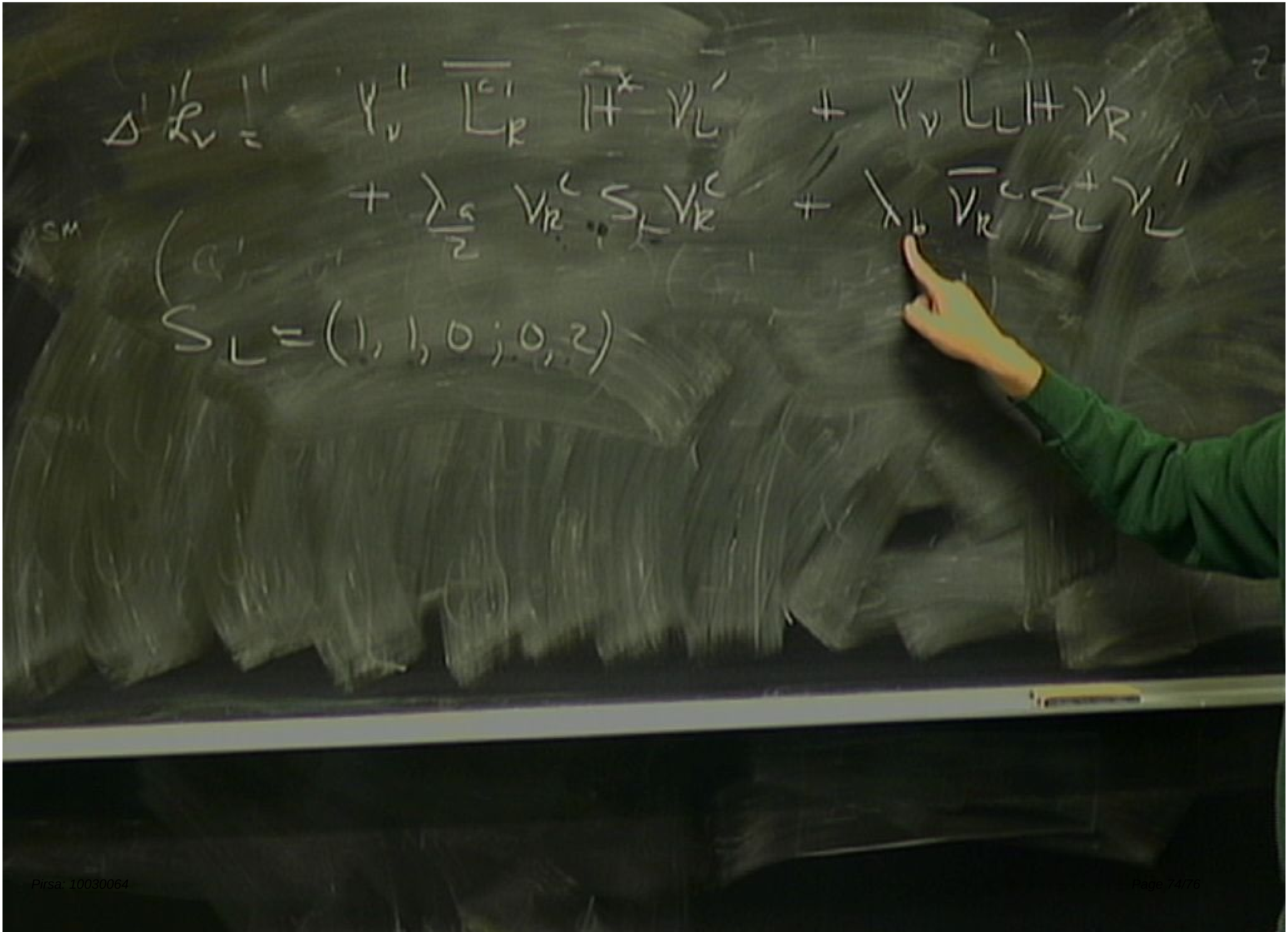

Degenerate
S = 0.22
T = 0
S = 0.03 ± 0.10
T = 0.07 ± 0.08
Non degenerate
Quark Sector
−ΔL q'-mass = Y'U Q̄'R H^ u'R + YD Q̄'R H dL + h.c.
Add a complex scalar (no VEV) X ~ (1, 1, 0; −2/3, 0)
−ΔL q'decay = λQ X Q̄L Q'R + λU X ŪR U'L + λD X d̄R d'L
−2/3 −1/3 1



$$\Delta \mathcal{L}_\nu = Y_\nu' \, \overline{L_R^c} \, H^* \, \nu_L' + Y_\nu \, \overline{L_L} \, H \, \nu_R$$

$$+ \frac{\lambda_a}{2} \, \overline{\nu_R^c} \, S_L \, \nu_R^c + \lambda_b \, \overline{\nu_R^c} \, S_L^+ \, \nu_L'$$

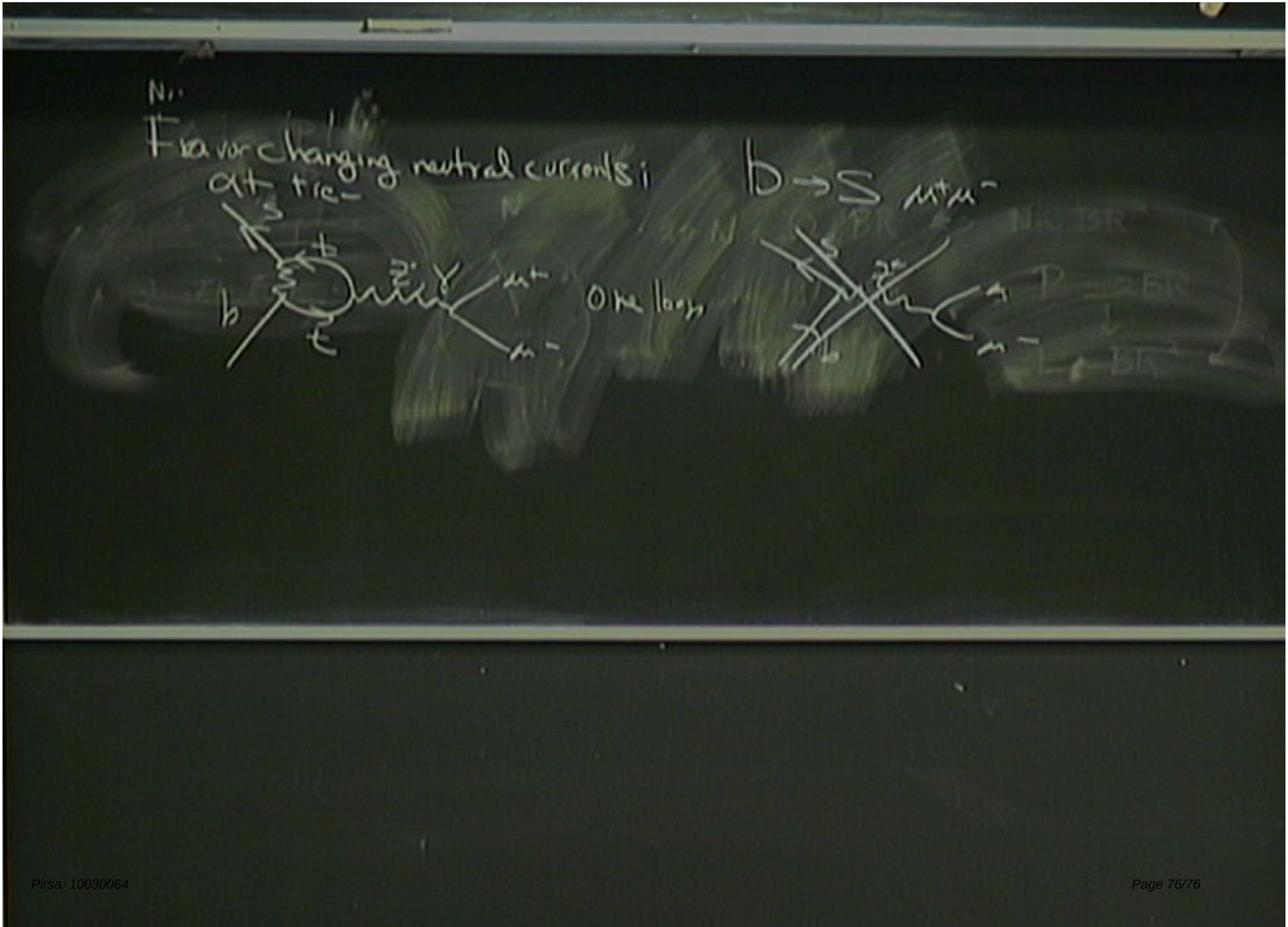
$$S_L = (1, 1, 0; 0, 2)$$


Δℒ_ν = y_ν' L̄_R^c' H* ν_L' + y_ν L_L H ν_R
+ λ_a/2 ν_R^c S_L ν_R^c + λ_b ν̄_R^c S_L^+ ν_L'
S_L = (1, 1, 0; 0, 2)

$$\Delta \mathcal{L}_\nu = Y_\nu' \, \overline{L_R'} \, H^* \nu_L' + Y_\nu L_L H \nu_R$$

$$+ \frac{\lambda_a}{2} \nu_R^c S_L \nu_R^c + \lambda_b \overline{\nu_R^c} S_L^+ \nu_L'$$

$$S_L = (1, 1, 0; 0, 2)$$


Flavor changing neutral currents:
at tree-
b → s μ+μ−
One loop