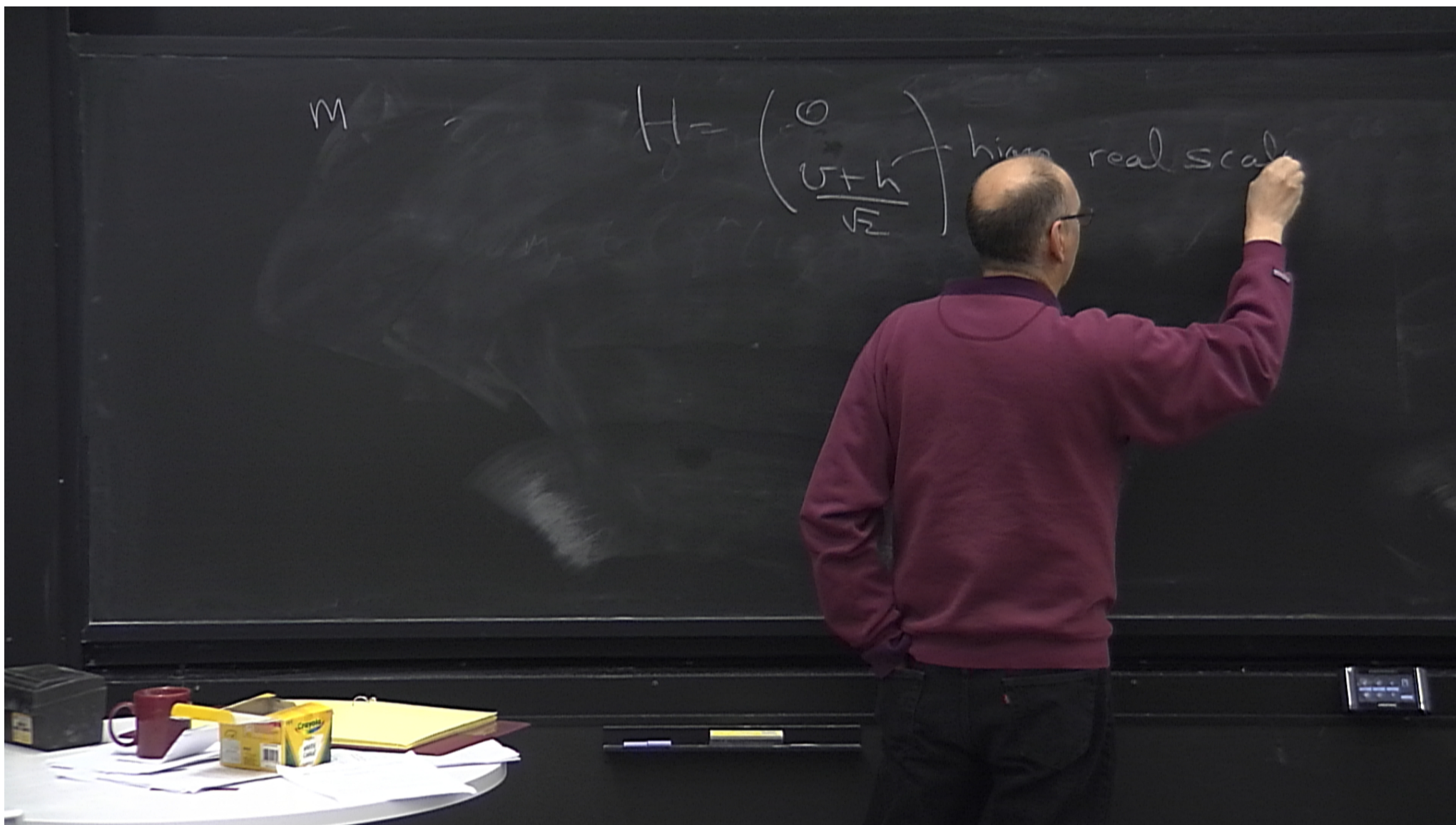


Title: 12/13 PSI - Standard Model Review Lecture 11

Date: Jan 21, 2013 09:00 AM

URL: <http://pirsa.org/13010038>

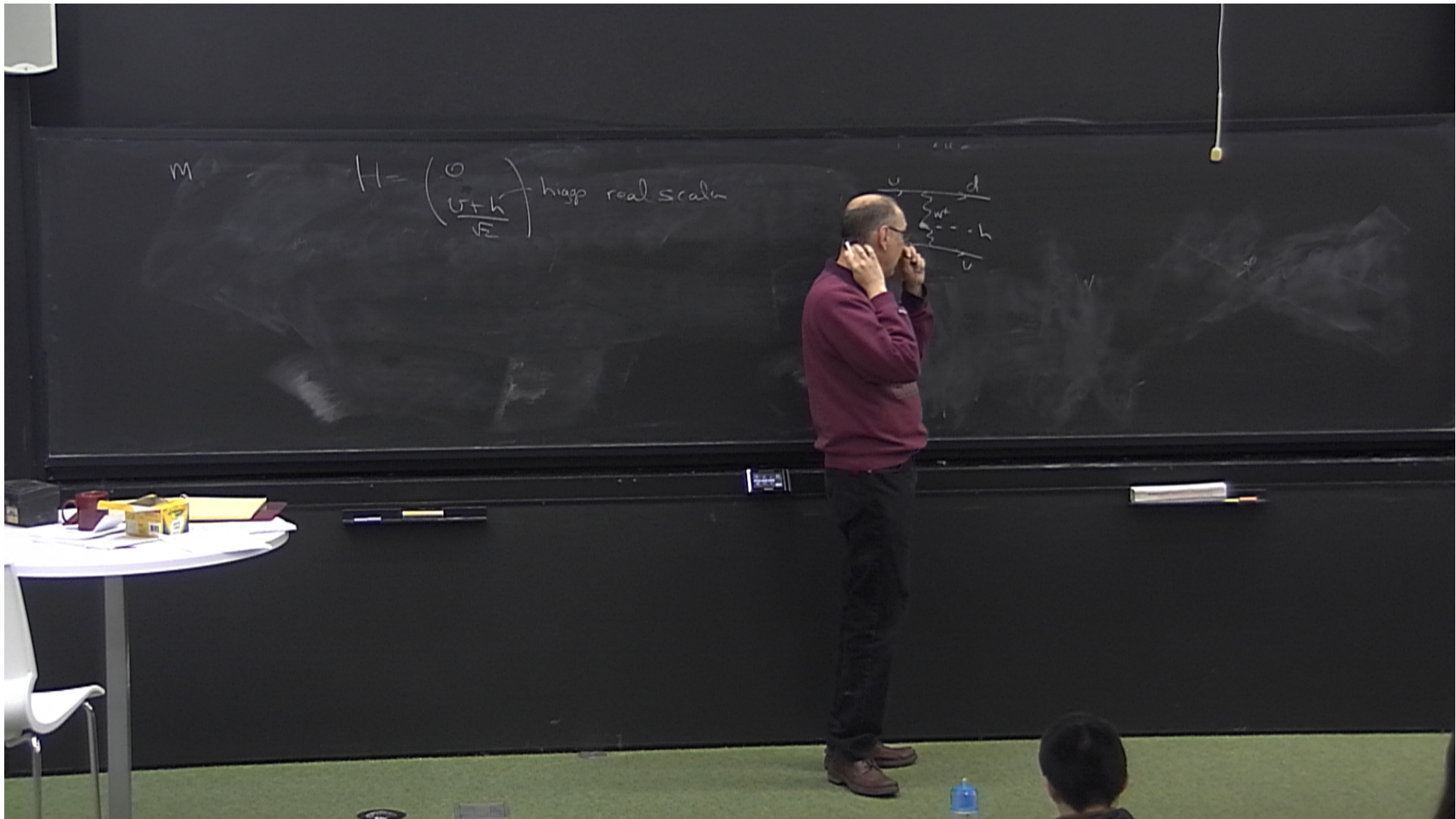
Abstract:



m

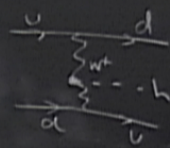
$$H = \begin{pmatrix} 0 \\ \frac{U+h}{\sqrt{2}} \end{pmatrix}$$

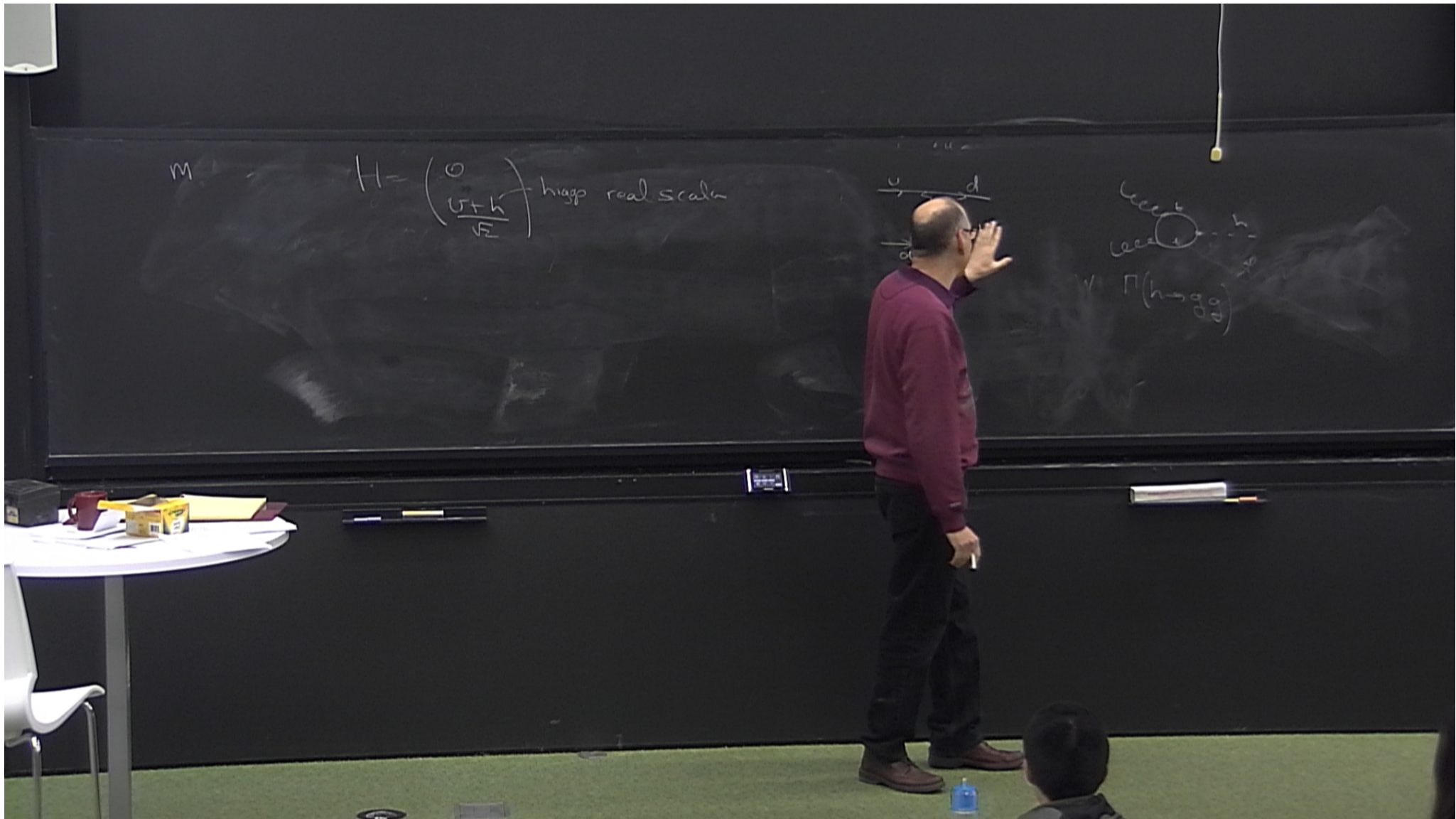
higgs real scalar

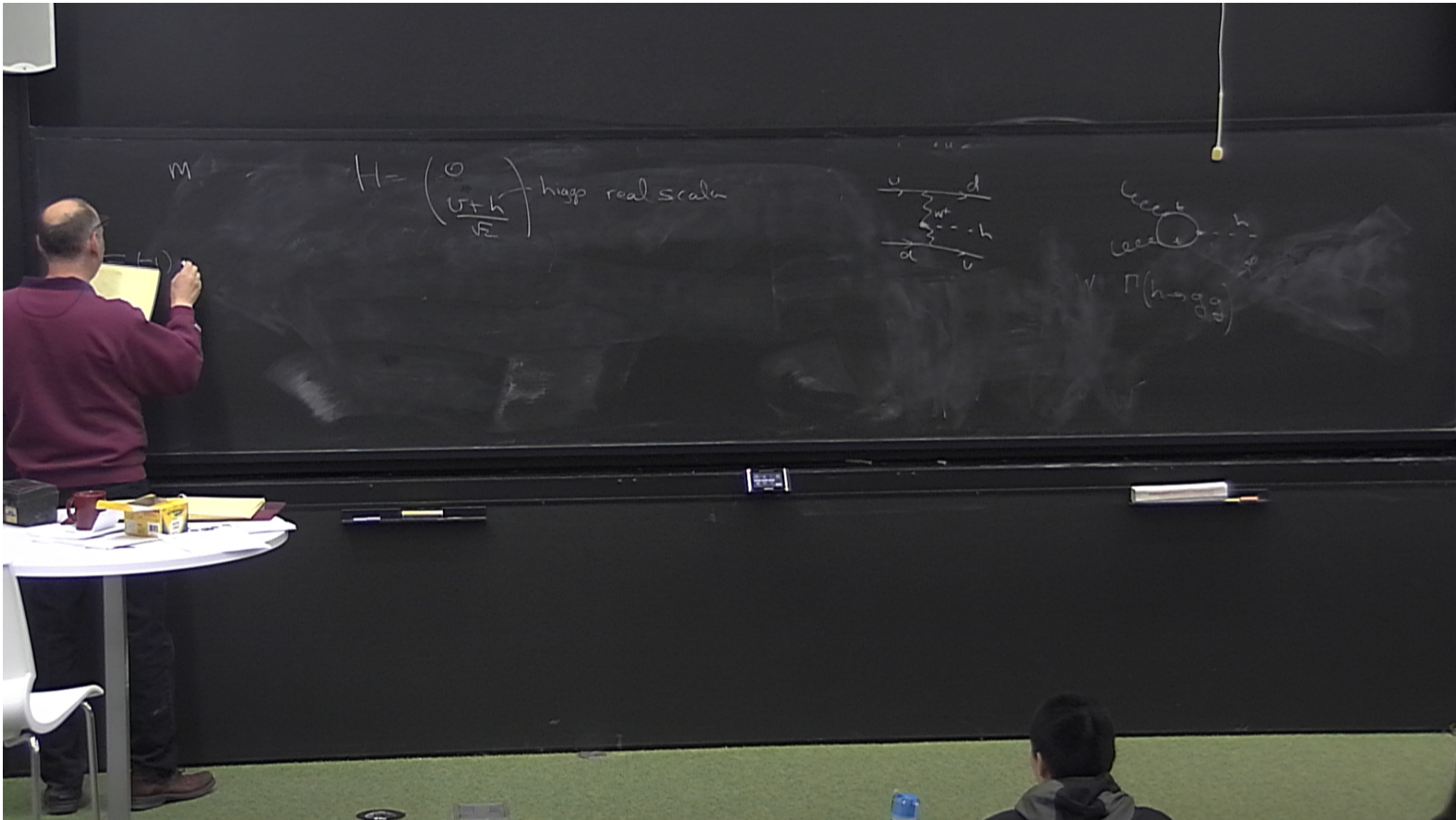


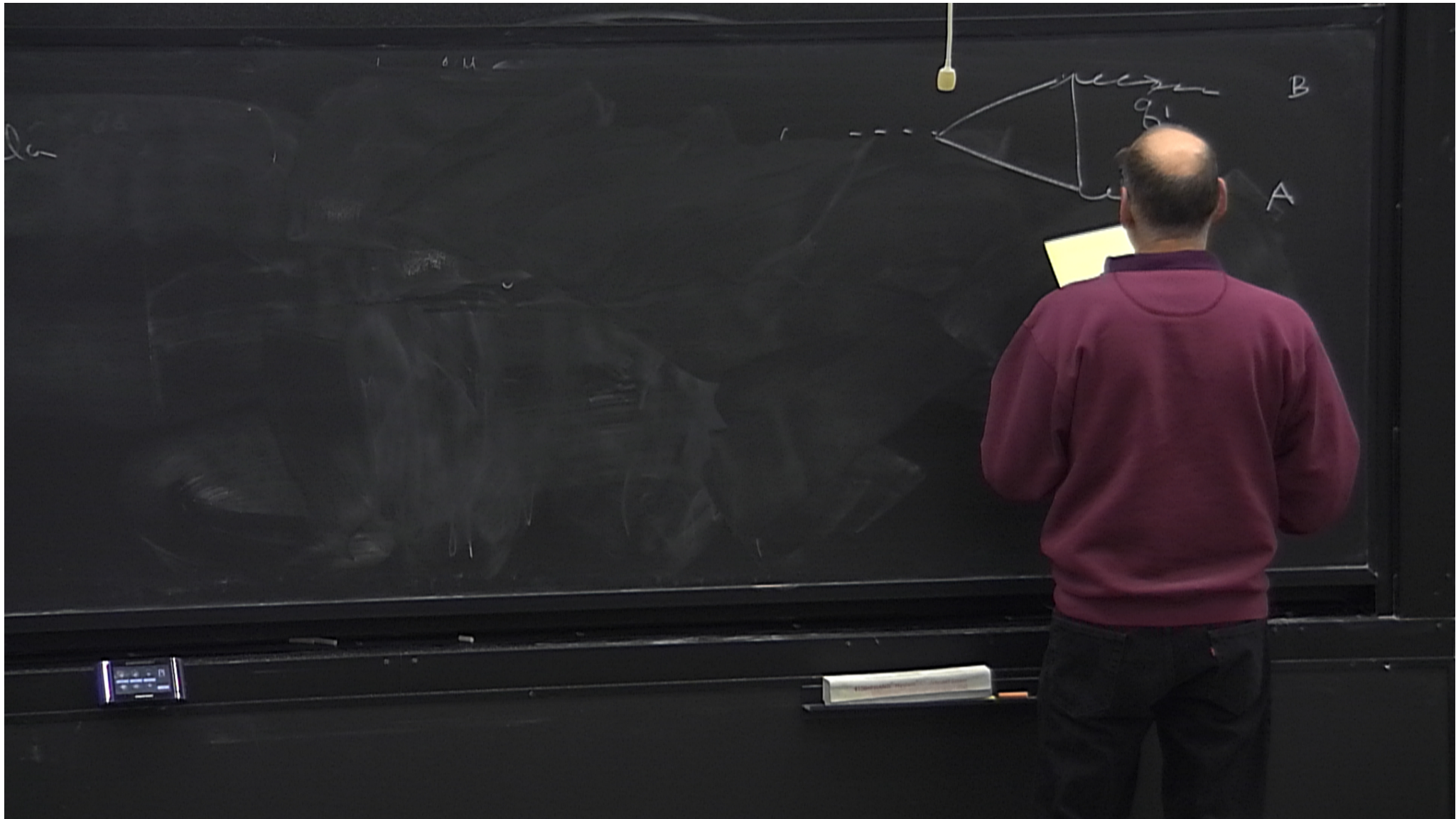
M

$$H = \begin{pmatrix} 0 \\ \frac{v+h}{\sqrt{2}} \end{pmatrix} \text{ higgs real scalar}$$

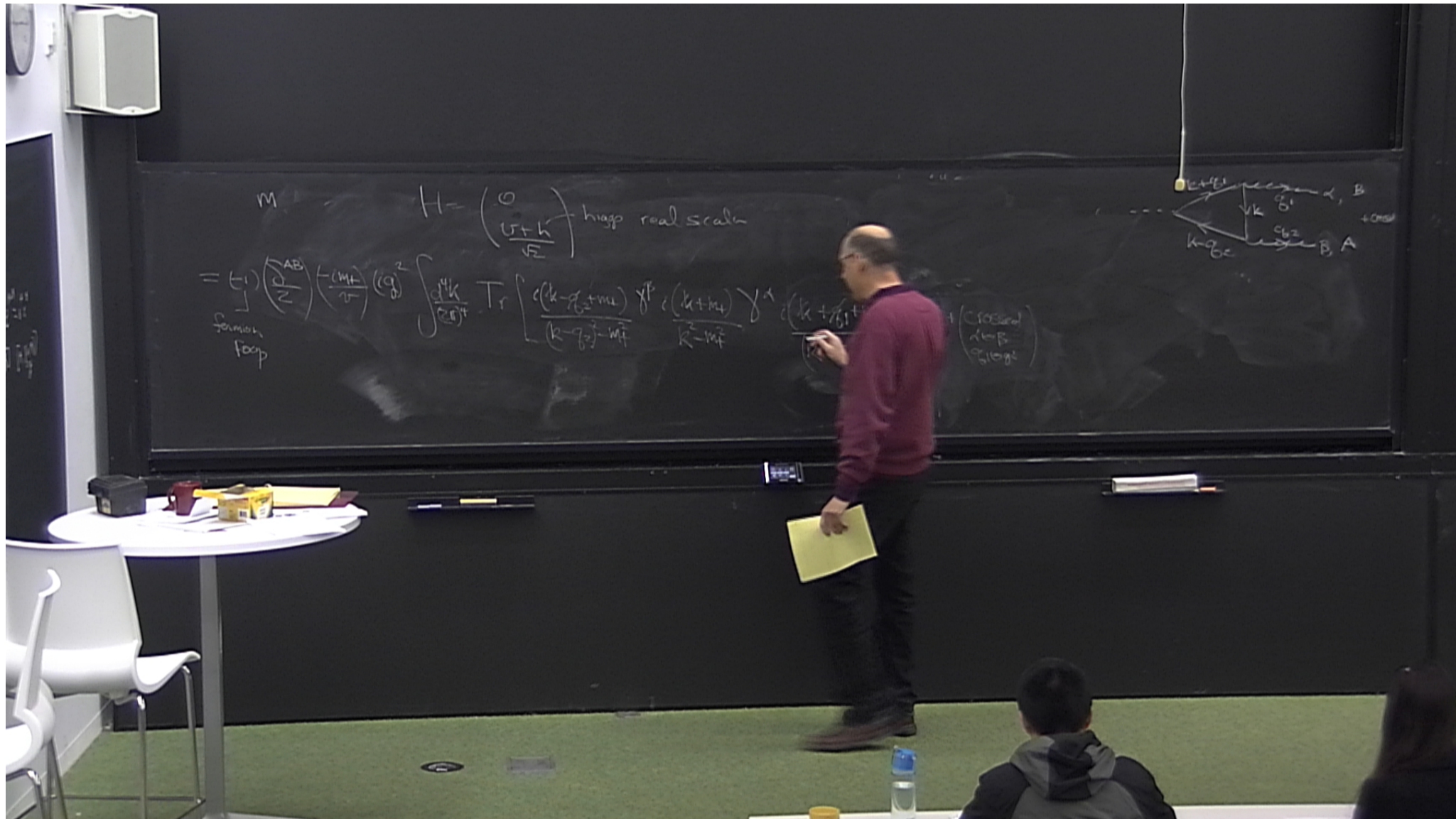








$$H = \begin{pmatrix} 0 \\ \frac{v+h}{\sqrt{2}} \end{pmatrix} \text{ higgs real scalar}$$



$$= (-1) \left(\frac{g}{2} \right)^{AB} \left(\frac{-im_+}{v} \right) (ig_a)^2 \int \frac{d^4 k}{(2\pi)^4} \text{Tr} \left[\frac{i(\not{k} - \not{q}_z + m_+)}{(k - q_z)^2 - m_+^2} \gamma^\beta \frac{i(\not{k} + m_+)}{k^2 - m_+^2} \gamma^\alpha \frac{i(\not{k} + m_+)}{(k - q_z)^2 - m_+^2} \right]$$

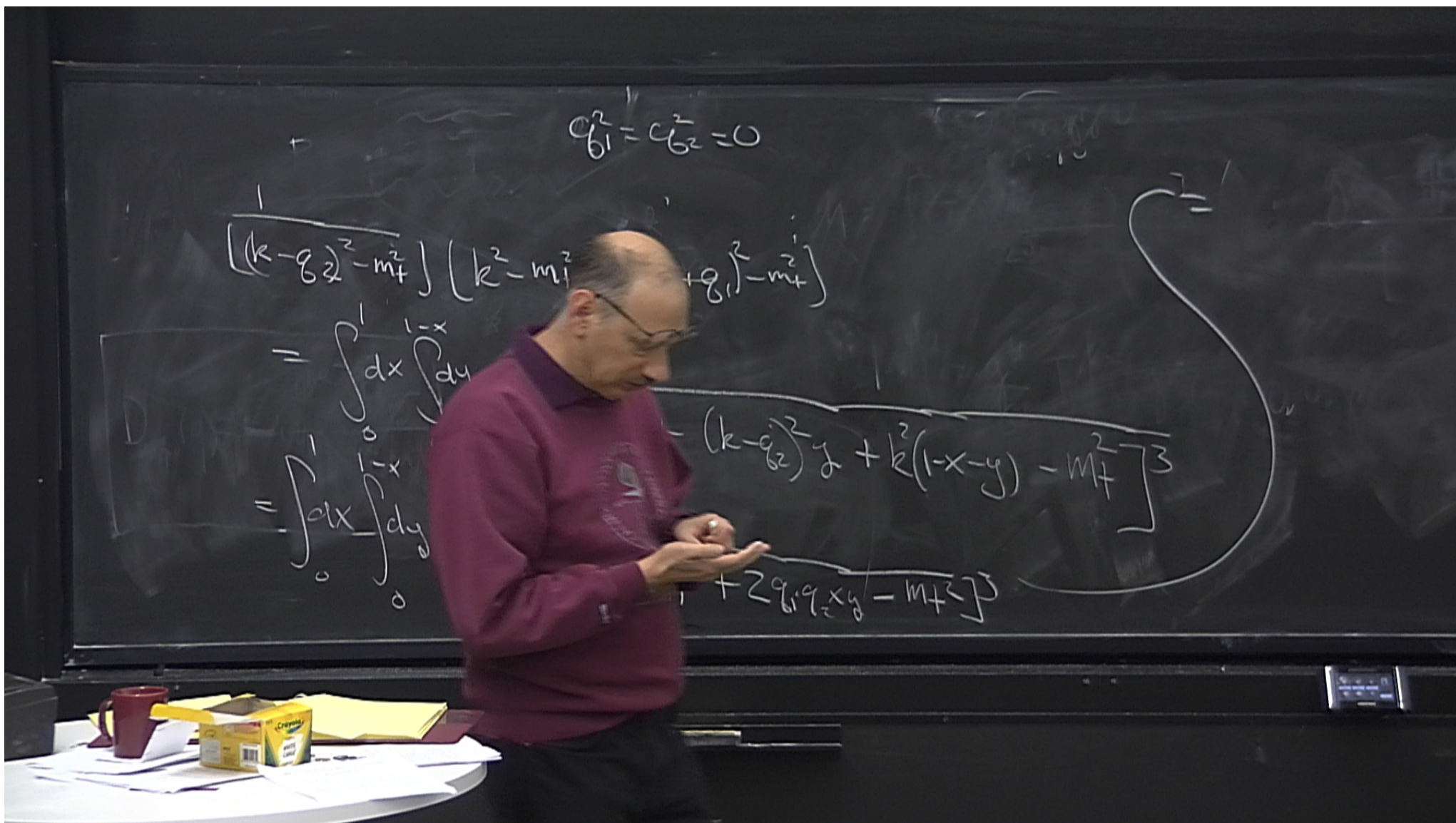
fermion loop

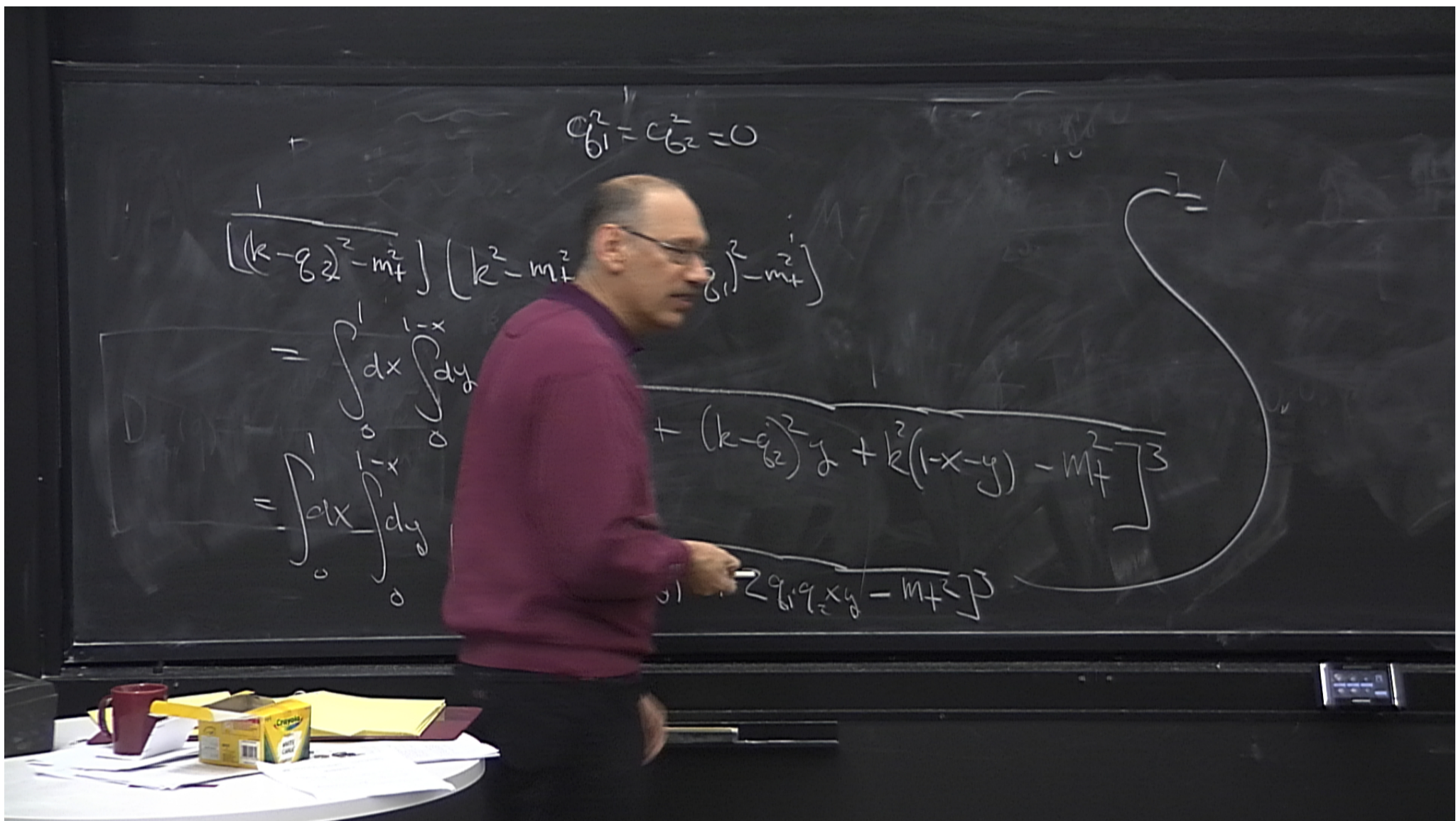
$$= - \frac{m_+^2}{2v} g_a^2 \int \frac{d^4 k}{(2\pi)^4} \text{Tr} \left[\gamma^\beta \gamma^\alpha \right]$$

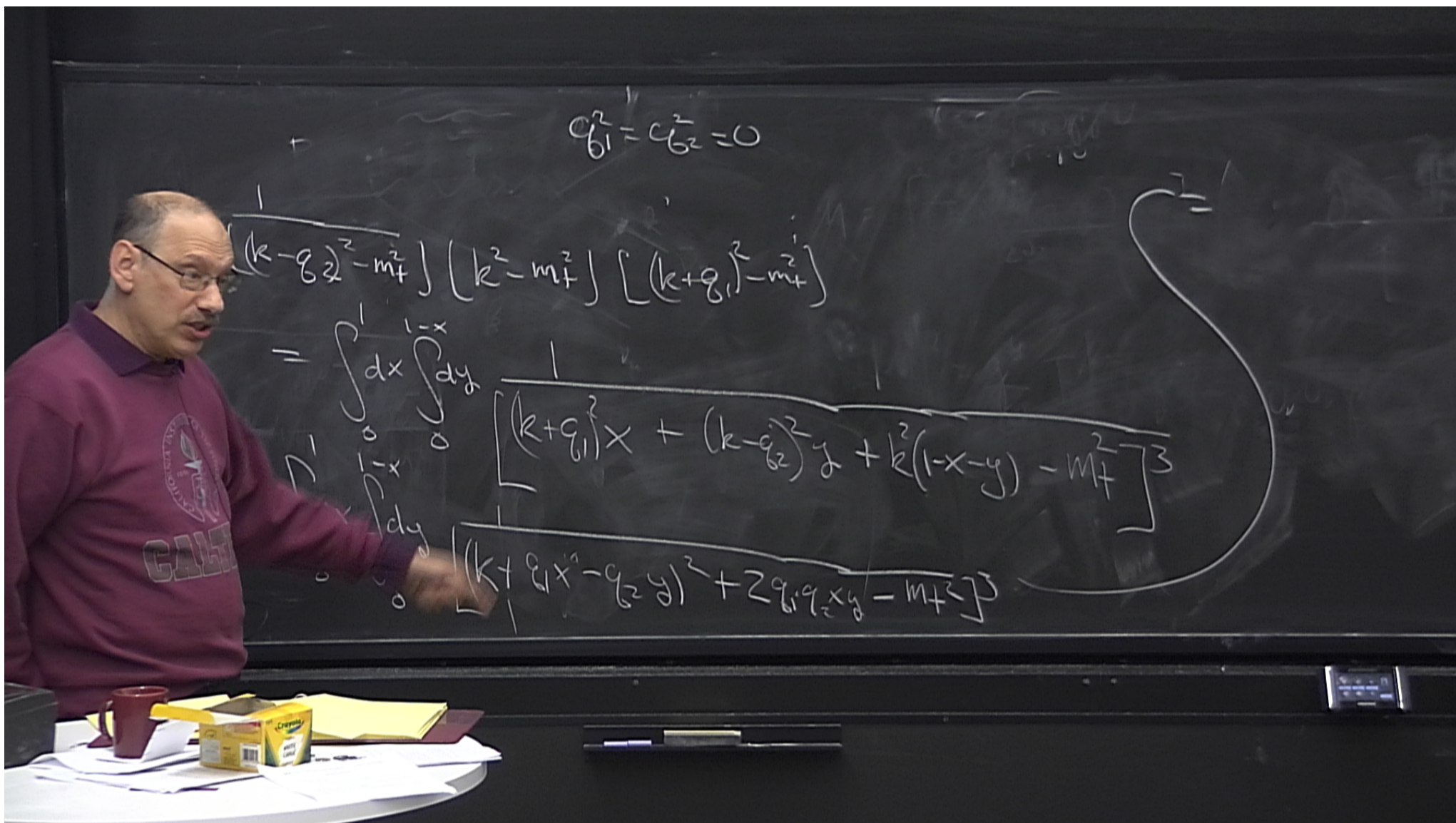
$$= (-1) \left(\frac{g}{2} \right)^{AB} \left(\frac{-im_+}{v} \right) (ig_2)^2 \int \frac{d^4 k}{(2\pi)^4} \text{Tr} \left[\frac{i(k - g_2 + m_+)}{(k - g_2)^2 - m_+^2} \gamma^B \frac{i(k + m_+)}{k^2 - m_+^2} \gamma^\alpha \frac{i(k - g_2 + m_+)}{(k - g_2)^2 - m_+^2} \gamma^A \right]$$

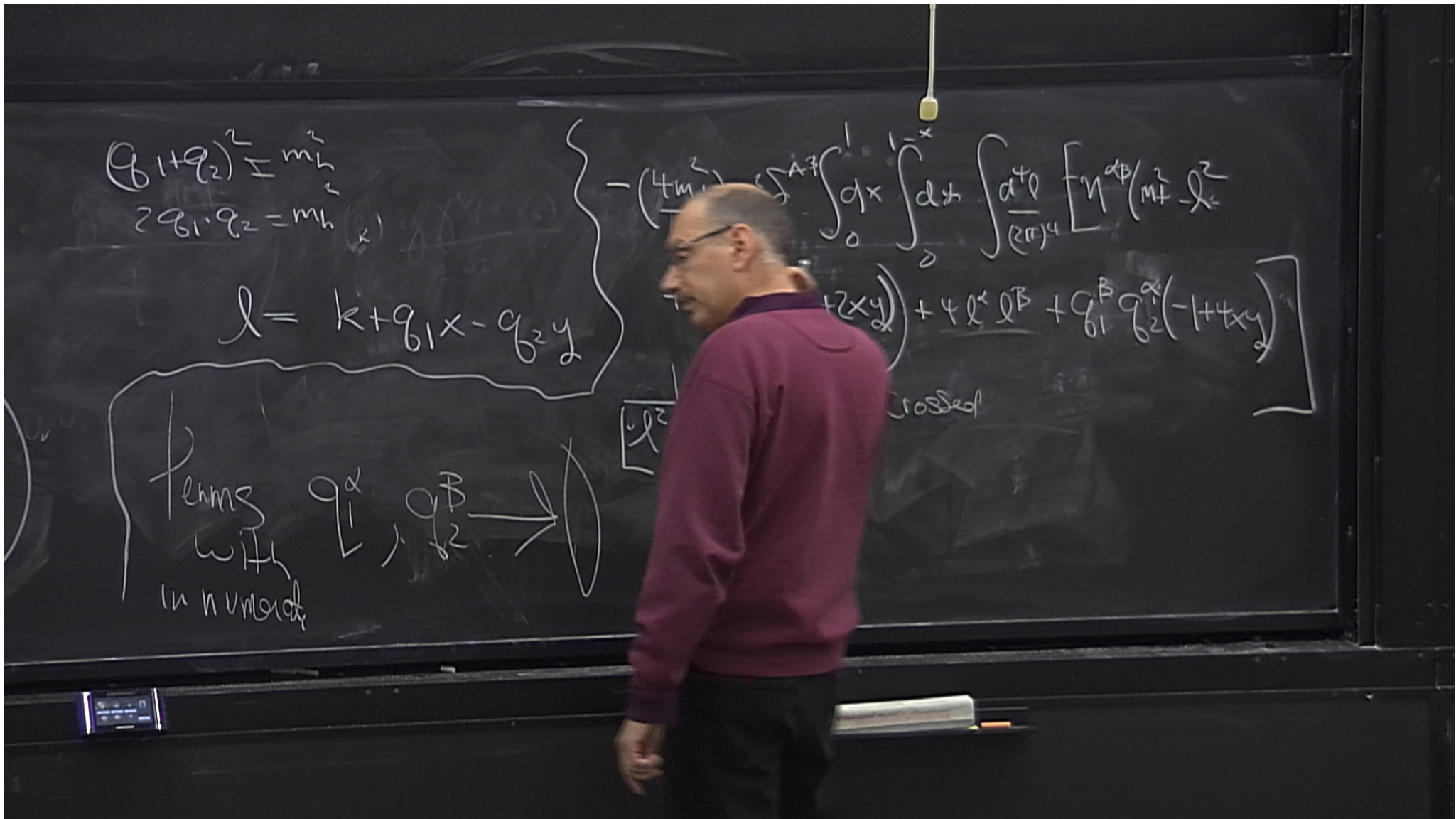
fermion loop

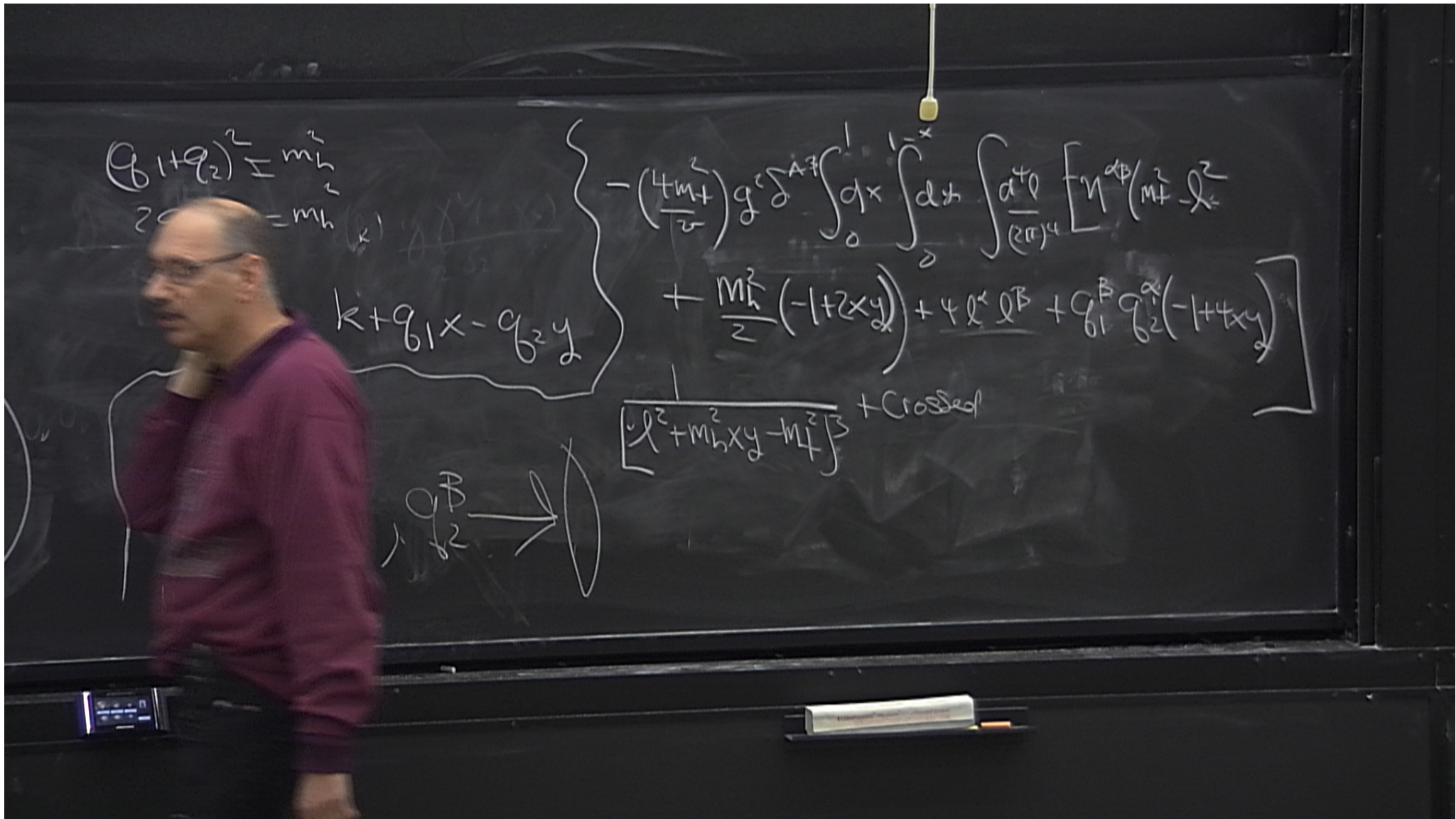
$$= -\frac{m_+^2}{2v} g_2^2 \delta^{AB} \int \frac{d^4 k}{(2\pi)^4} \text{Tr} \left[\cancel{(k - g_2)} \gamma^B \cancel{k} \gamma^\alpha + (k - g_2) \gamma^B \gamma^\alpha \right]$$











$$(q_1 + q_2)^2 = m_h^2$$

$$2q_1 \cdot q_2 = m_h^2$$

$$l = k + q_1 x - q_2 y$$

Terms with q_1^α, q_2^β in numerators $\rightarrow$

$$\left\{ -\left(\frac{4m_h^2}{z}\right) g^2 \delta^{AB} \int_0^1 dx \int_0^{1-x} dy \int \frac{d^4 \ell}{(2\pi)^4} \left[\eta^{\alpha\beta} \left(\frac{m_h^2}{m_l^2} \right) \right. \right.$$

$$\left. \left. + \frac{m_h^2}{z} (-1 + 2xy) + 4 \ell^\alpha \ell^\beta + q_1^\beta q_2^\alpha (-1 + 4xy) \right] \right.$$

$$\left. \frac{1}{[\ell^2 + m_h^2 xy - m_l^2]^3} + \text{Crossed} \right\}$$

$$(q_1 + q_2)^2 = m_h^2$$

$$2q_1 \cdot q_2 = m_h^2$$

$$l = k + q_1 x - q_2 y$$

Terms with q_1^α, q_2^β in numerators $\rightarrow$

$$\left\{ -\left(\frac{4m^2}{z}\right) g^2 \delta^{AB} \int_0^1 dx \int_0^{1-x} dy \int \frac{d^4 \ell}{(2\pi)^4} \left[\eta^{\alpha\beta} \left(\frac{m^2}{4} - \ell^2 \right) + \frac{m_h^2}{z} (-1 + 2xy) + 4 \ell^\alpha \ell^\beta + q_1^\beta q_2^\alpha (-1 + 4xy) \right] \right.$$

$$\left. \frac{1}{[\ell^2 + m_h^2 xy - m_t^2]^3} + \text{Crossed} \right\}$$

$$\begin{aligned}
 \ell^\alpha \ell^\beta &\rightarrow \frac{\ell^2}{n} \eta^{\alpha\beta} \\
 &= \left(\frac{4m_+^2}{v} \right) g^2 \delta^{AB} \left(1 - \frac{4}{n} \right) \int_0^1 dx \int_0^{1-x} dy \int \frac{d^4 \ell}{(2\pi)^4} \frac{\ell^\alpha \ell^\beta}{[\ell^2 + m_h^2 xy - m_+^2]^3} \\
 &\quad - \frac{4m_+^2}{v} g^2 \delta^{AB} \int \frac{d^4 \ell}{(2\pi)^4} \frac{[\eta^{\alpha\beta} (m_+^2 + \frac{m_h^2}{2} (-1+2xy)) + g_1^\alpha g_2^\beta (-1+4xy)]}{[\ell^2 + m_h^2 xy - m_+^2]^3}
 \end{aligned}$$

$$l^\alpha l^\beta \rightarrow \frac{l^2}{n} \eta^{\alpha\beta}$$

$$= \left(\frac{4m_+^2}{v} \right) g^2 \delta^{AB} \left(1 - \frac{4}{n} \right) \int_0^1 dx \int_0^{1-x} dy \int \frac{d^n l}{(2\pi)^n} \frac{l^2 \eta^{\alpha\beta}}{[l^2 + m_h^2 xy - m_+^2]^3} - \frac{4m_+^2}{v} g^2 \delta^{AB} \int \frac{d^n l}{(2\pi)^n} \frac{[\eta^{\alpha\beta} (m_+^2 + \frac{m_h^2}{2} (-1+2xy)) + g_1^\beta g_2^\alpha (-1+4xy)]}{[l^2 + m_h^2 xy - m_+^2]^3}$$

$$n=4-\epsilon$$

$$1 - \frac{4}{n} = 1 - \frac{1}{1-\epsilon/4} \approx \frac{\epsilon}{4}, \quad \int \frac{d^n l}{(2\pi)^n} \frac{l^2}{[l^2 + \dots]} = \frac{\epsilon}{16\pi^2} + \dots$$

$$\begin{aligned}
 I_1 &= \int_0^1 dx \int_0^{1-x} \frac{1-4xy}{1 - \left(\frac{m_h^2}{m_t^2}\right)xy} \\
 &= g_{2\gamma}^{AB} \frac{4m_h^2}{2} \left(\frac{1}{1 - \frac{m_h^2}{m_t^2}} - \frac{g_{61}^B g_z^A}{m_h^2} \right)
 \end{aligned}$$

$$I_1 = \int_0^1 dx \int_0^{1-x} dy \frac{1-4xy}{1 - \left(\frac{m_h^2}{m_t^2}\right)xy}$$

$$M^{AB} = \frac{g^2 \delta^{AB}}{4\pi^2} \frac{m_h^2}{2} \left(\frac{1}{2} \eta^{AB} - \frac{g_1^B g_2^A}{m_h^2} \right)$$

$$M^{AB} = \frac{g^2 \delta^{AB}}{4\pi^2} \frac{m_h^2}{2} \left(\epsilon_1 \cdot \epsilon_2 - \frac{g_1^B \epsilon_2^A}{m_h^2} \right)$$

$\sum$
cdurs
SPRS

4

$$I_1 = \int_0^1 dx \int_0^{1-x} dy \frac{1 - 4xy}{1 - \left(\frac{m_h^2}{m_{H^\pm}^2}\right)xy}$$

$$\sum_{\text{colors}} \sum_{\text{spins}} M^2 = \frac{4\alpha_s^2(m_h)}{\pi L} m_h^2 I_1^2$$

$$I_1 \sim \frac{1}{3}$$

$$\Gamma(h \rightarrow g g) = \frac{\alpha_s^2(m_h)}{8\pi^3 v^2} I_1^2$$

$$M^{AB} = \frac{g_{\gamma\gamma}^{AB}}{4\pi^2} \frac{m_h^2}{2} \left(\epsilon_1 \cdot \epsilon_2 - \frac{q_1^\mu \epsilon_2^\mu - q_2^\mu \epsilon_1^\mu}{m_h^2} \right)$$

$$I_1 = \int_0^1 dx \int_0^{1-x} dy \frac{1 - 4xy}{1 - \left(\frac{m_h^2}{m_t^2}\right)xy}$$

$$\sum_{\text{colors}} \sum_{\text{spins}} M^2 = \frac{4\alpha_s^2(m_h)}{\pi L} m_h^2 I_1^2$$

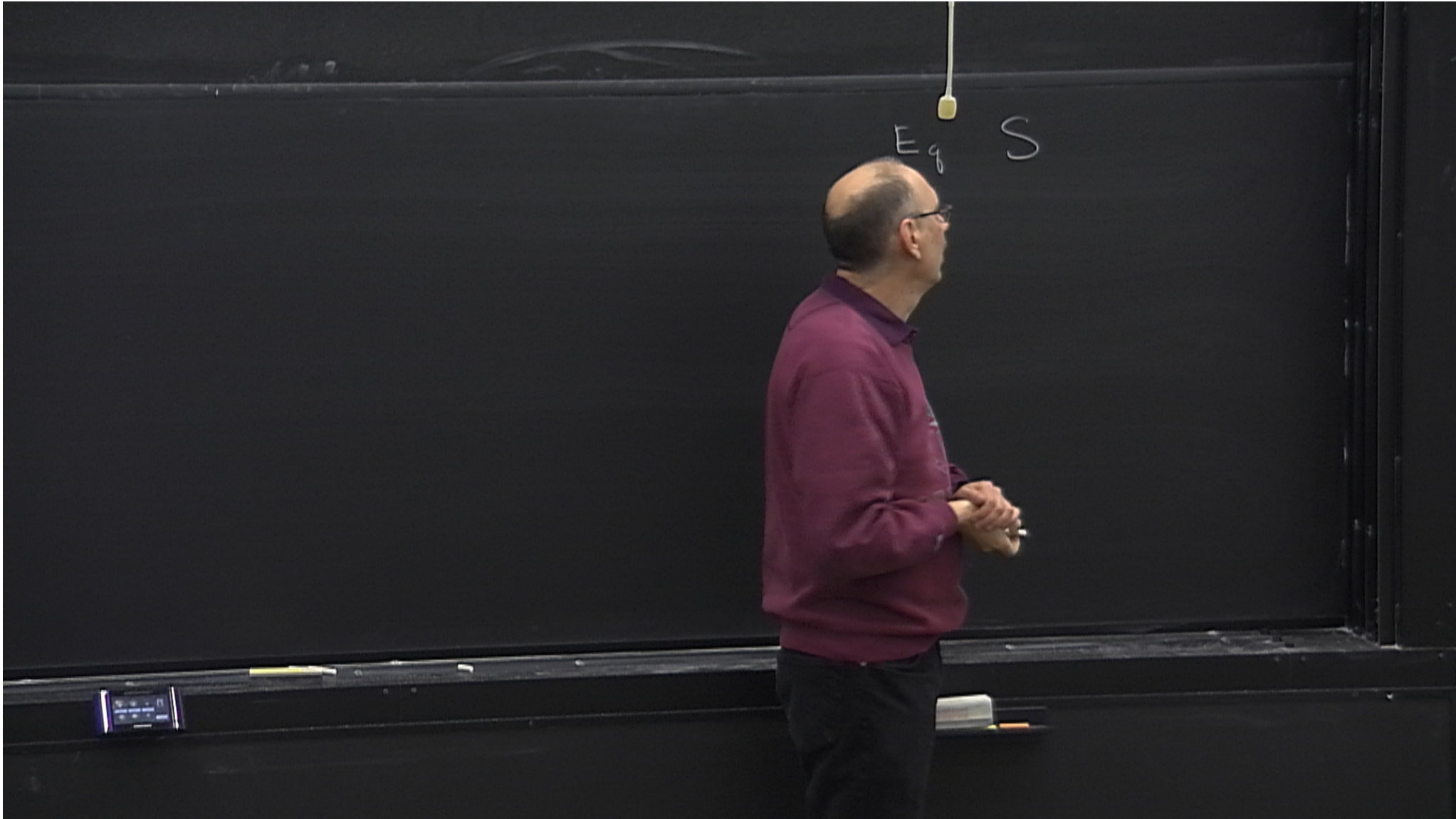
$$I_1 \sim \frac{1}{3}$$

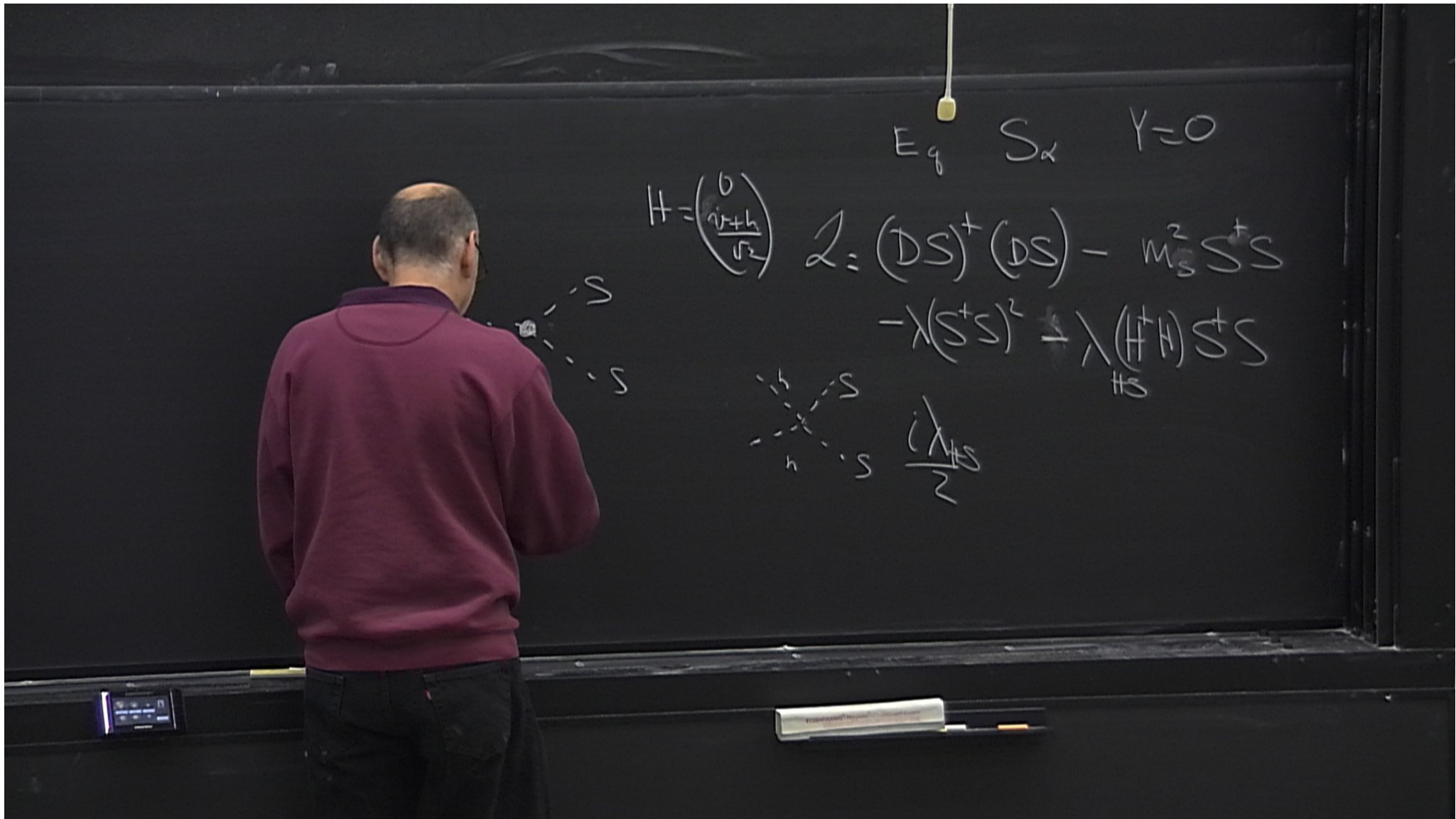
$$\Gamma(h \rightarrow g g) = \frac{\alpha_s^2(m_h)}{8\pi^3 v^2} I_1^2$$

$$M^{AB} = \frac{g_{SAB}^2}{4\pi^2} \frac{m_h^2}{2} \left(\frac{g_1^A g_2^B}{m_h^2} - \frac{g_1^B g_2^A}{m_h^2} \right)$$

$$h \rightarrow \gamma\gamma \quad \text{Br} \sim 0.2\%$$

h

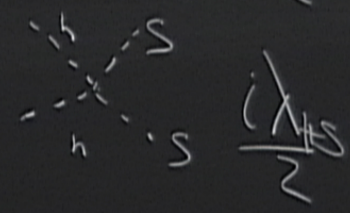


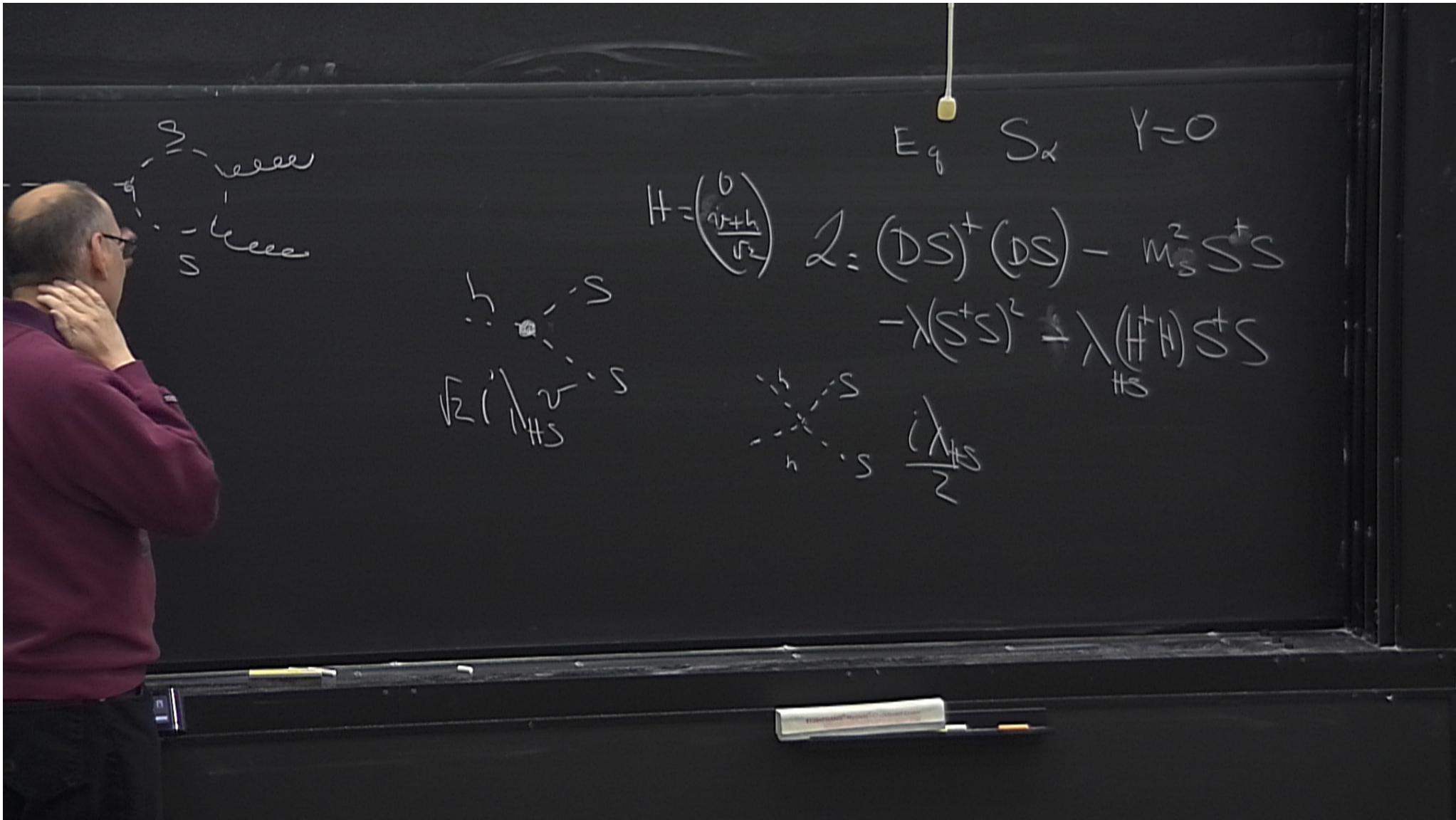


$$E_g \quad S_\alpha \quad Y=0$$

$$H = \begin{pmatrix} 0 \\ \frac{v+h}{\sqrt{2}} \end{pmatrix}$$

$$\mathcal{L} = (DS)^+ (DS) - m_S^2 S^+ S - \lambda (S^+ S)^2 + \lambda \frac{(H^+ H)}{H_S} S^+ S$$

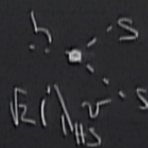
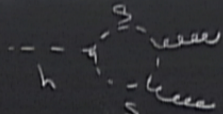




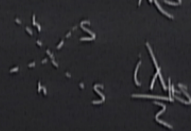
$$= \int_0^{\infty} dx \int_0^{\infty} dy \left[(k_1^2 x^2 - q_2^2 y^2)^2 + 2 q_1 q_2 x y - m_1^2 \right]$$

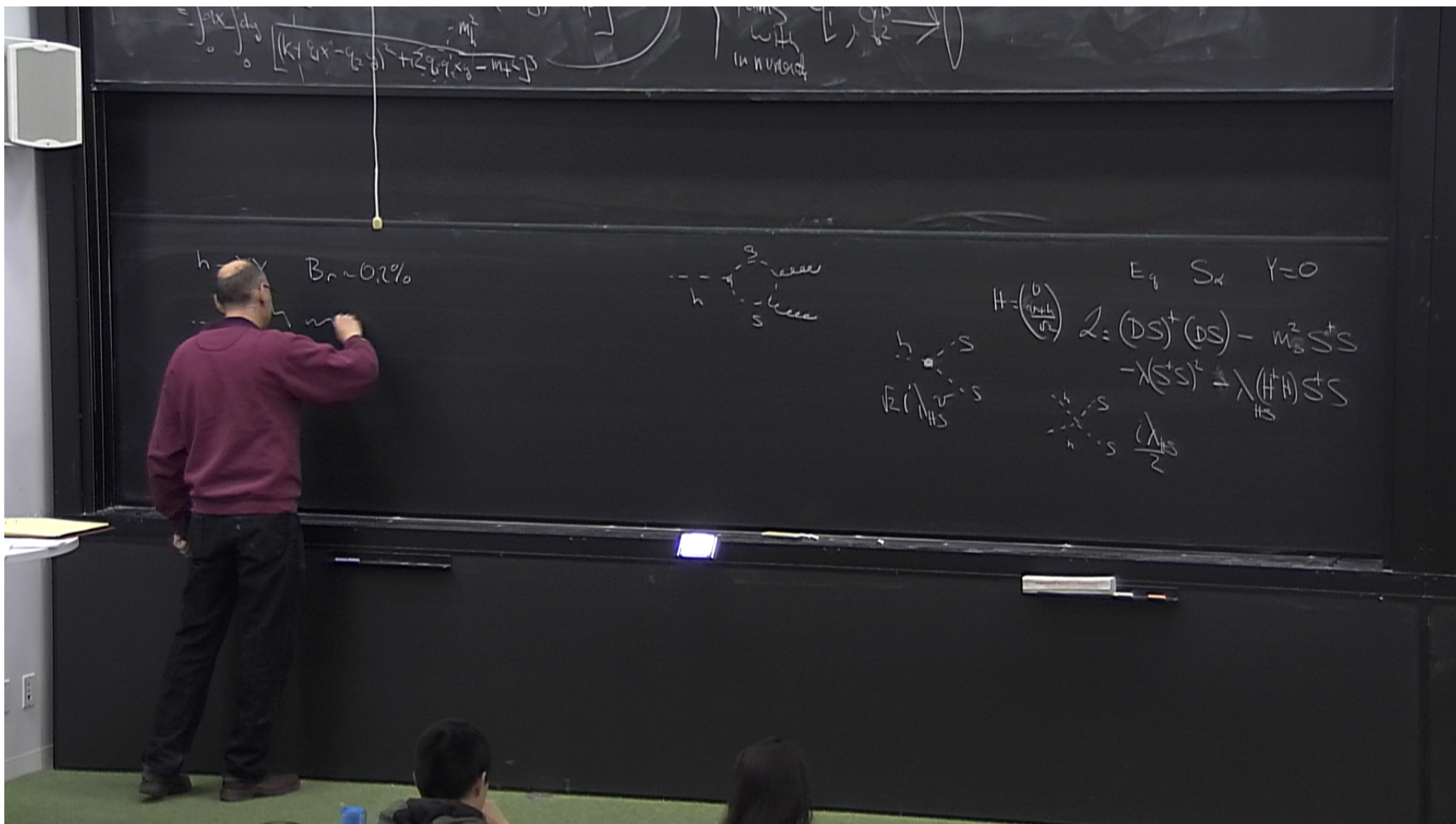
$$h \rightarrow \gamma\gamma \quad B_r \sim 0.2\%$$

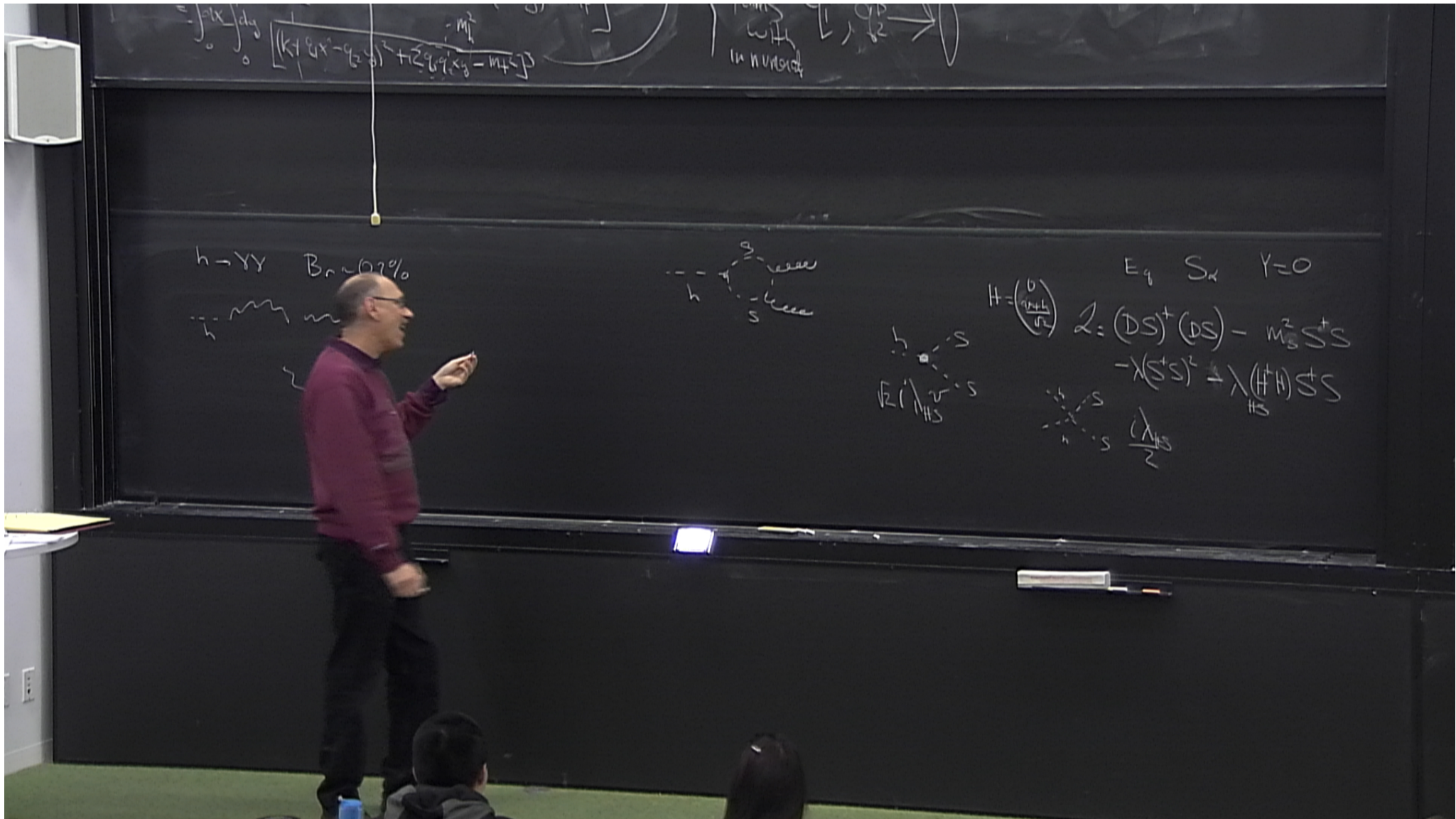
h



$$H = \begin{pmatrix} 0 \\ \frac{m_h}{\sqrt{2}} \end{pmatrix} \quad \mathcal{L} = (DS)^\dagger (DS) - m_S^2 S^\dagger S - \lambda (S^\dagger S)^2 + \lambda (H^\dagger H) S^\dagger S$$

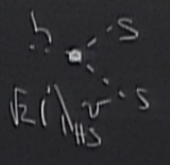
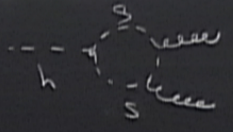






$$= \int_0^1 dx \int_0^1 dy \left[(k_1^2 + q_1^2 - q_2^2)^2 + 2q_1 \cdot q_2 - m_1^2 \right]$$

$h \rightarrow \gamma\gamma$ $\text{Br} \sim 0.2\%$

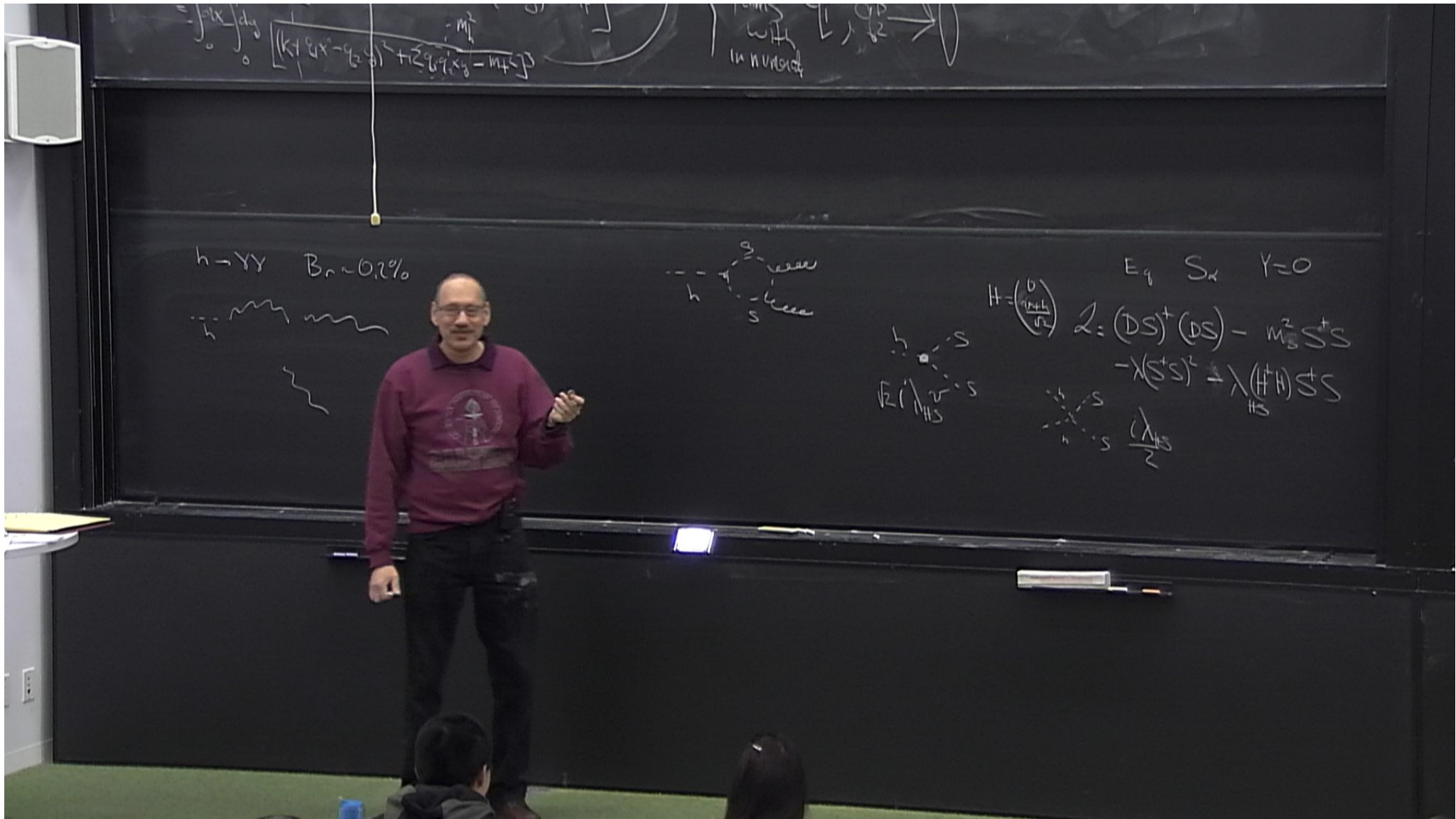


E_γ S_γ $\gamma=0$

$$H = \begin{pmatrix} 0 \\ \frac{v+h}{\sqrt{2}} \end{pmatrix}$$

$$\mathcal{L} = (DS)^\dagger (DS) - m_S^2 S^\dagger S - \lambda (S^\dagger S)^2 + \lambda \frac{(H^\dagger H)}{v} S^\dagger S$$

$\frac{\lambda v}{2}$



$$h \rightarrow \gamma\gamma \quad \text{Br} \sim 0.2\%$$

