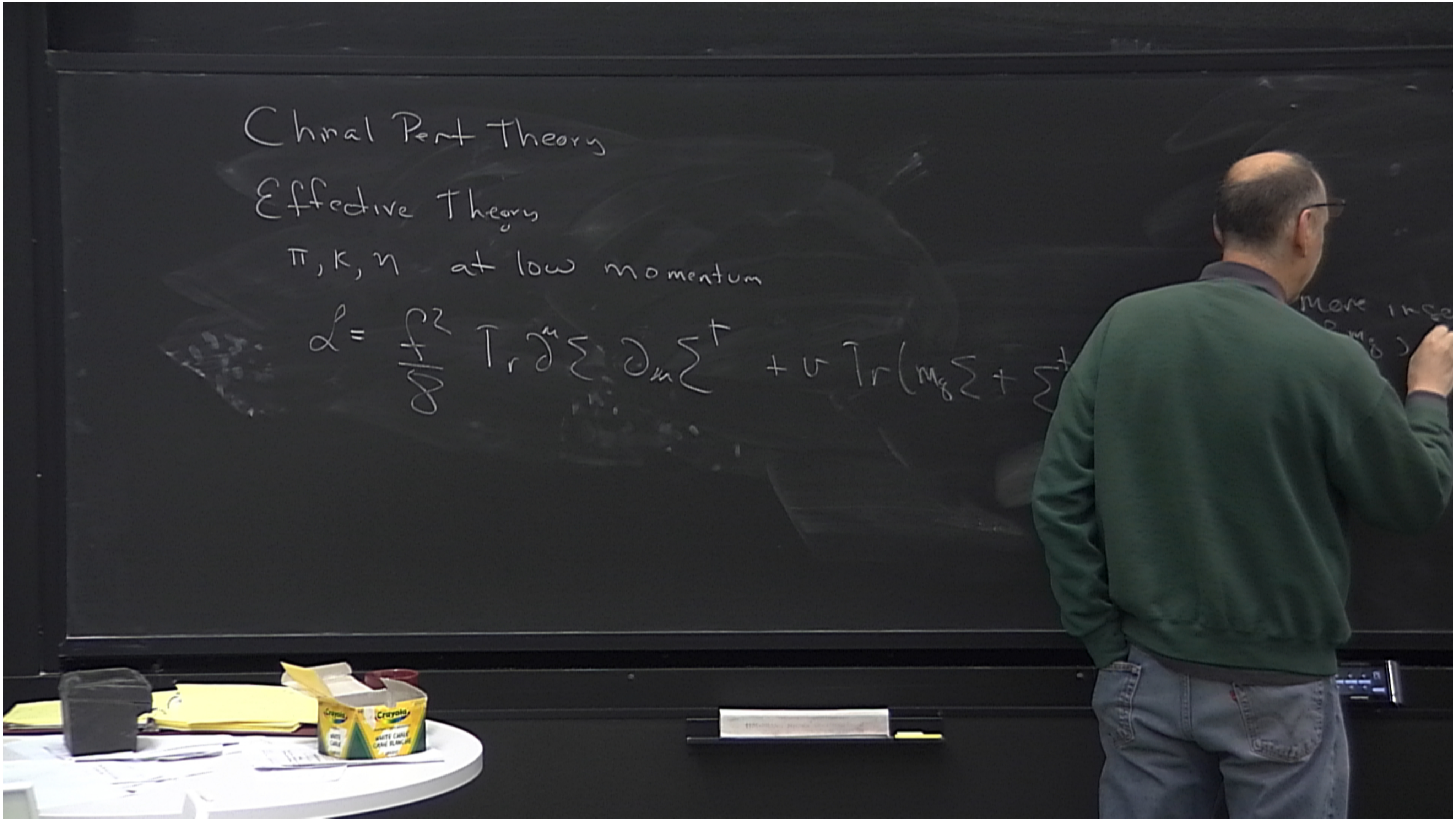
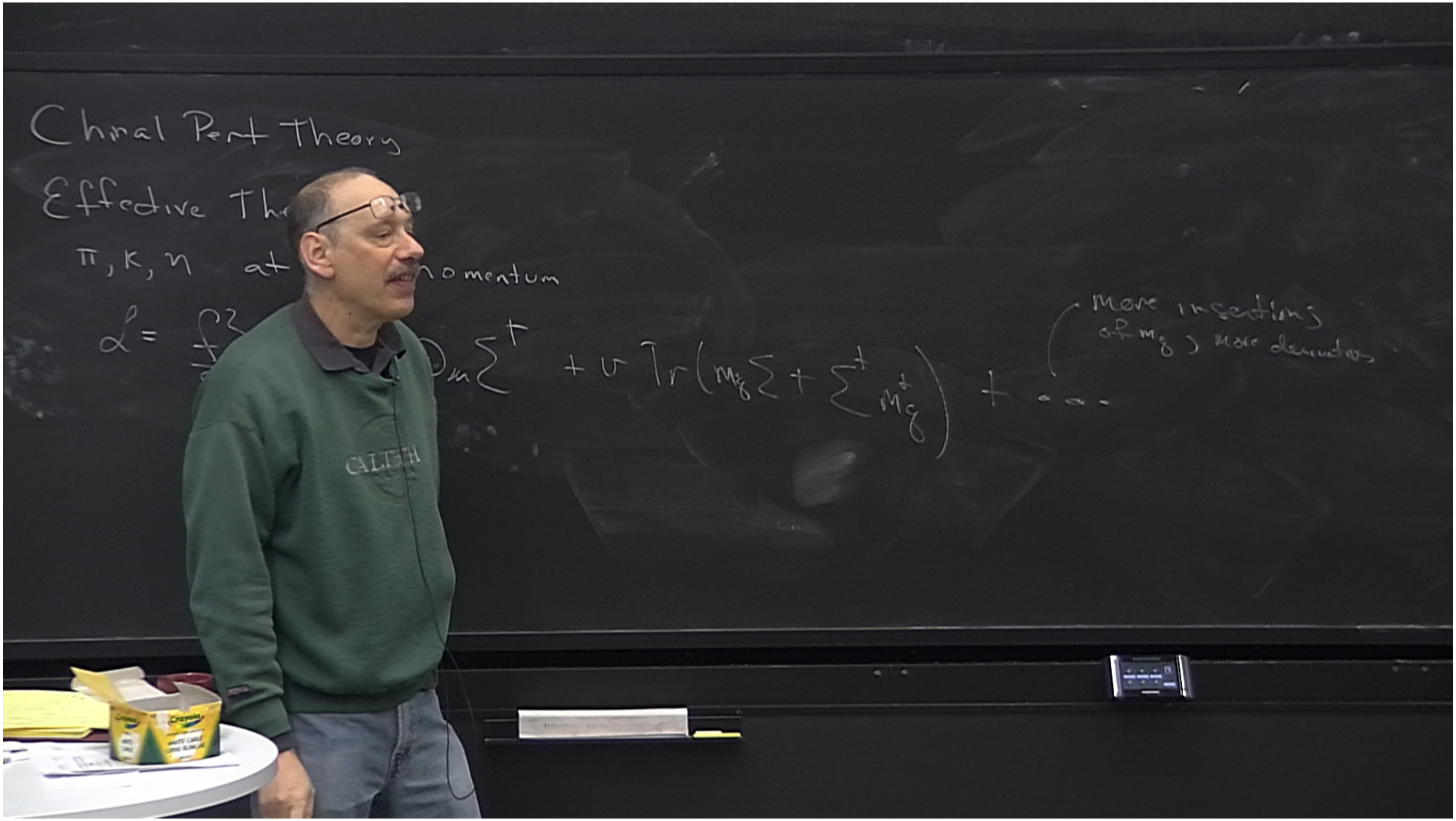
Title: 12/13 PSI - Standard Model Review Lecture 14

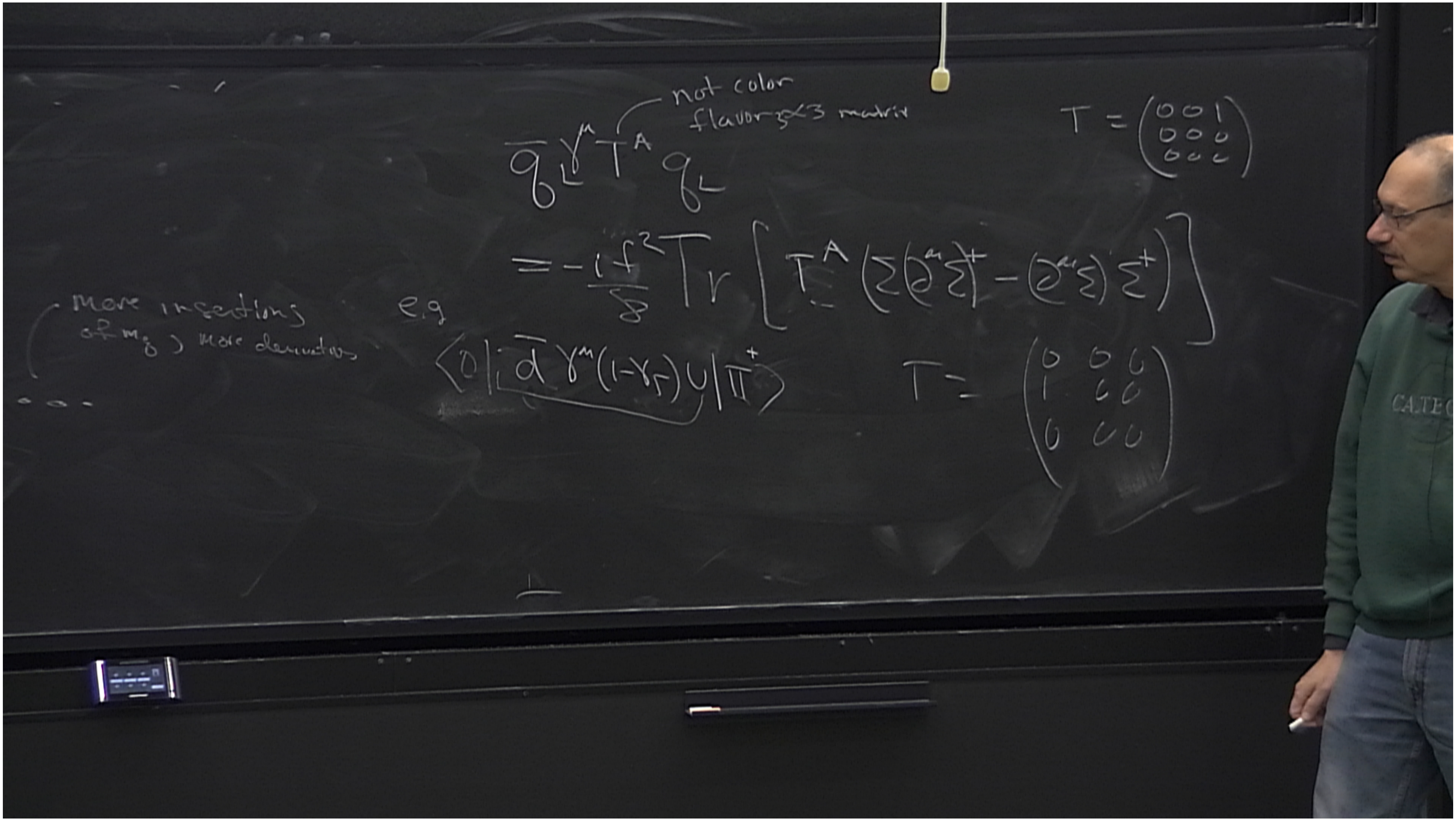
Date: Jan 24, 2013 09:00 AM

URL: http://pirsa.org/13010041

Abstract:


Chiral Pert Theory
Effective Theory
π, K, η at low momentum
$\mathcal{L} = \frac{f^2}{8} \mathrm{Tr}\, \partial^\mu \Sigma\, \partial_\mu \Sigma^\dagger + v\, \mathrm{Tr}(m_q \Sigma + \Sigma^\dagger$


Chiral Pert Theory
Effective The
π, K, η at
momentum
more insertions
of m_q, more derivatives


not color
flavor 3×3 matrix
$\bar{q}_L \gamma^\mu T^A q_L$
$= -\frac{i f^2}{8} \mathrm{Tr}\left[T^A \left(\Sigma \partial^\mu \Sigma^\dagger - (\partial^\mu \Sigma) \Sigma^\dagger \right) \right]$
$T = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$
(more insertions of m_q, more derivatives
...
e.g.
$\langle 0 | \bar{d} \gamma^\mu (1-\gamma_5) u | \pi^+ \rangle$
$T = \begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$

not color
flavor 3×3 matrix

$$\bar{q}_L \gamma^\mu T^A q_L \qquad \Sigma = \exp \frac{2iM}{f} \qquad T = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$= -\frac{i f^2}{8} \mathrm{Tr}\left[T^A \left(\Sigma (\partial^\mu \Sigma)^\dagger - (\partial^\mu \Sigma) \Sigma^\dagger \right) \right]$$

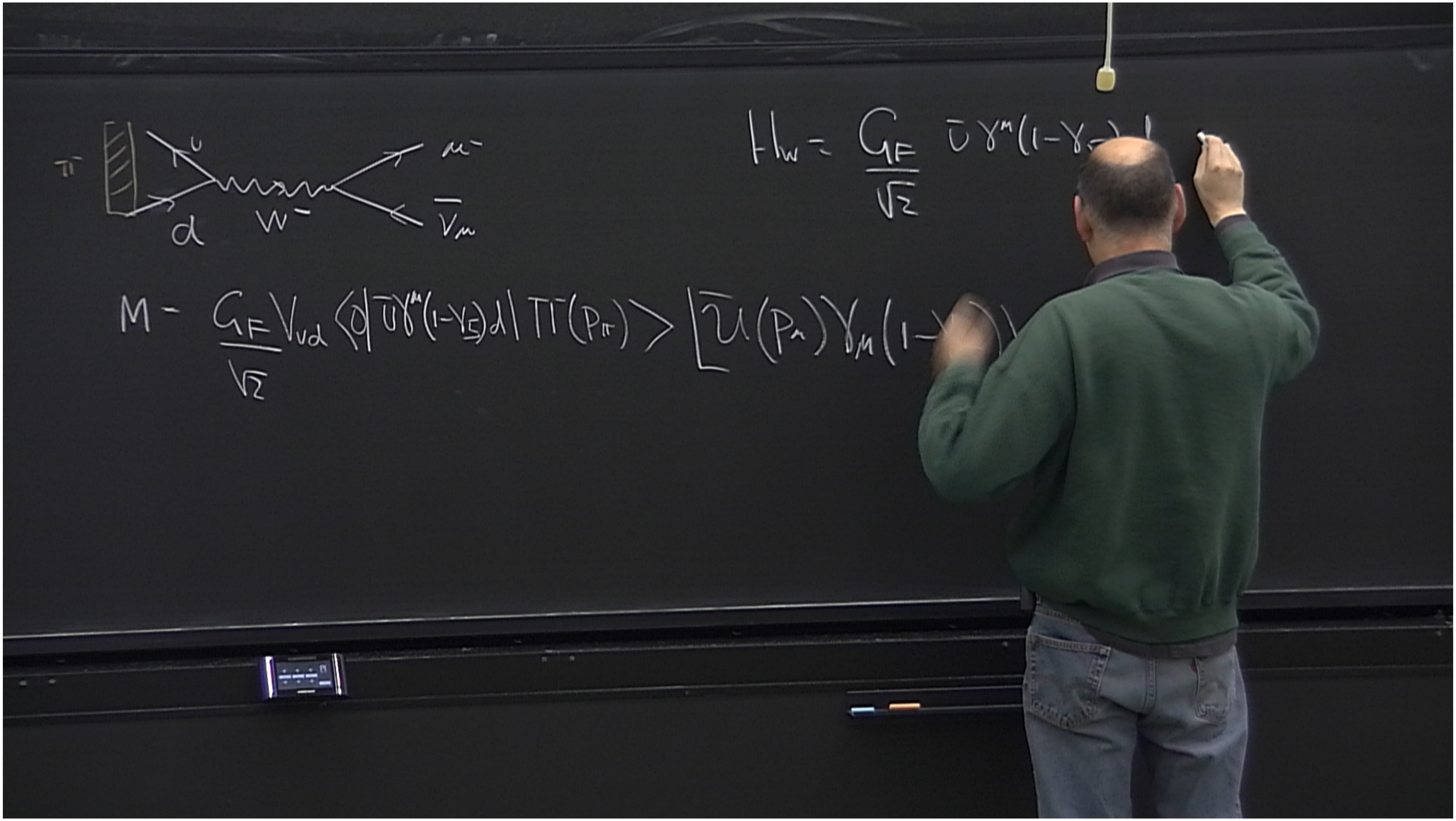
(more insertions of m_q ⇒ more derivatives

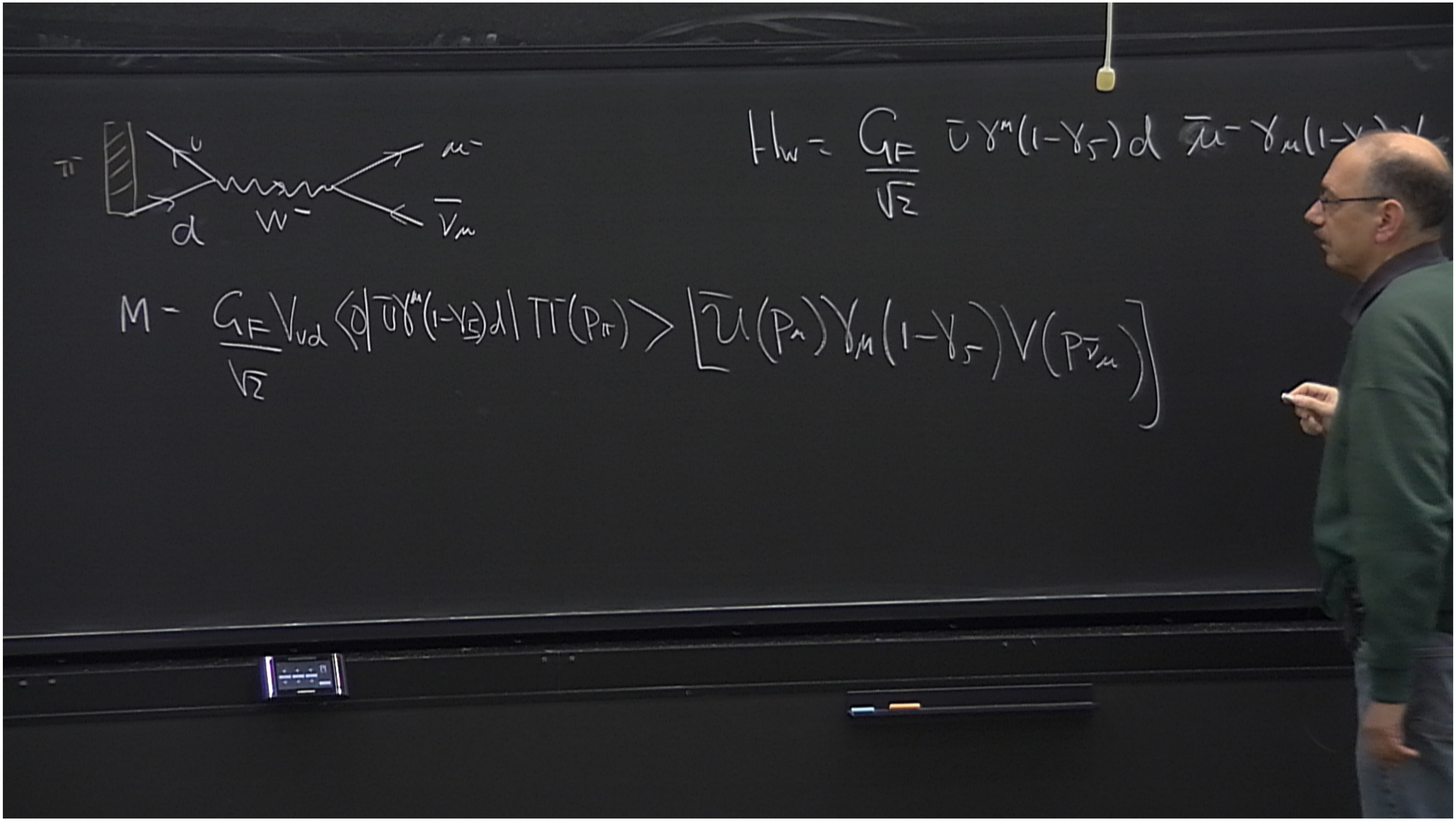
...

e.g.

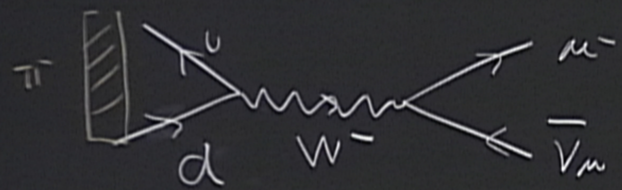
$$\langle 0 | \bar{d} \gamma^\mu (1-\gamma_5) u | \pi^+ \rangle \qquad T = \begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$\langle \pi^0 | \bar{u} \gamma^\mu (1-\gamma_5) s | K^- \rangle$$


π⁻
u
d
W⁻
μ⁻
ν̄μ
Hw = GF/√2 ū γ^μ (1−γ
M = GF/√2 Vud ⟨0| ū γ^μ (1−γ5) d | π⁻(pπ)⟩ [ū(pμ) γμ (1−

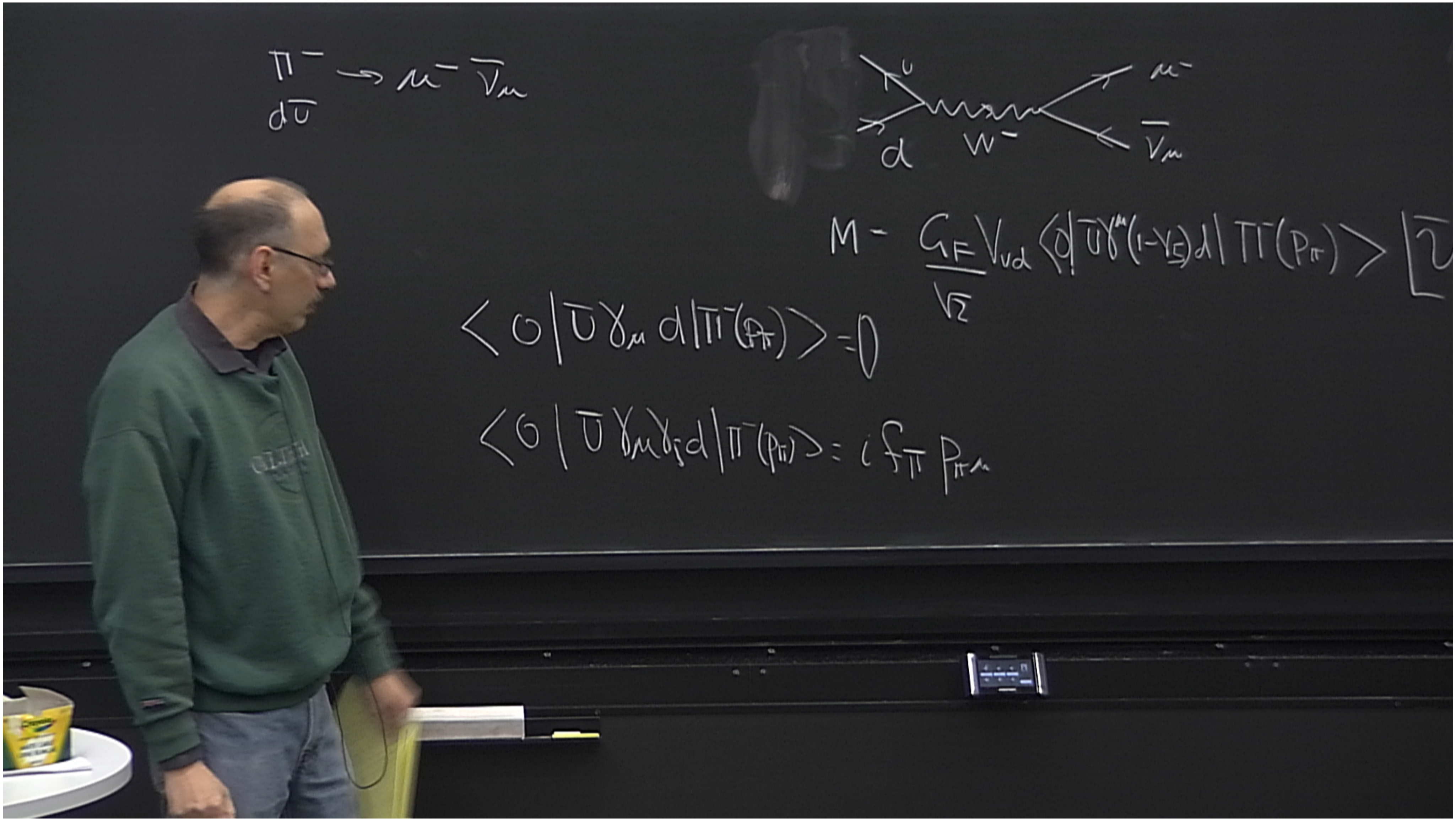


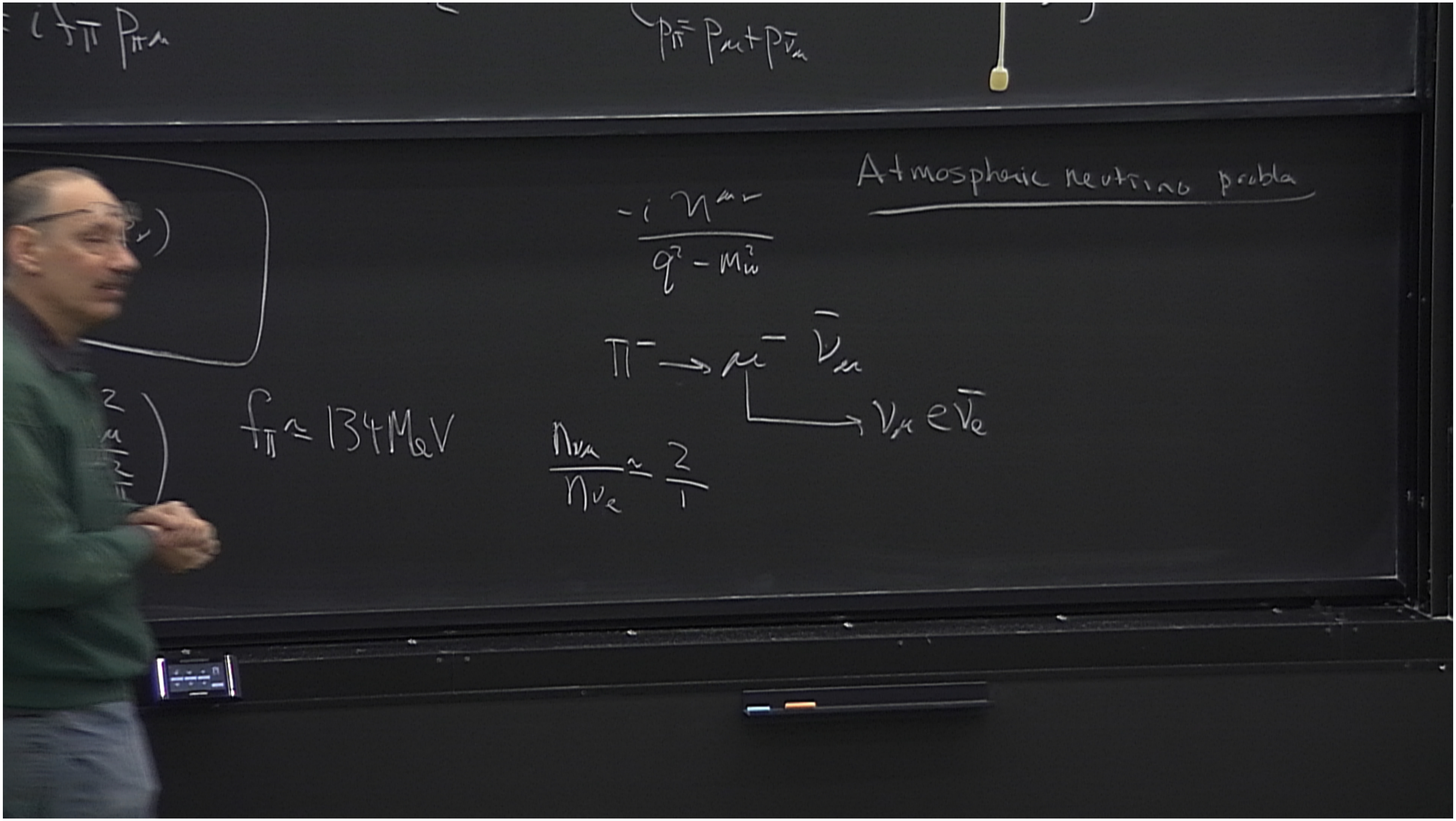
π^-
u
d
W^-
μ^-
$\bar{\nu}_\mu$
$H_W = \frac{G_F}{\sqrt{2}} \bar{u}\gamma^\mu(1-\gamma_5)d \; \bar{\mu}^- \gamma_\mu(1-\gamma_5)\nu$
$M = \frac{G_F}{\sqrt{2}} V_{ud} \langle 0|\bar{u}\gamma^\mu(1-\gamma_5)d|\pi^-(p_\pi)\rangle \left[\bar{u}(p_\mu)\gamma_\mu(1-\gamma_5)v(p_{\bar{\nu}_\mu})\right]$

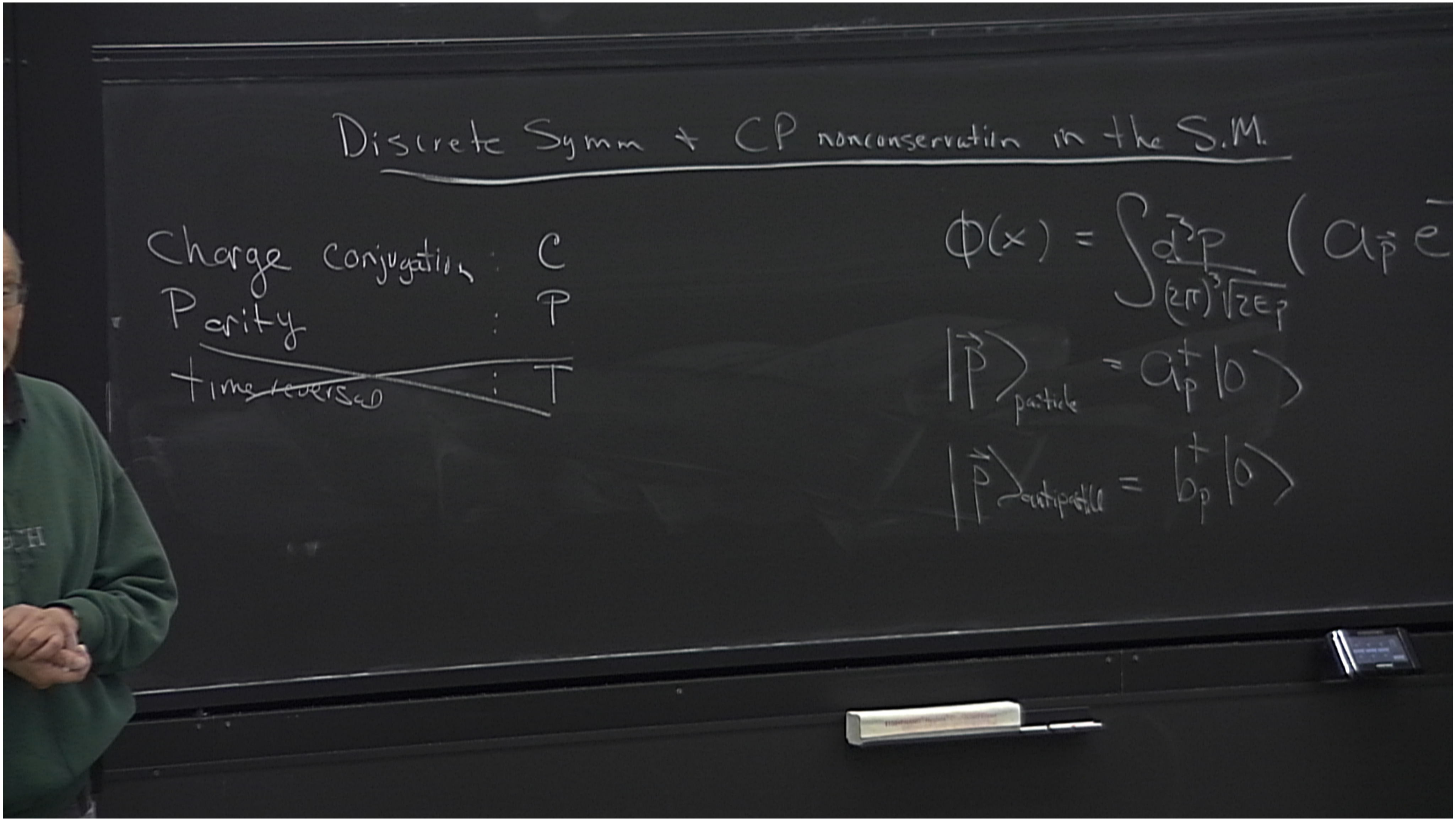


$$H_W = \frac{G_F}{\sqrt{2}} \left[\bar{u}\gamma^\mu(1-\gamma_5)d\right]\left[\bar{\mu}^-\gamma_\mu(1-\gamma_5)\nu_\mu\right]$$

$$M = \frac{G_F}{\sqrt{2}} V_{ud} \langle 0|\bar{u}\gamma^\mu(1-\gamma_5)d|\pi^-(p_\pi)\rangle \left[\bar{u}(p_\mu)\gamma_\mu(1-\gamma_5)v(p_{\bar{\nu}_\mu})\right]$$


$\pi^- \to \mu^- \bar{\nu}_\mu$
$d\bar{u}$
u
d
W^-
μ^-
$\bar{\nu}_\mu$
$M = \frac{G_F}{\sqrt{2}} V_{ud} \langle 0 | \bar{u}\gamma^\mu(1-\gamma_5) d | \pi^-(p_\pi) \rangle [\bar{u}$
$\langle 0 | \bar{u}\gamma_\mu d | \pi^-(p_\pi) \rangle = 0$
$\langle 0 | \bar{u}\gamma_\mu\gamma_5 d | \pi^-(p_\pi) \rangle = i f_\pi p_{\pi\mu}$


i fπ pπμ
pπ = pμ + pν̄μ
Atmospheric neutrino proble
-i η^μν / (q² - M_W²)
π⁻ → μ⁻ ν̄μ
νμ e ν̄e
fπ ≃ 134 MeV
nνμ / nνe ≃ 2/1


Discrete Symm + CP nonconservation in the S.M.
Charge conjugation : C
Parity : P
~~time reversal : T~~
$\Phi(x) = \int \frac{d^3p}{(2\pi)^3 \sqrt{2E_p}} (a_{\vec{p}} e$
$|\vec{p}\rangle_{particle} = a_p^\dagger |0\rangle$
$|\vec{p}\rangle_{antiparticle} = b_p^\dagger |0\rangle$

$$P\,|\vec{p}\rangle = P\,a^{\dagger}_{\vec{p}}\,|0\rangle = P\,a^{\dagger}_{\vec{p}}\,P\;P|0\rangle$$

$$= \left(P\,a^{\dagger}_{\vec{p}}\,P\right)|0\rangle$$

$$\eta\,|-\vec{p}\rangle = \left(P\,a^{\dagger}_{\vec{p}}\,P\right)|0\rangle$$

$$P\,a^{\dagger}_{\vec{p}}\,P = \eta\,a^{\dagger}_{-\vec{p}}$$