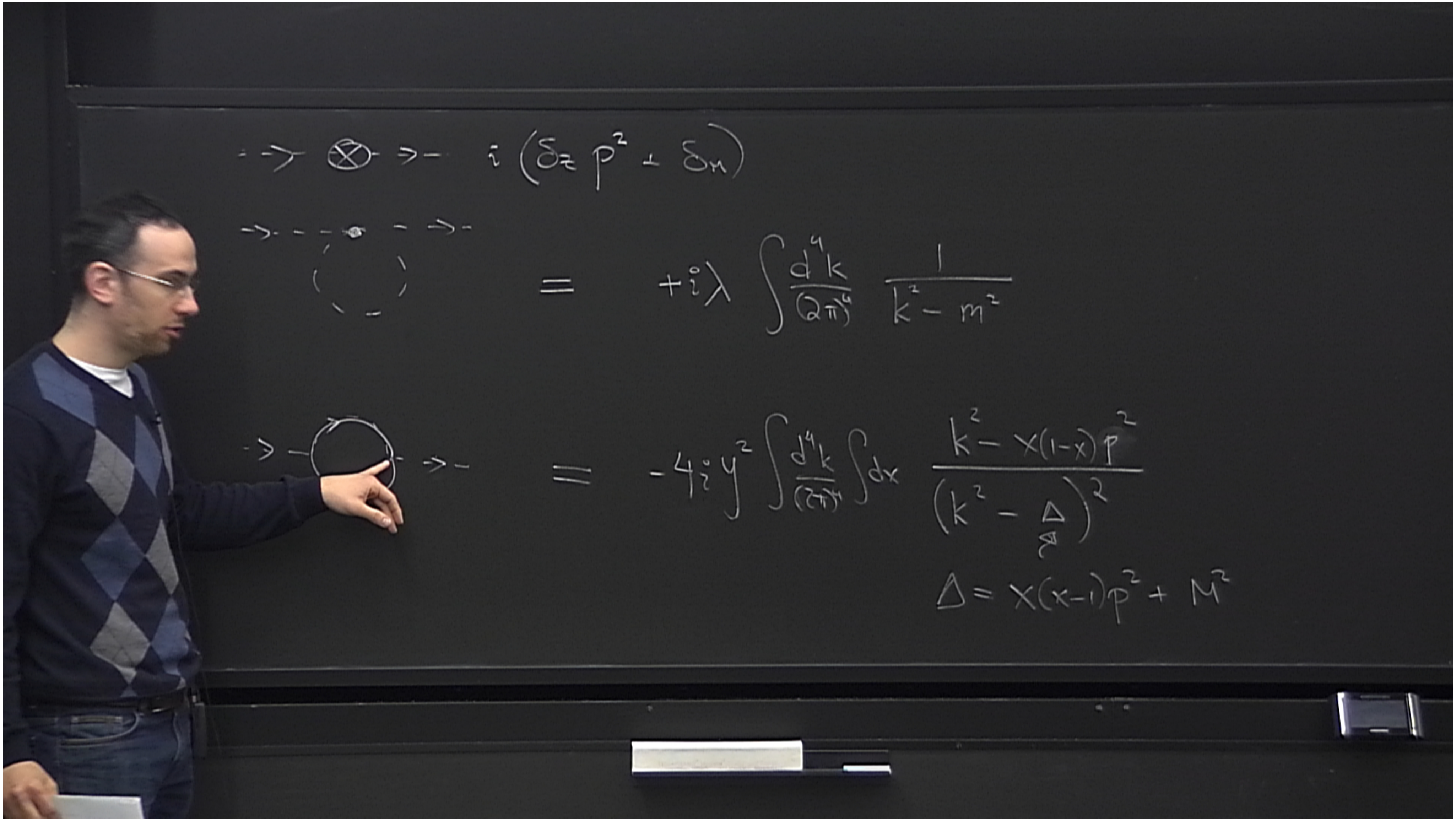
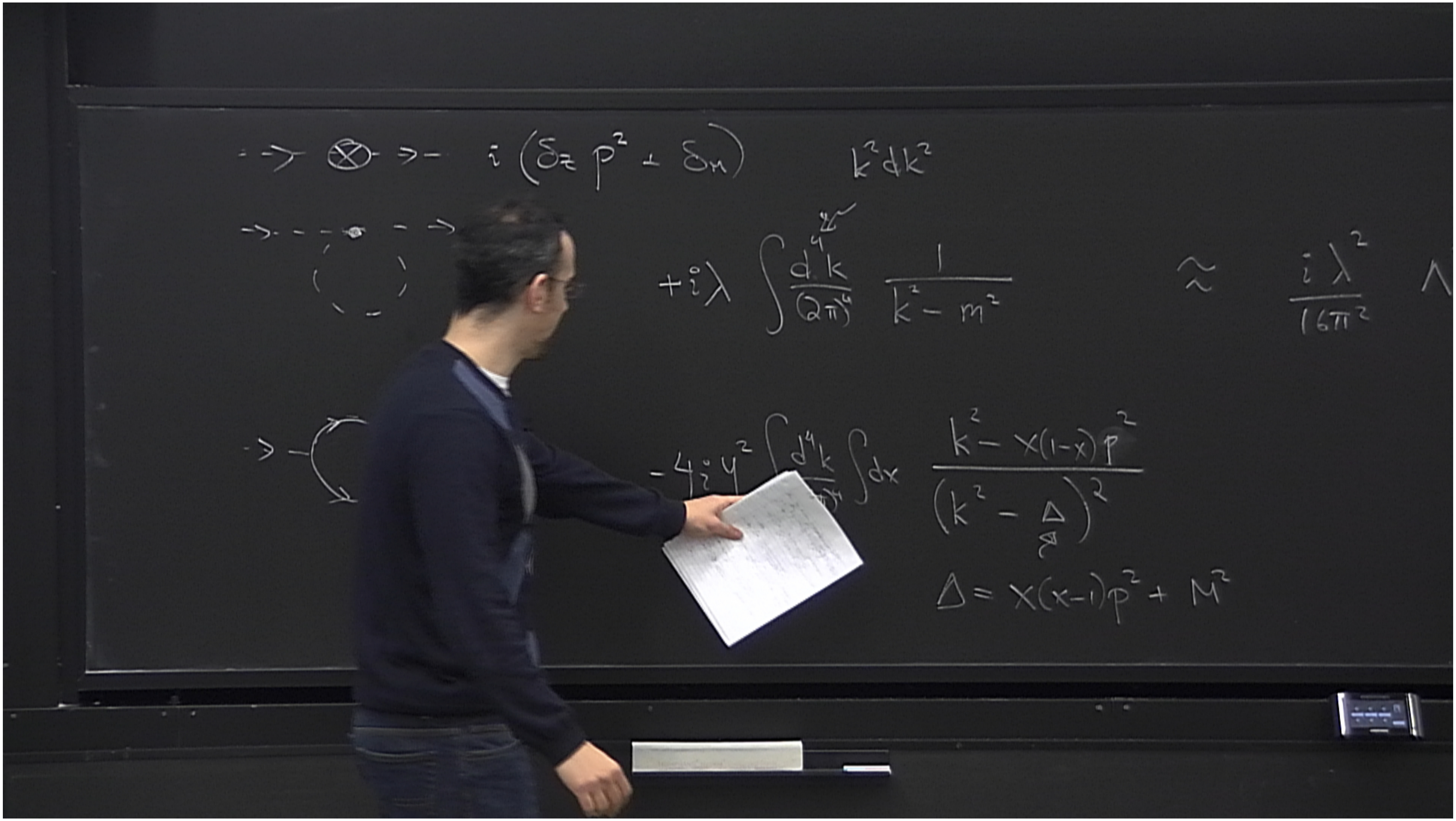
Title: 12/13 PSI - Beyond the Standard Model Lecture 3

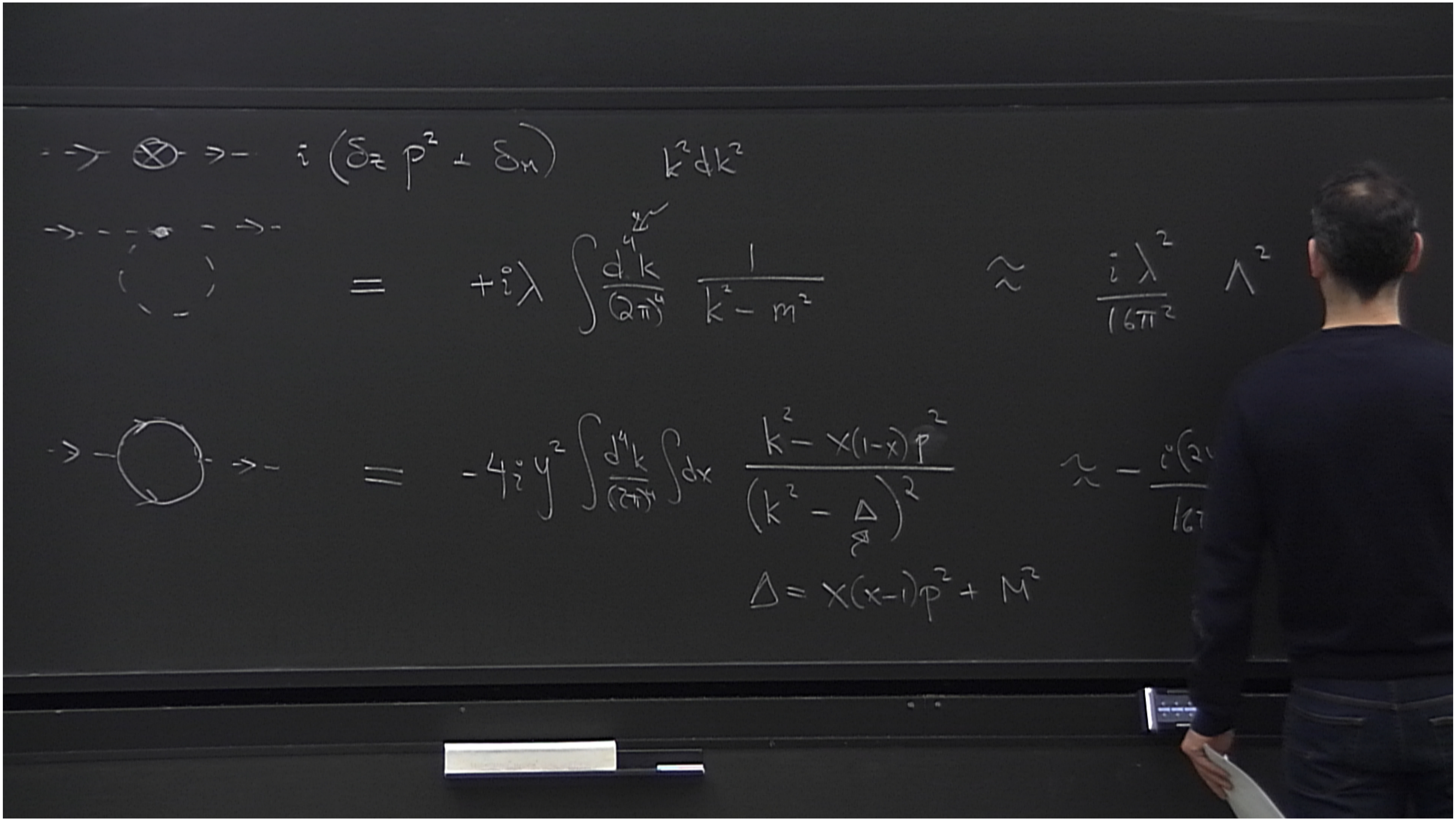
Date: Feb 21, 2013 09:00 AM

URL: http://pirsa.org/13020091

Abstract:


$i(\delta_Z p^2 - \delta_m)$
$= +i\lambda \int \frac{d^4k}{(2\pi)^4} \frac{1}{k^2 - m^2}$
$= -4i y^2 \int \frac{d^4k}{(2\pi)^4} \int dx \frac{k^2 - x(1-x)p^2}{(k^2 - \Delta)^2}$
$\Delta = x(x-1)p^2 + M^2$


$i(\delta_Z p^2 + \delta_m)$
$k^2 dk^2$
$+i\lambda \int \frac{d^4k}{(2\pi)^4} \frac{1}{k^2 - m^2} \approx \frac{i\lambda^2}{16\pi^2} \Lambda$
$-4iy^2 \int \frac{d^4k}{(2\pi)^4} \int dx \frac{k^2 - x(1-x)p^2}{(k^2 - \Delta)^2}$
$\Delta = x(x-1)p^2 + M^2$



$i(\delta_Z p^2 - \delta_M)$
$k^2 dk^2$
$= +i\lambda \int \frac{d^4k}{(2\pi)^4} \frac{1}{k^2 - m^2} \approx \frac{i\lambda^2}{16\pi^2} \Lambda^2$
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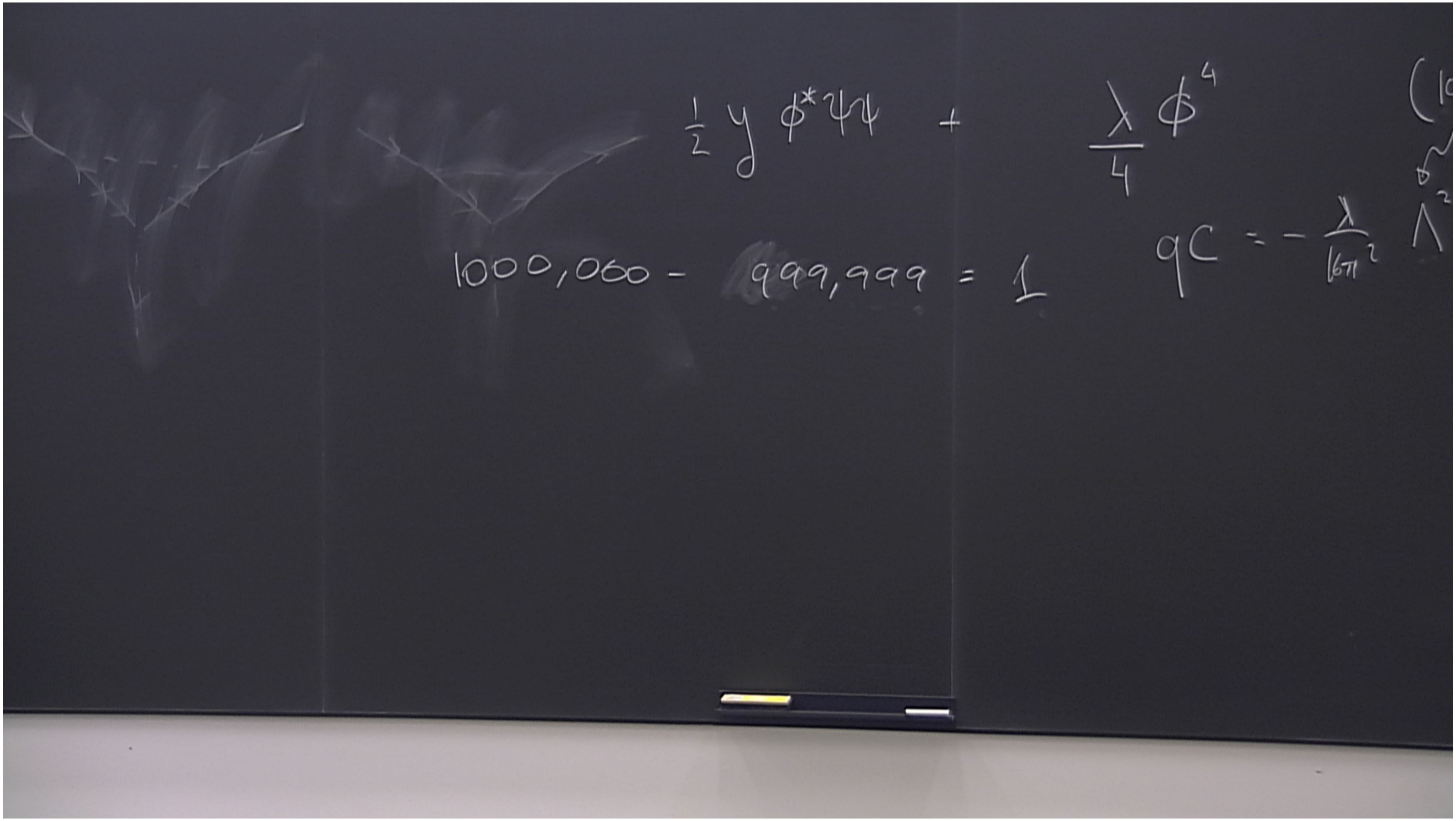
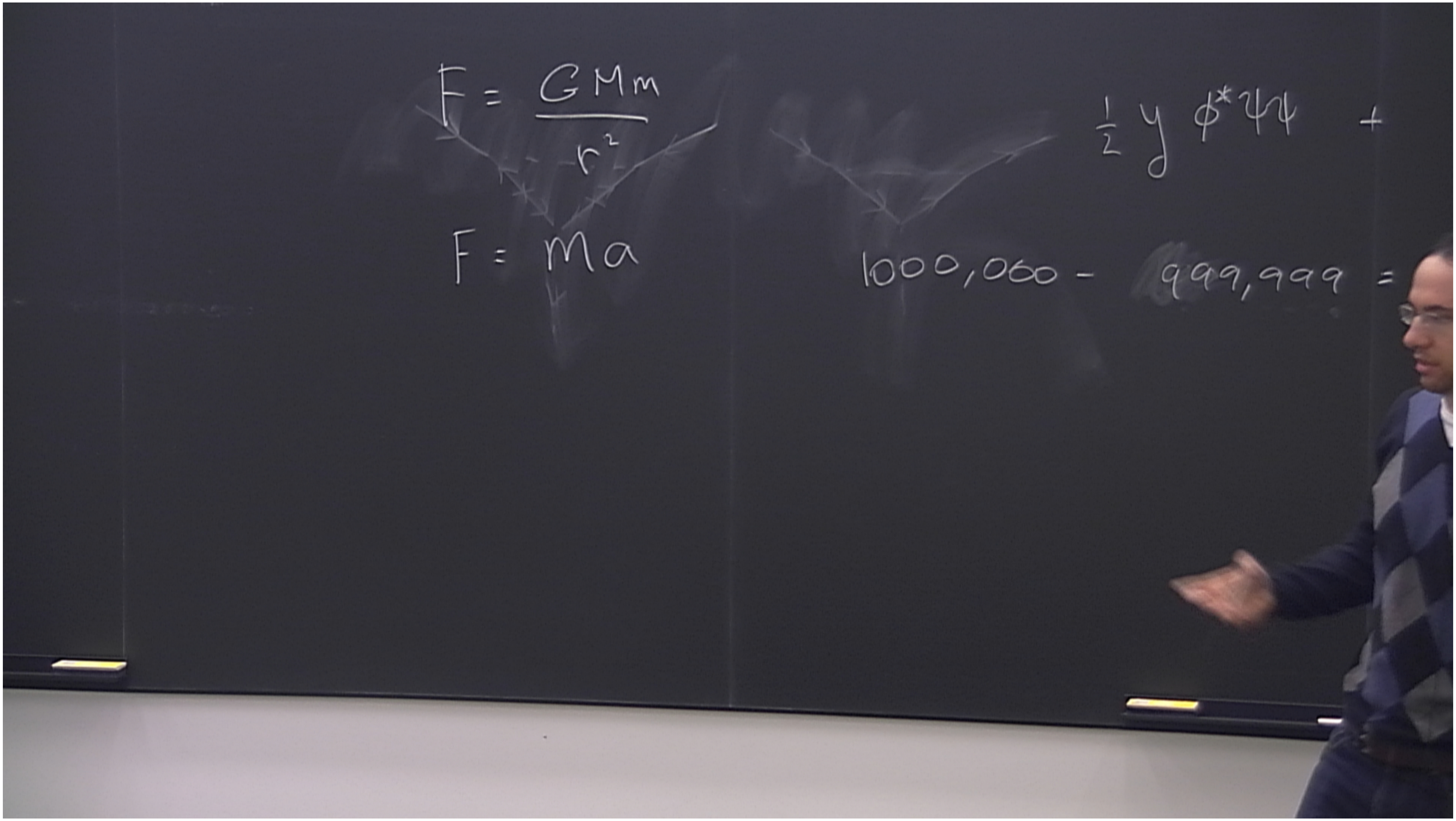
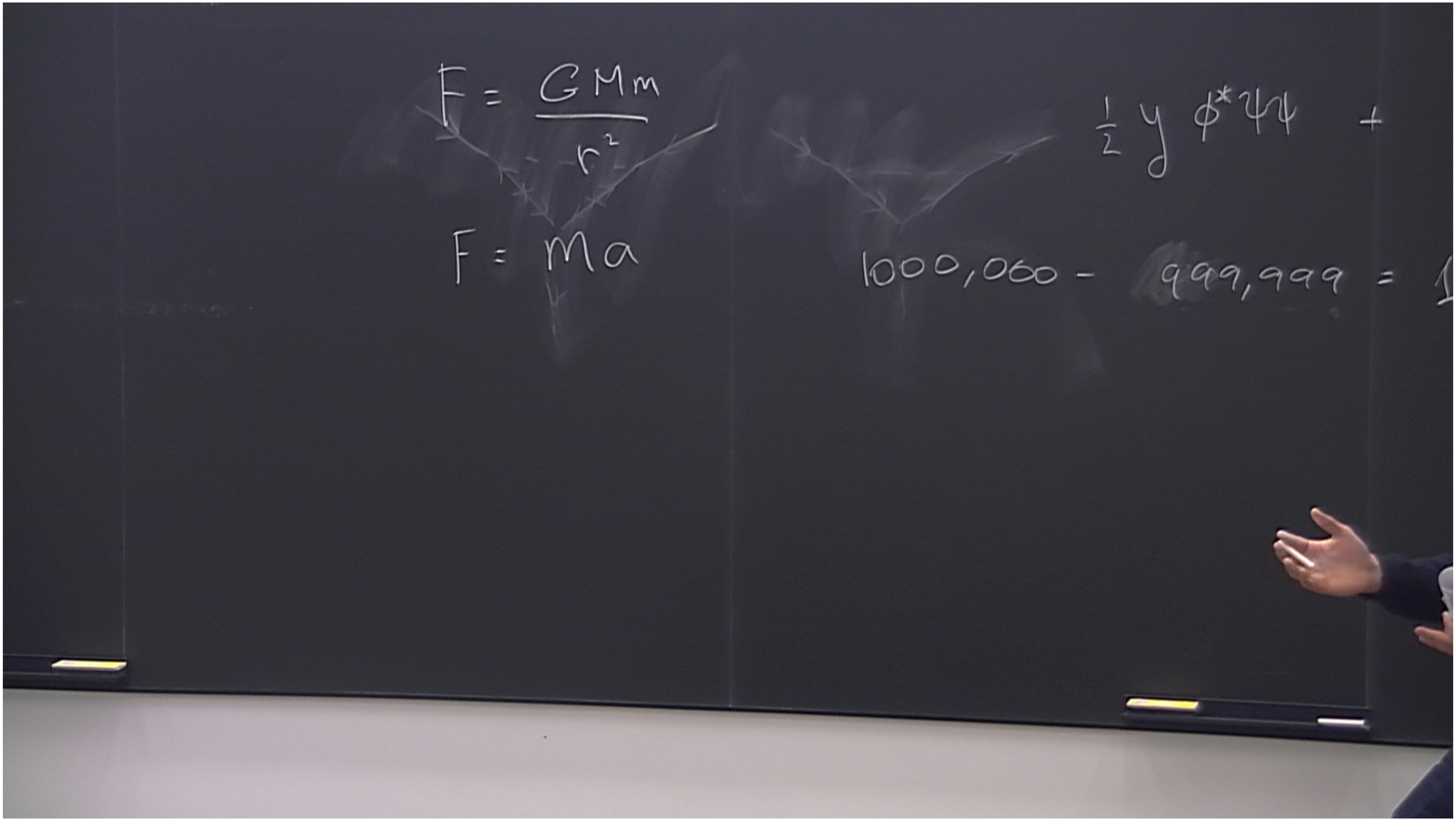
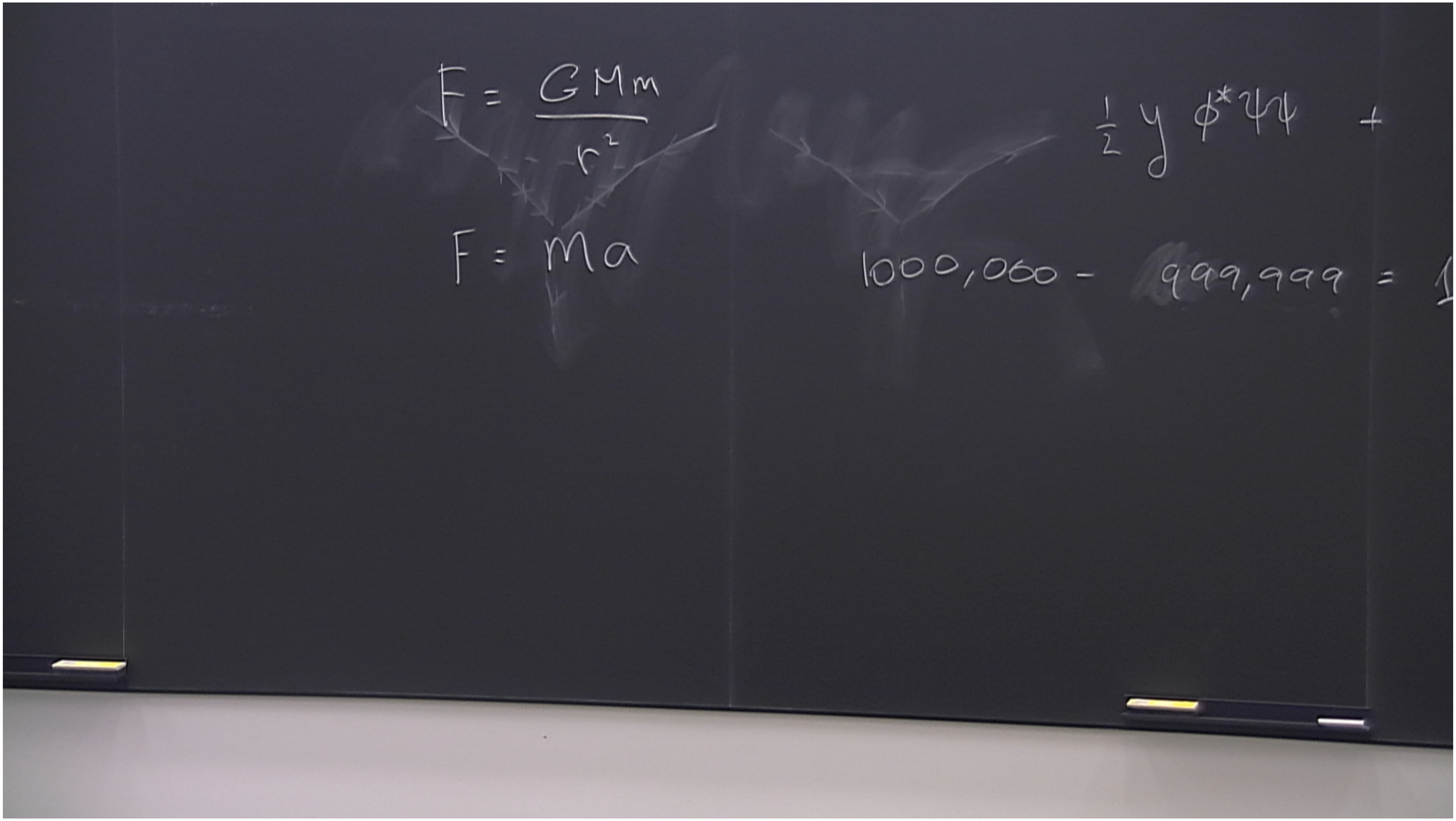
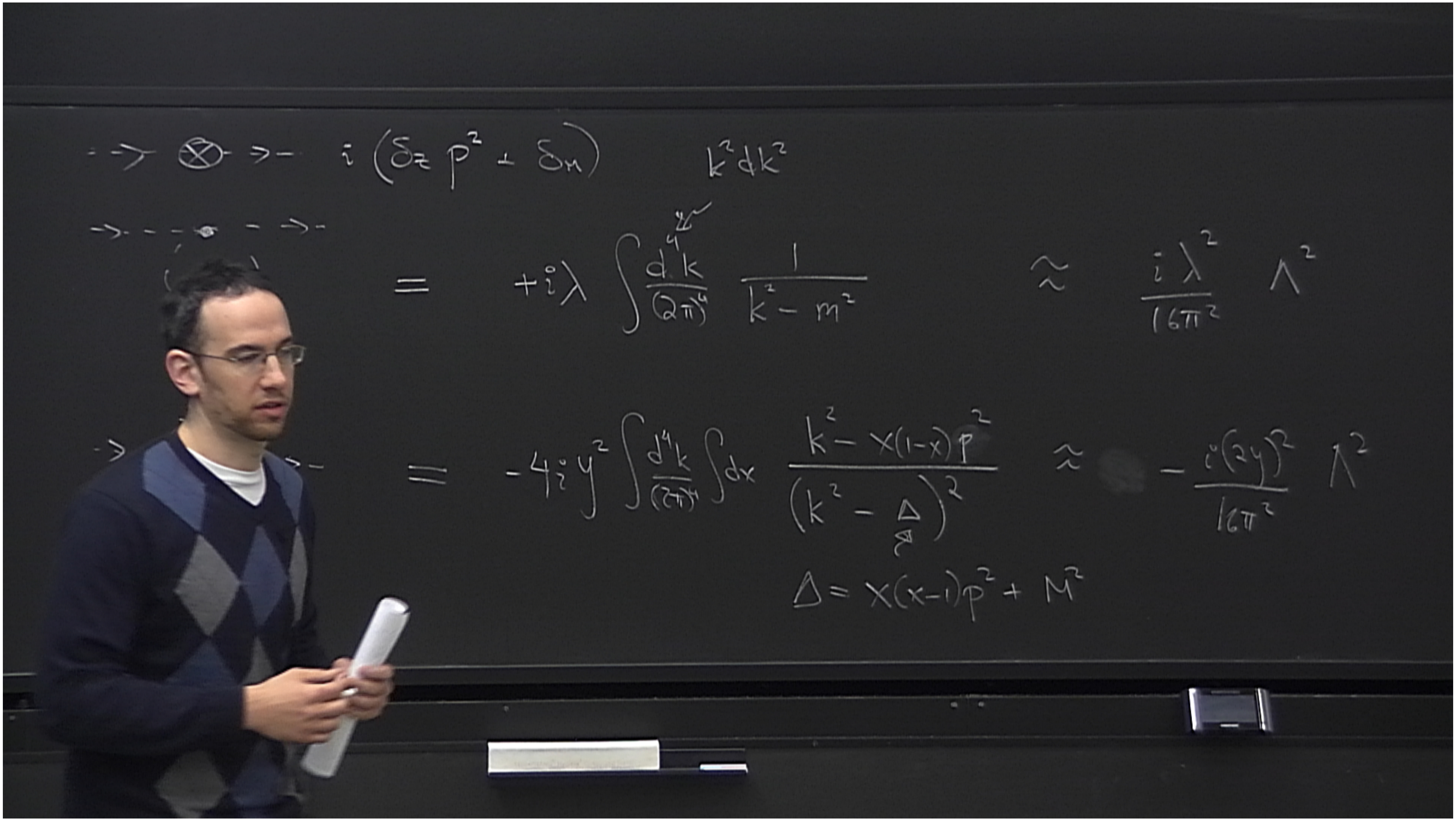
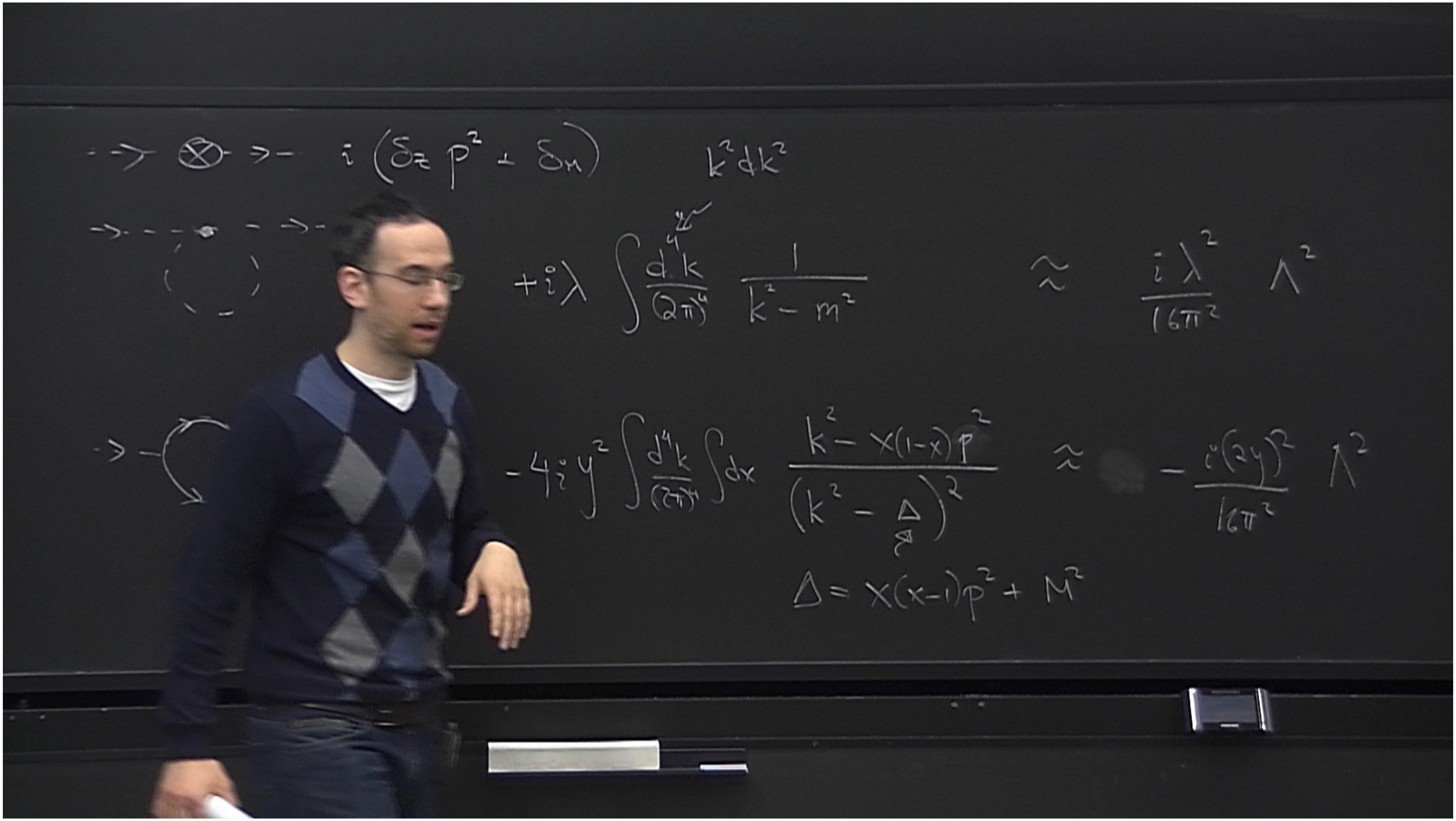

$\frac{1}{2} y \phi^* \psi \psi + \frac{\lambda}{4} \phi^4$
1000,000 - 999,999 = 1
$qC = -\frac{\lambda}{16\pi^2} \Lambda^2$


F = GMm / r²
F = Ma
½ y φ* ψ ψ +
1000,000 - 999,999 =


F = GMm / r²
½ y φ*ψψ +
F = Ma
1000,000 − 999,999 =


$F = \frac{GMm}{r^2}$
$F = Ma$
$\frac{1}{2} y \phi^* \psi \psi +$
1000,000 - 999,999 =


$i(\delta_Z p^2 - \delta_m)$
$k^2 dk^2$
$= +i\lambda \int \frac{d^4k}{(2\pi)^4} \frac{1}{k^2 - m^2} \approx \frac{i\lambda^2}{16\pi^2} \Lambda^2$
$= -4iy^2 \int \frac{d^4k}{(2\pi)^4} \int dx \frac{k^2 - x(1-x)p^2}{(k^2 - \Delta)^2} \approx -\frac{i(2y)^2}{16\pi^2} \Lambda^2$
$\Delta = x(x-1)p^2 + M^2$


$i(\delta_Z p^2 + \delta_m)$
$k^2 dk^2$
$+i\lambda \int \frac{d^4k}{(2\pi)^4} \frac{1}{k^2 - m^2} \approx \frac{i\lambda^2}{16\pi^2} \Lambda^2$
$-4iy^2 \int \frac{d^4k}{(2\pi)^4} \int dx \frac{k^2 - x(1-x)p^2}{(k^2-\Delta)^2} \approx -\frac{i(2y)^2}{16\pi^2} \Lambda^2$
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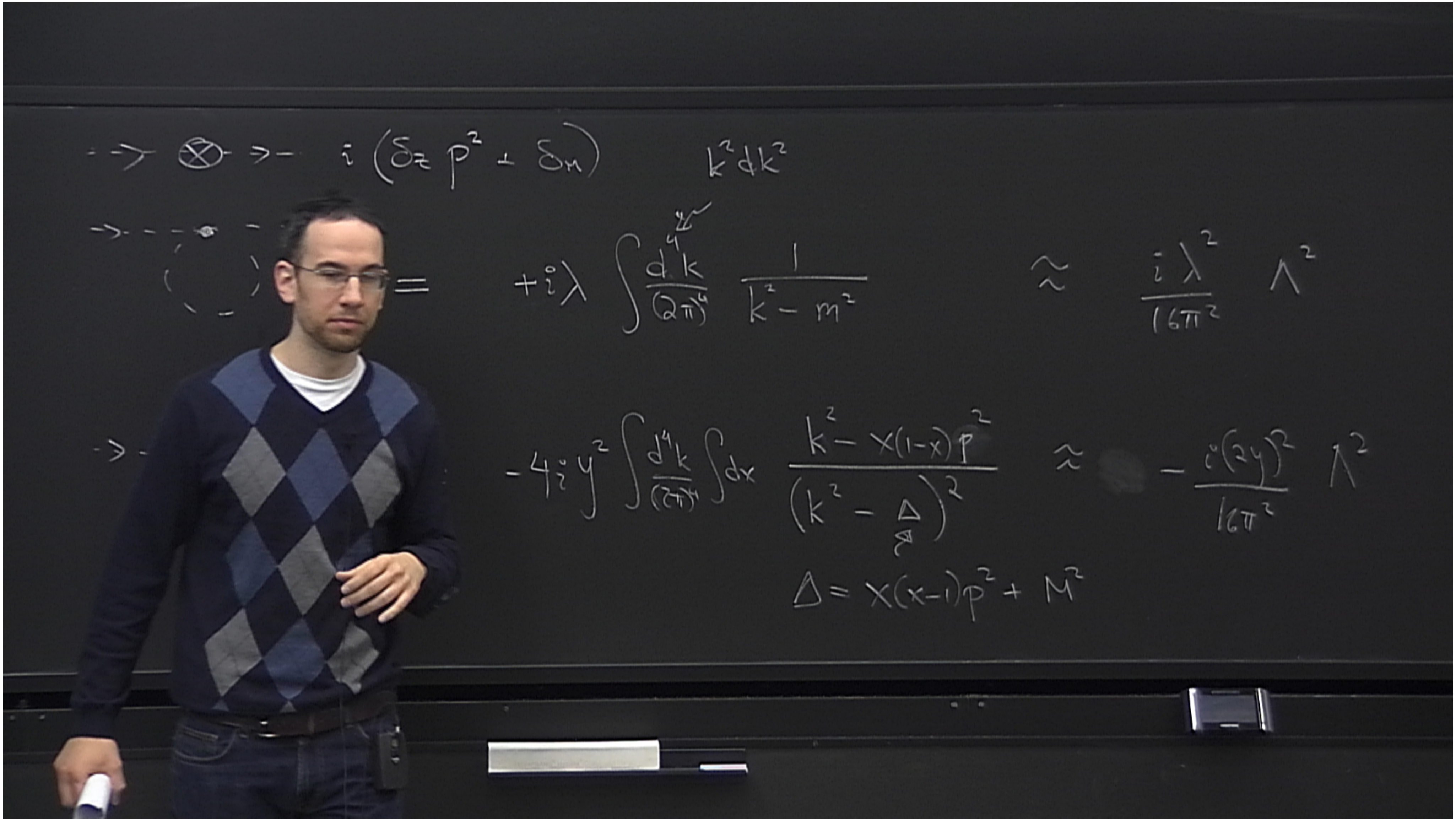
$i(\delta_Z p^2 + \delta_m)$
$k^2 dk^2$
$= +i\lambda \int \frac{d^4k}{(2\pi)^4} \frac{1}{k^2 - m^2} \approx \frac{i\lambda^2}{16\pi^2} \Lambda^2$
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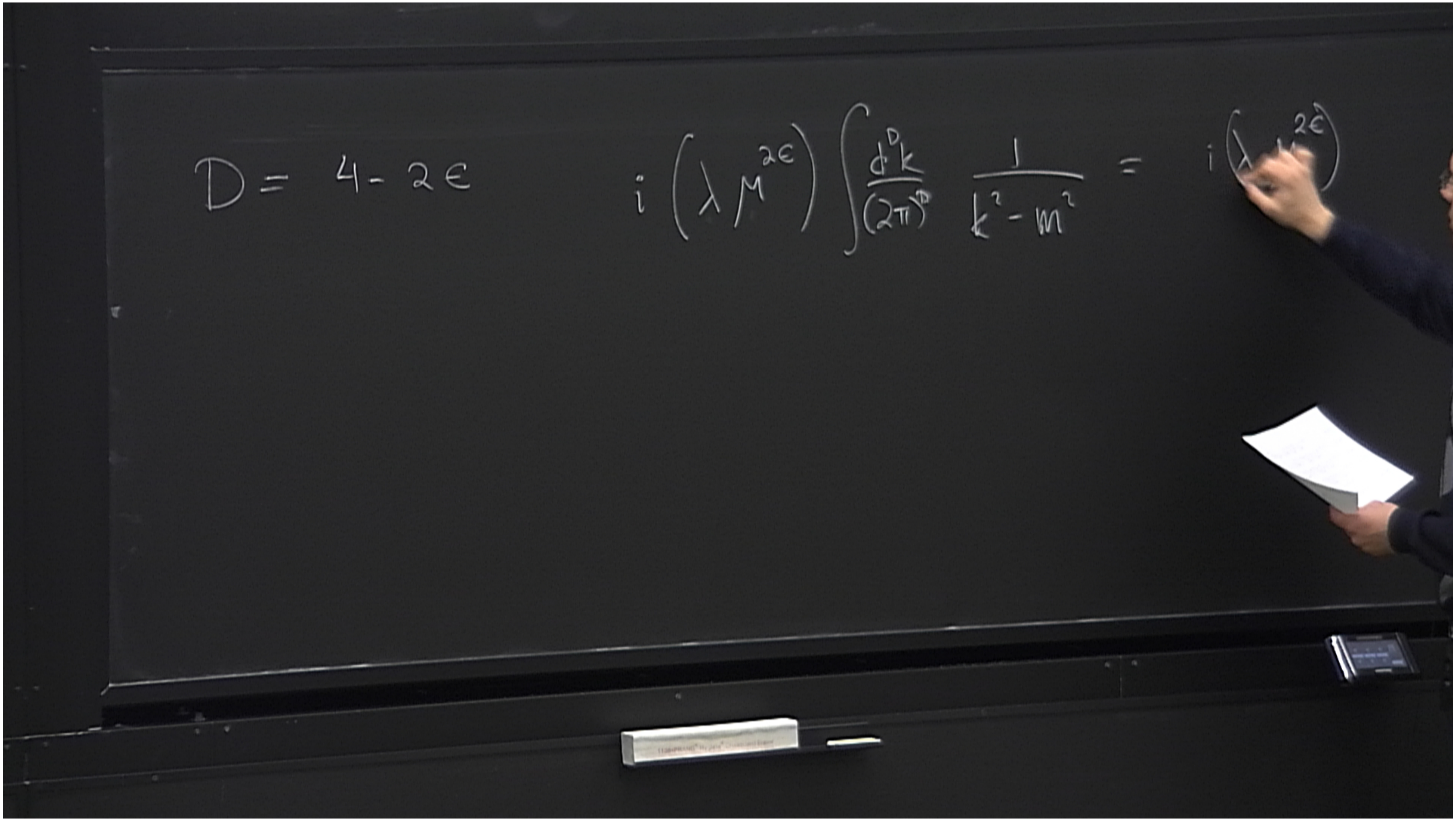
$\Delta = x(x-1)p^2 + M^2$

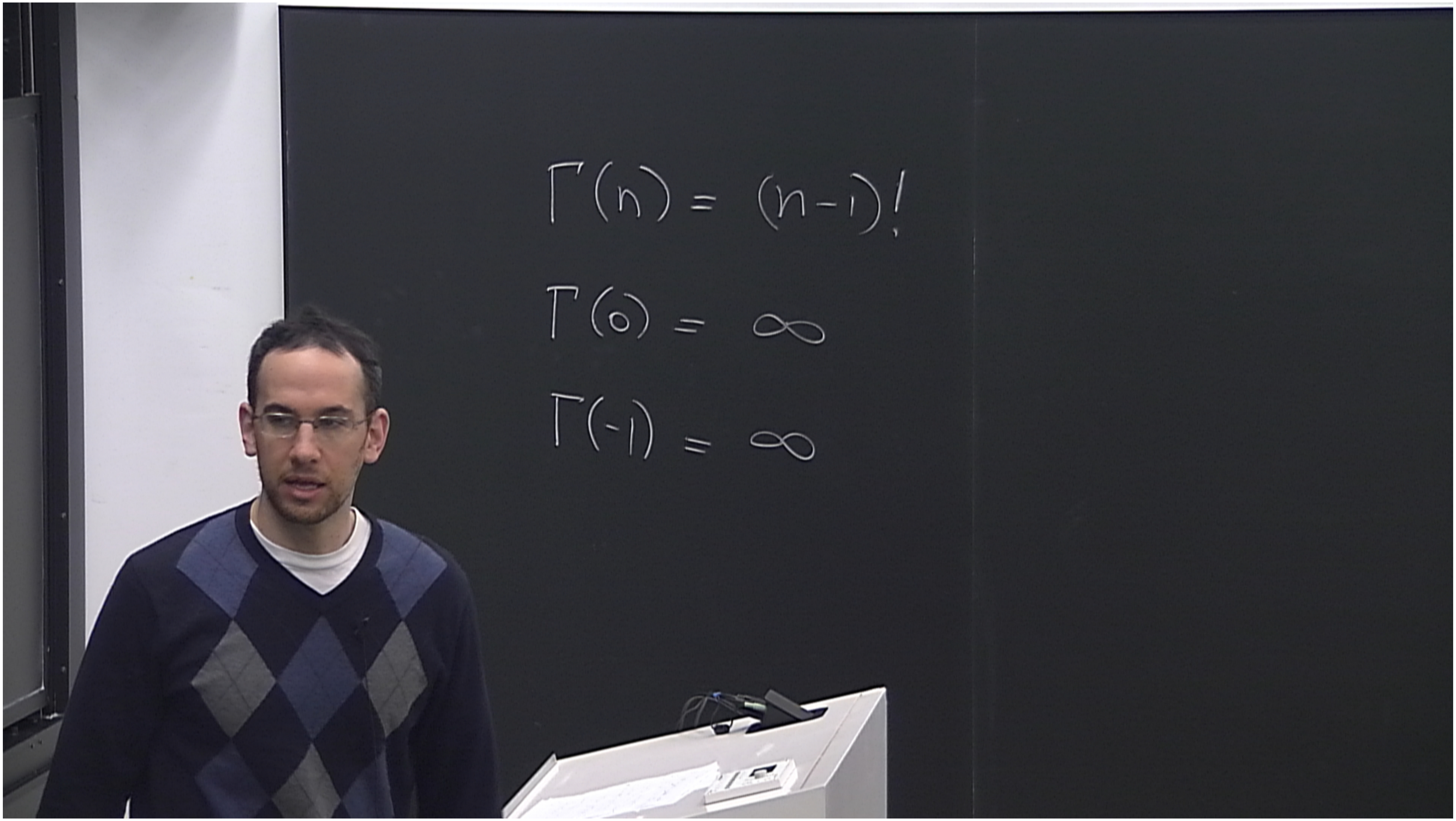
$$D = 4 - 2\epsilon$$

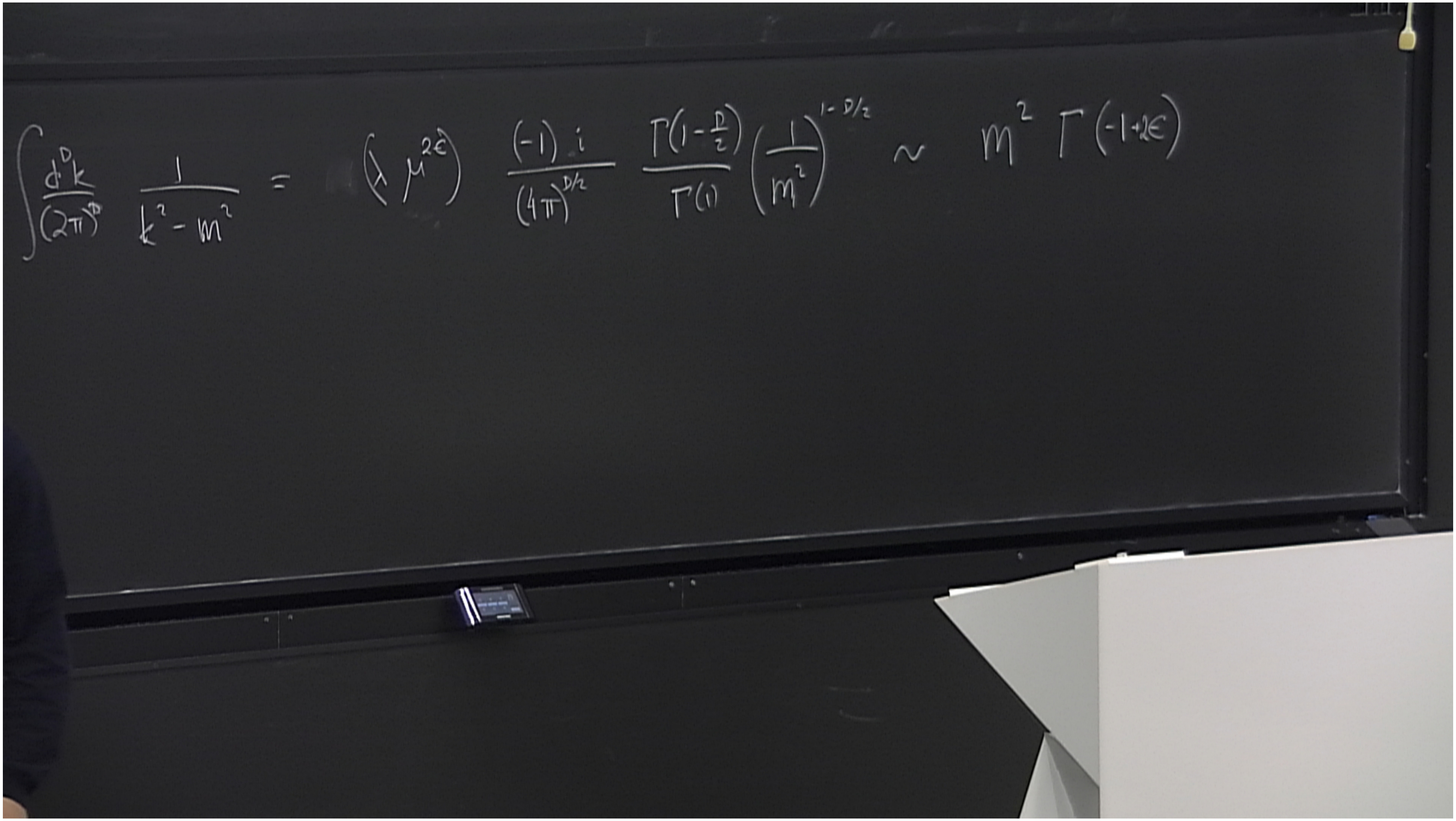
$$i\left(\lambda \mu^{2\epsilon}\right) \int \frac{d^D k}{(2\pi)^D} \frac{1}{k^2 - m^2} =$$

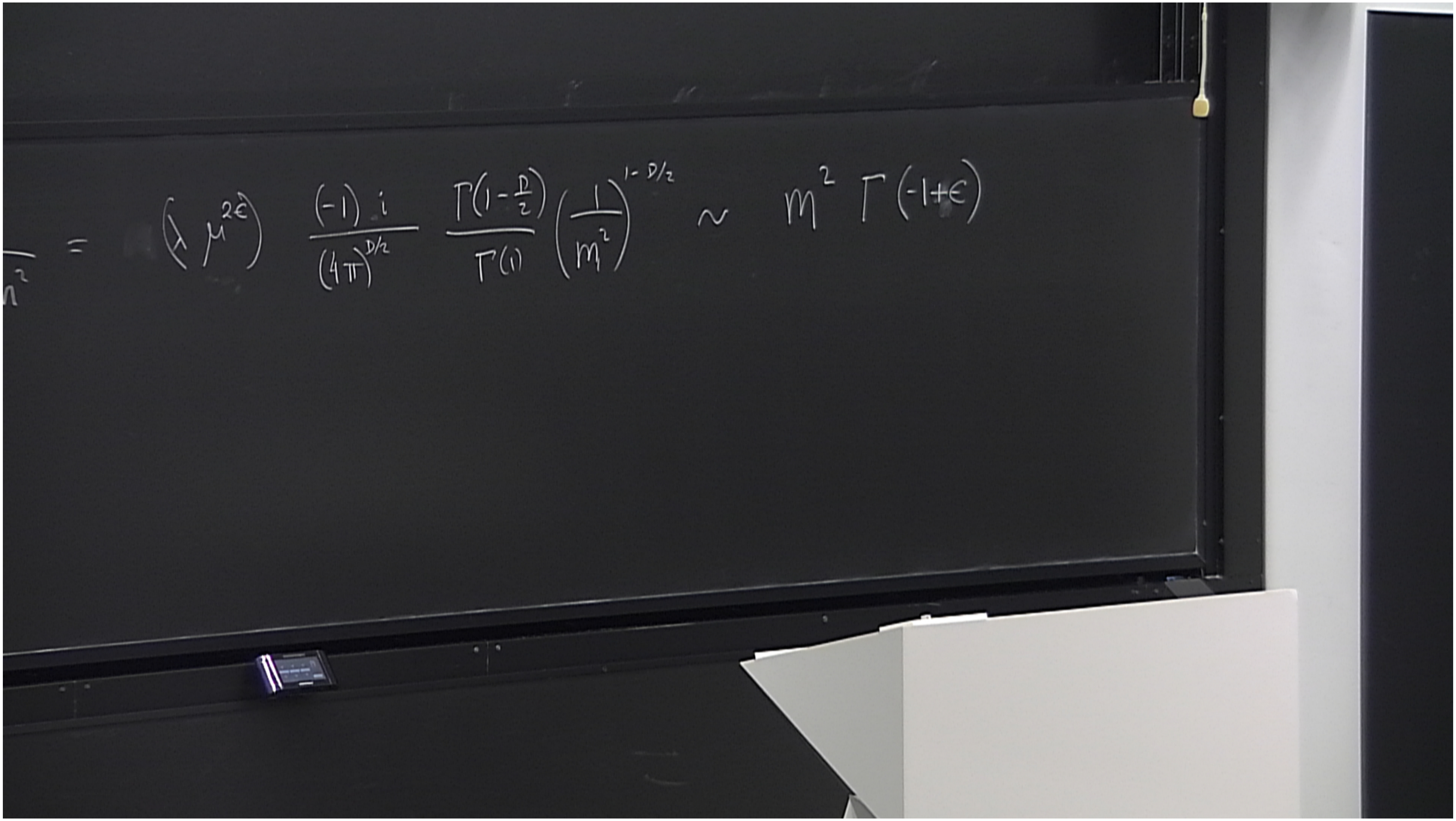

$D = 4 - 2\epsilon$
$i\left(\lambda\mu^{2\epsilon}\right)\int\frac{d^Dk}{(2\pi)^D}\frac{1}{k^2-m^2} = i\left(\lambda\mu^{2\epsilon}\right)$

$$D = 4 - 2\epsilon$$

$$\left(\lambda \mu^{2\epsilon}\right) \int \frac{d^D k}{(2\pi)^D} \frac{1}{k^2 - m^2} = \left(\lambda \mu^{2\epsilon}\right) \frac{(-1)\, i}{(4\pi)^{D/2}} \Gamma(1$$

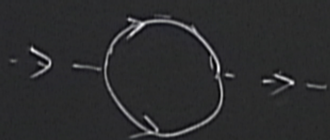

$\Gamma(n) = (n-1)!$
$\Gamma(0) = \infty$
$\Gamma(-1) = \infty$


$\int \frac{d^D k}{(2\pi)^D} \frac{1}{k^2 - m^2} = (\lambda \mu^{2\epsilon}) \frac{(-1)\, i}{(4\pi)^{D/2}} \frac{\Gamma(1-\frac{D}{2})}{\Gamma(1)} \left(\frac{1}{m^2}\right)^{1-D/2} \sim m^2\, \Gamma(-1+2\epsilon)$


$= (\lambda \mu^{2\epsilon}) \frac{(-1)\ i}{(4\pi)^{D/2}} \frac{\Gamma(1-\frac{D}{2})}{\Gamma(1)} \left(\frac{1}{m^2}\right)^{1-D/2} \sim m^2\, \Gamma(-1+\epsilon)$

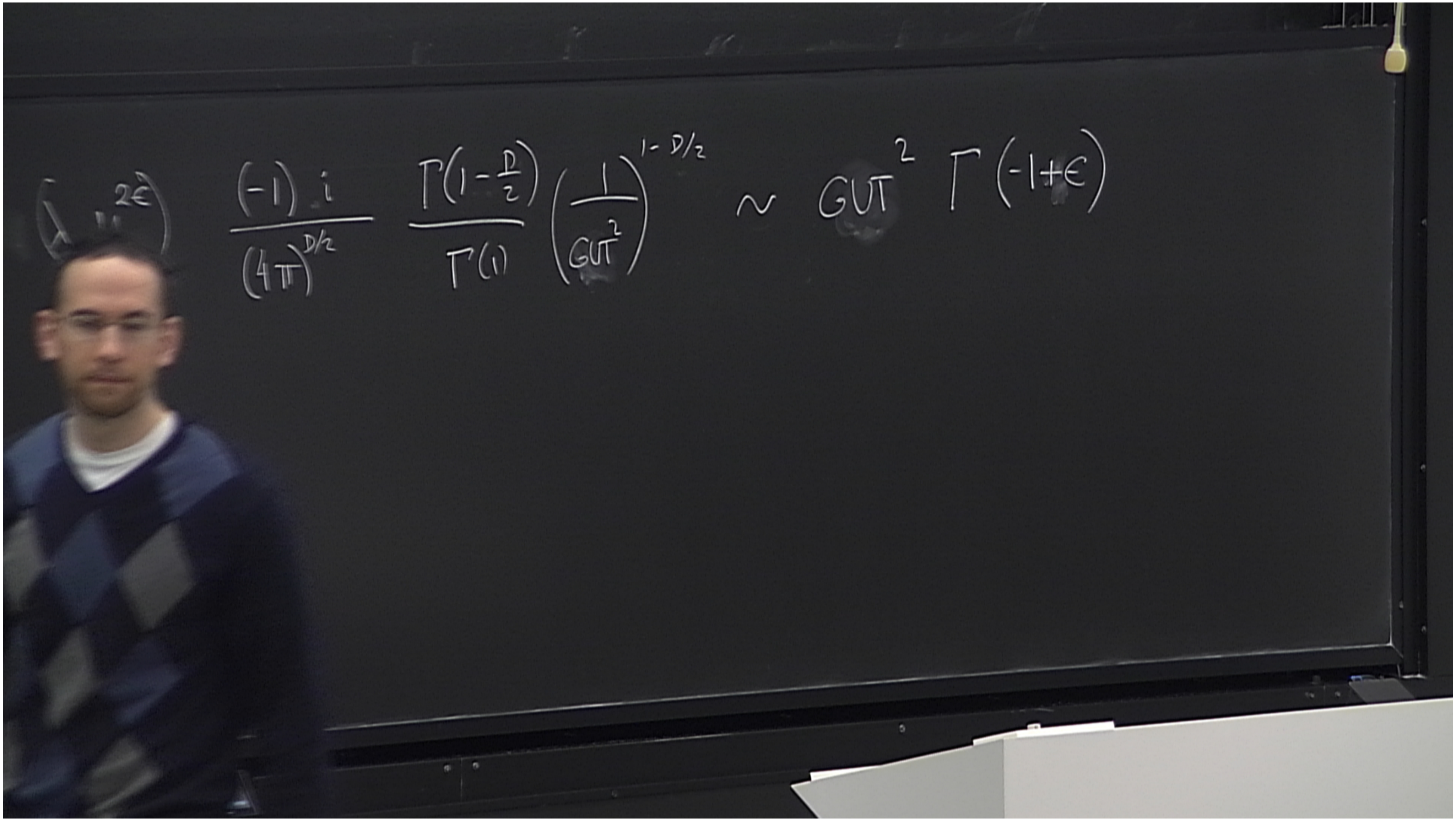
 $i\left(\delta_Z p^2 - \delta_M\right)$ $\qquad k^2 dk^2$

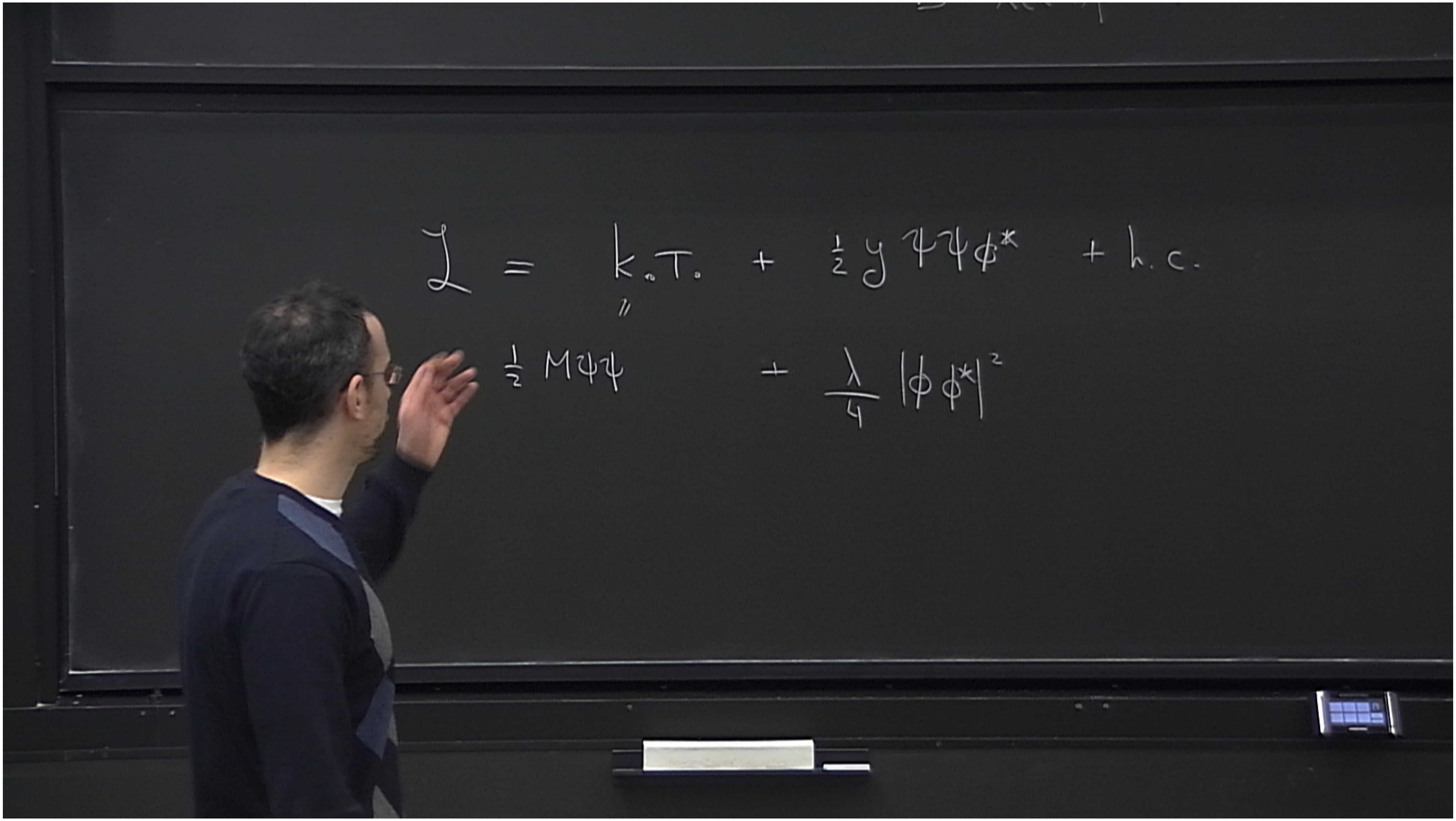
$$= +i\lambda \int_0^\infty \frac{d^D k_E}{(2\pi)^D} \frac{1}{k^2 - GUT^2} \approx \frac{i\lambda^2}{16\pi^2}$$

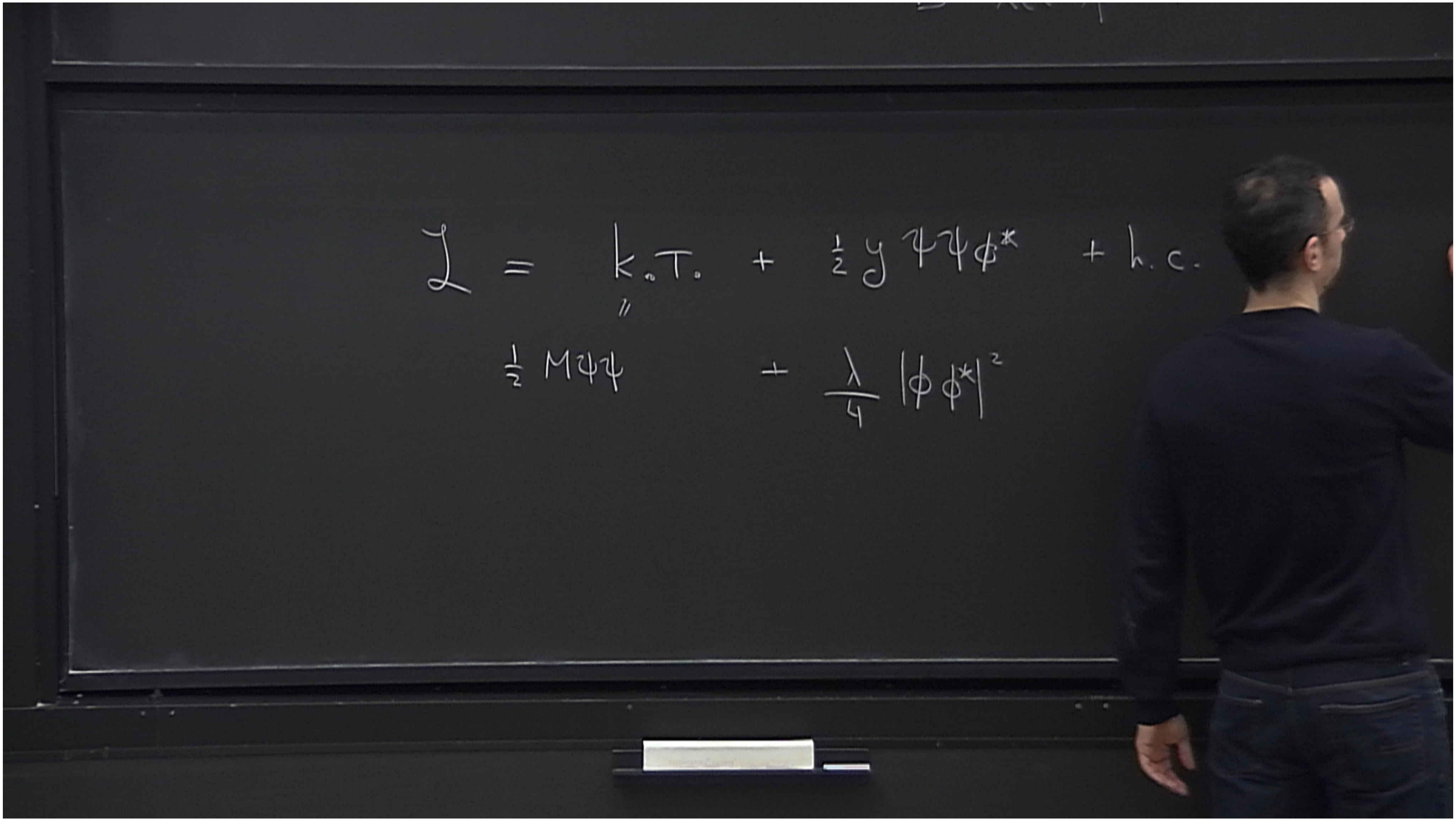


$$= -4iy^2 \int \frac{d^4 k_E}{(2\pi)^4} \int dx \, \frac{k^2 - x(1-x)p^2}{\left(k^2 - \Delta\right)^2} \approx -\frac{i(2y)^2}{16\pi^2}$$

$$\Delta = x(x-1)p^2 + M^2$$

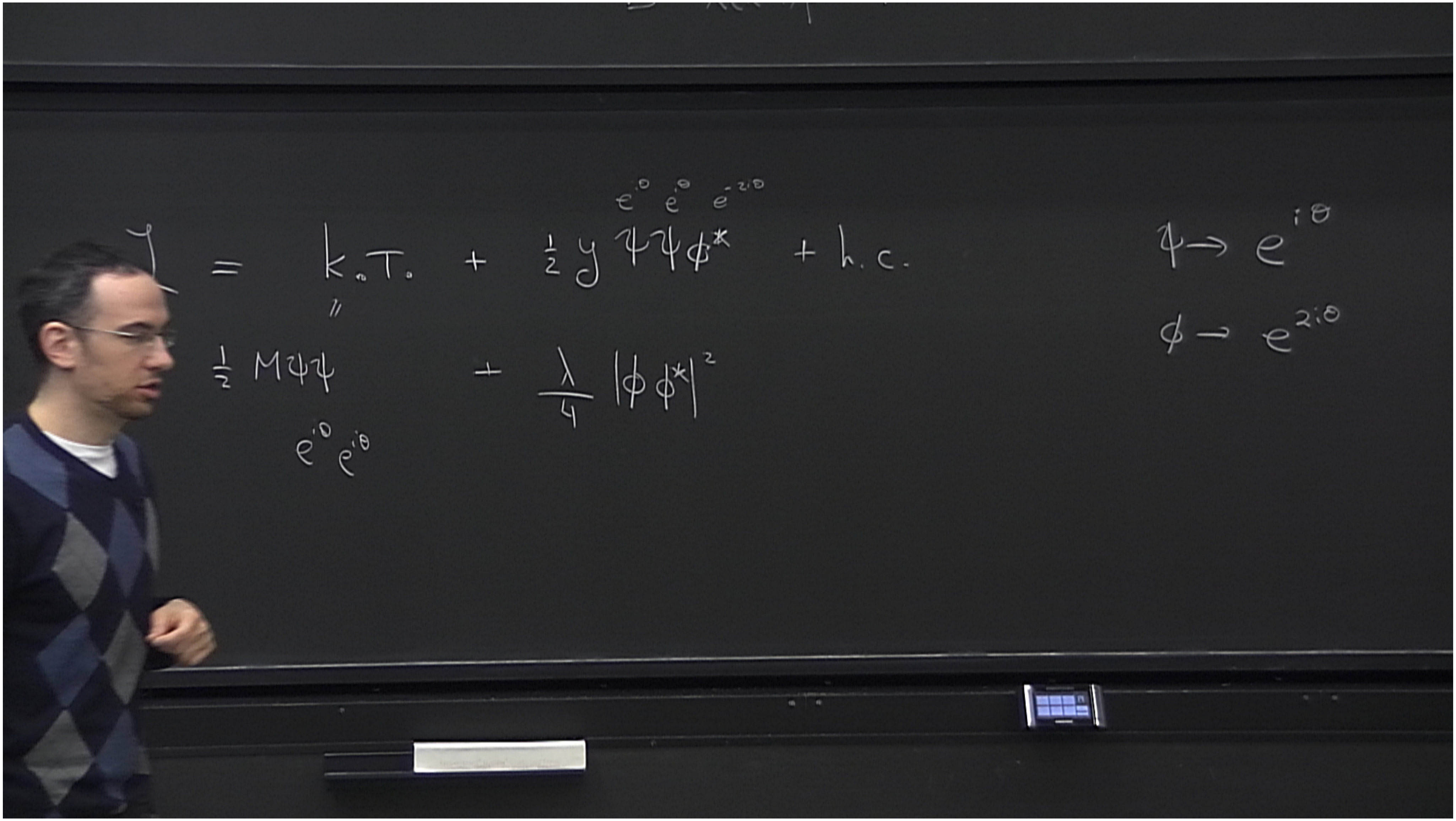

$\left(\lambda \mu^{2\epsilon}\right) \frac{(-1)\, i}{(4\pi)^{D/2}} \frac{\Gamma(1-\frac{D}{2})}{\Gamma(1)} \left(\frac{1}{GUT^2}\right)^{1-D/2} \sim GUT^2\, \Gamma(-1+\epsilon)$

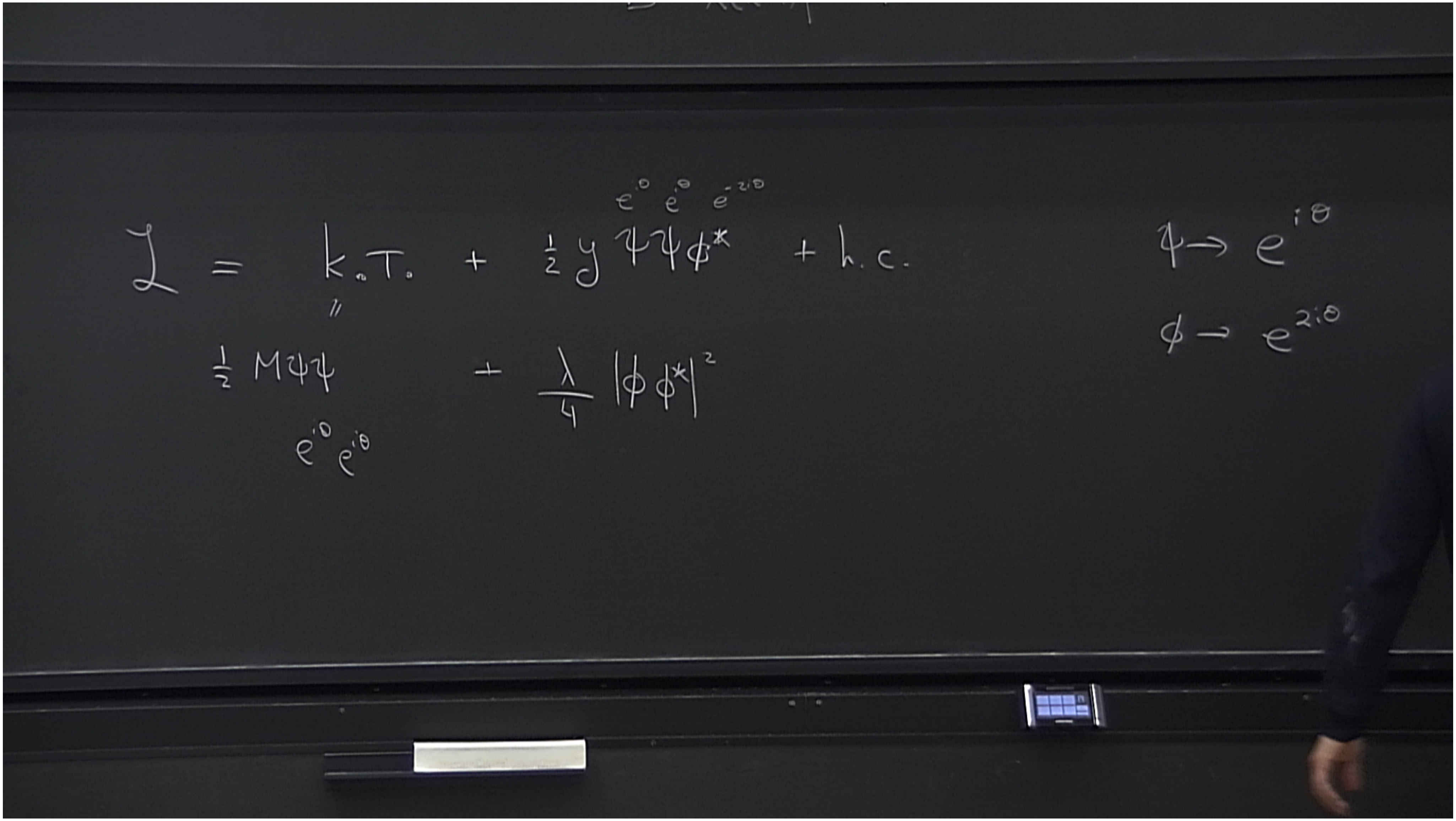

L = k.T. + ½ y ψψφ* + h.c.
½ Mψψ + λ/4 |φφ*|²


$\mathcal{L} = k.T. + \frac{1}{2} y \psi\psi\phi^* + h.c.$
$\frac{1}{2} M\psi\psi + \frac{\lambda}{4} |\phi\phi^*|^2$

$$\ldots T. + \frac{1}{2} y \psi \psi \phi^* + h.c. \qquad \phi \to e^{i\theta}$$

$$+ \frac{\lambda}{4} |\phi \phi^*|^2$$


$\mathcal{L} = K.T. + \frac{1}{2} y \psi\psi\phi^* + h.c.$
$\frac{1}{2} M\psi\psi + \frac{\lambda}{4} |\phi\phi^*|^2$
$\psi \to e^{i\theta}$
$\phi \to e^{2i\theta}$



$e^{i\theta}\ e^{i\theta}\ e^{-2i\theta}$
$\mathcal{L} = k.T. + \frac{1}{2} y \psi\psi\phi^* + h.c.$
$\psi \to e^{i\theta}$
$\phi \to e^{2i\theta}$
$\frac{1}{2} M\psi\psi + \frac{\lambda}{4} |\phi\phi^*|^2$
$e^{i\theta}\ e^{i\theta}$

$$\psi \to e^{i\theta}\psi \qquad \tfrac{1}{2}M\psi\psi \to e^{2i\theta}\tfrac{1}{2}M\psi\psi \qquad \theta = \pi$$

$$\phi \to e^{2i\theta}\phi \qquad \psi \to -\psi$$

$$\psi \to e^{i\theta}\psi \qquad \tfrac{1}{2}M\psi\psi \to e^{2i\theta}\,\tfrac{1}{2}M\psi\psi \qquad \theta = \pi$$

$$\phi \to e^{2i\theta}\phi \qquad \psi \to -\psi \qquad Z_2 \text{ gp}$$

$$\psi \to e^{i\theta}\psi \qquad \tfrac{1}{2}M\psi\psi \to e^{2i\theta}\,\tfrac{1}{2}M\psi\psi \qquad \theta = \pi$$

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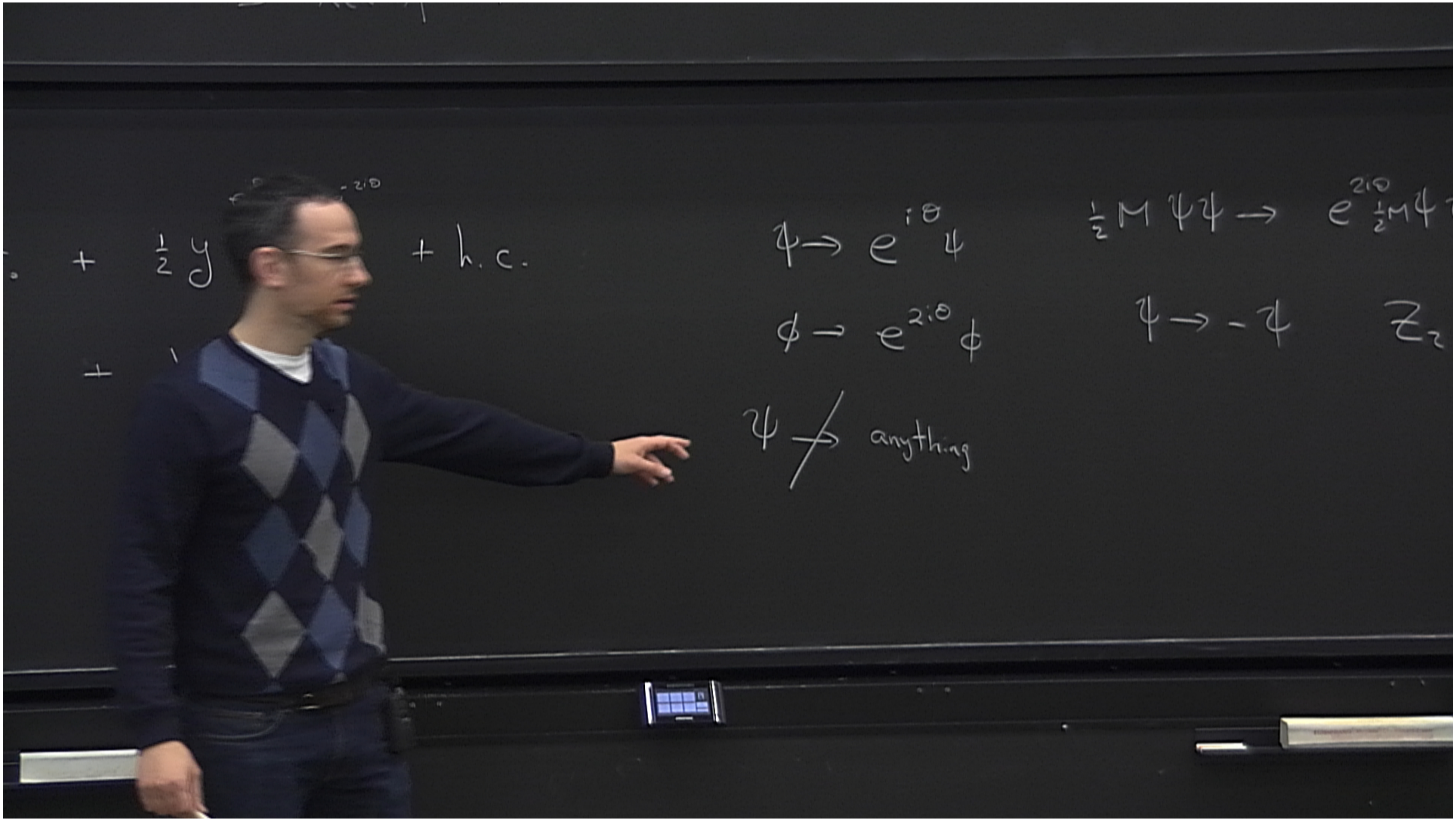

$+ \frac{1}{2} y \quad + h.c.$
$\psi \to e^{i\theta} \psi$
$\phi \to e^{2i\theta} \phi$
$\psi \not\to$ anything
$\frac{1}{2} M \psi\psi \to e^{2i\theta} \frac{1}{2} M \psi$
$\psi \to -\psi \quad Z_2$

$$\begin{array}{cccc} & e^{i\theta} & e^{i\theta} & e^{-2i\theta} \\ + \frac{1}{2} y & \psi & \psi & \phi^* \end{array} + h.c.$$

$$+ \frac{\lambda}{4} |\phi \phi^*|^2$$

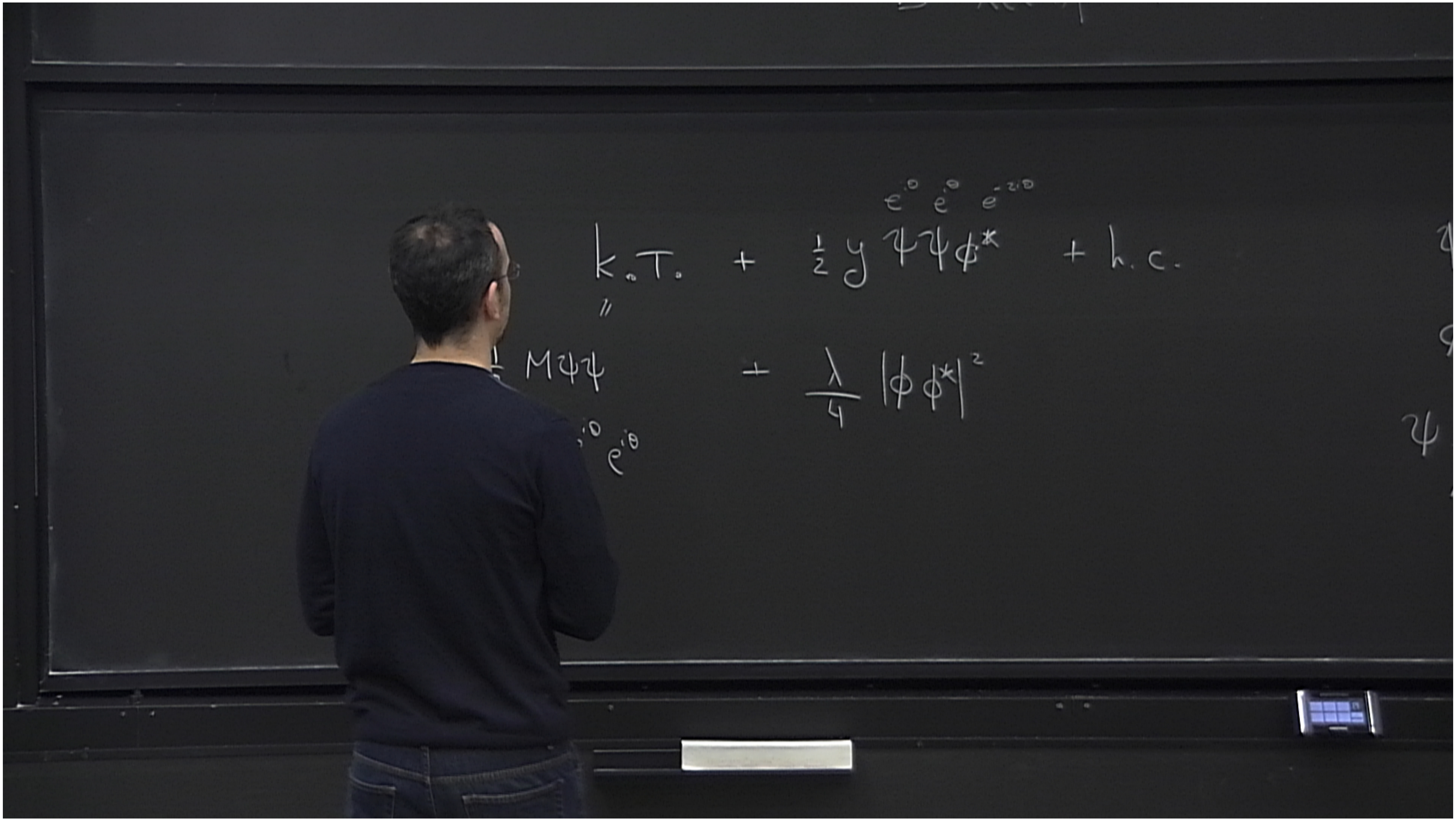
$$\psi \to e^{i\theta} \psi$$

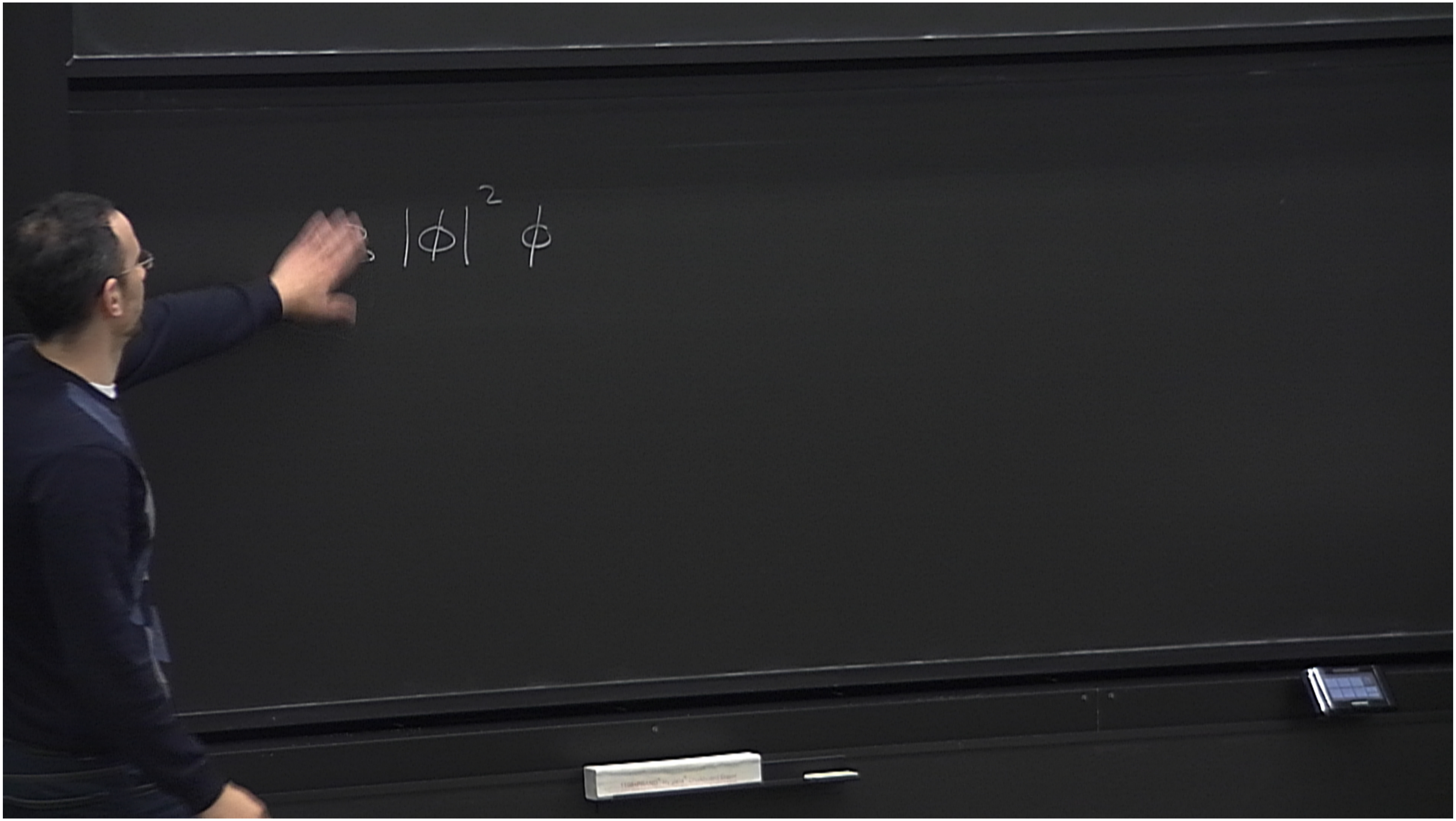
$$\phi \to e^{2i\theta} \phi$$

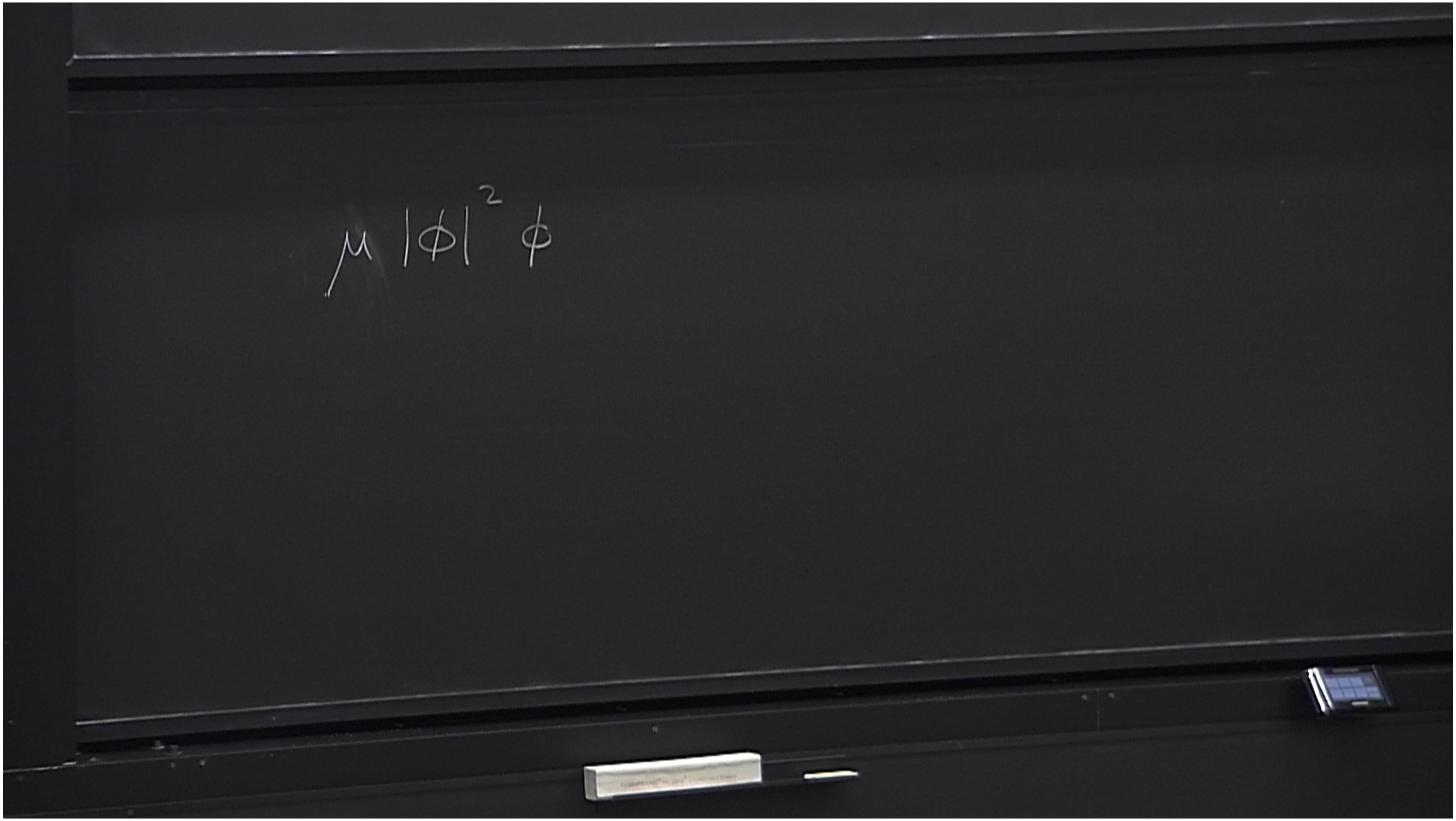
$$\psi \not\to \text{anything}$$

$$\frac{1}{2} M \psi \psi \to e^{2i\theta} \frac{1}{2} M \psi \psi$$

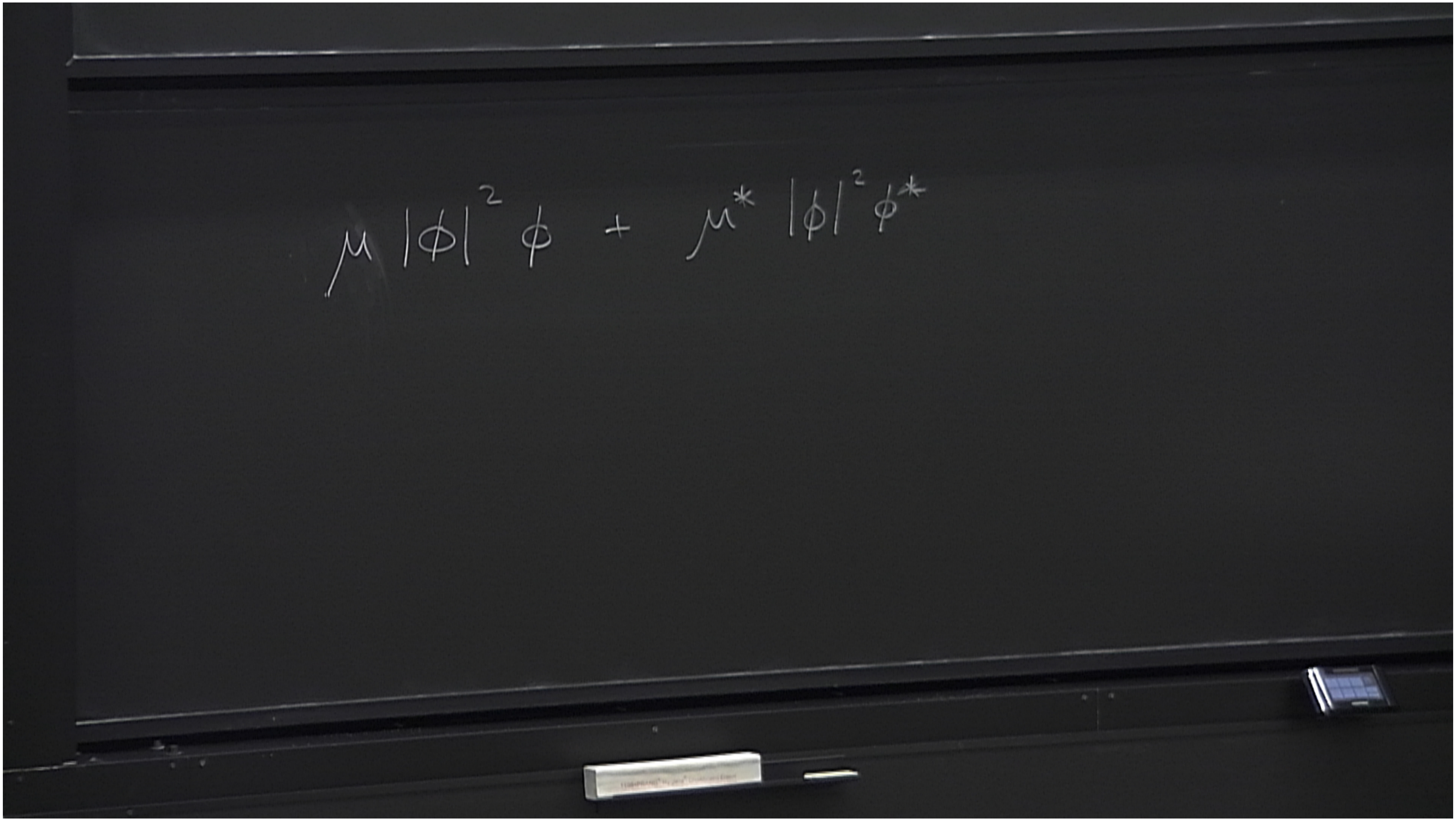
$$\psi \to -\psi \qquad Z_2$$

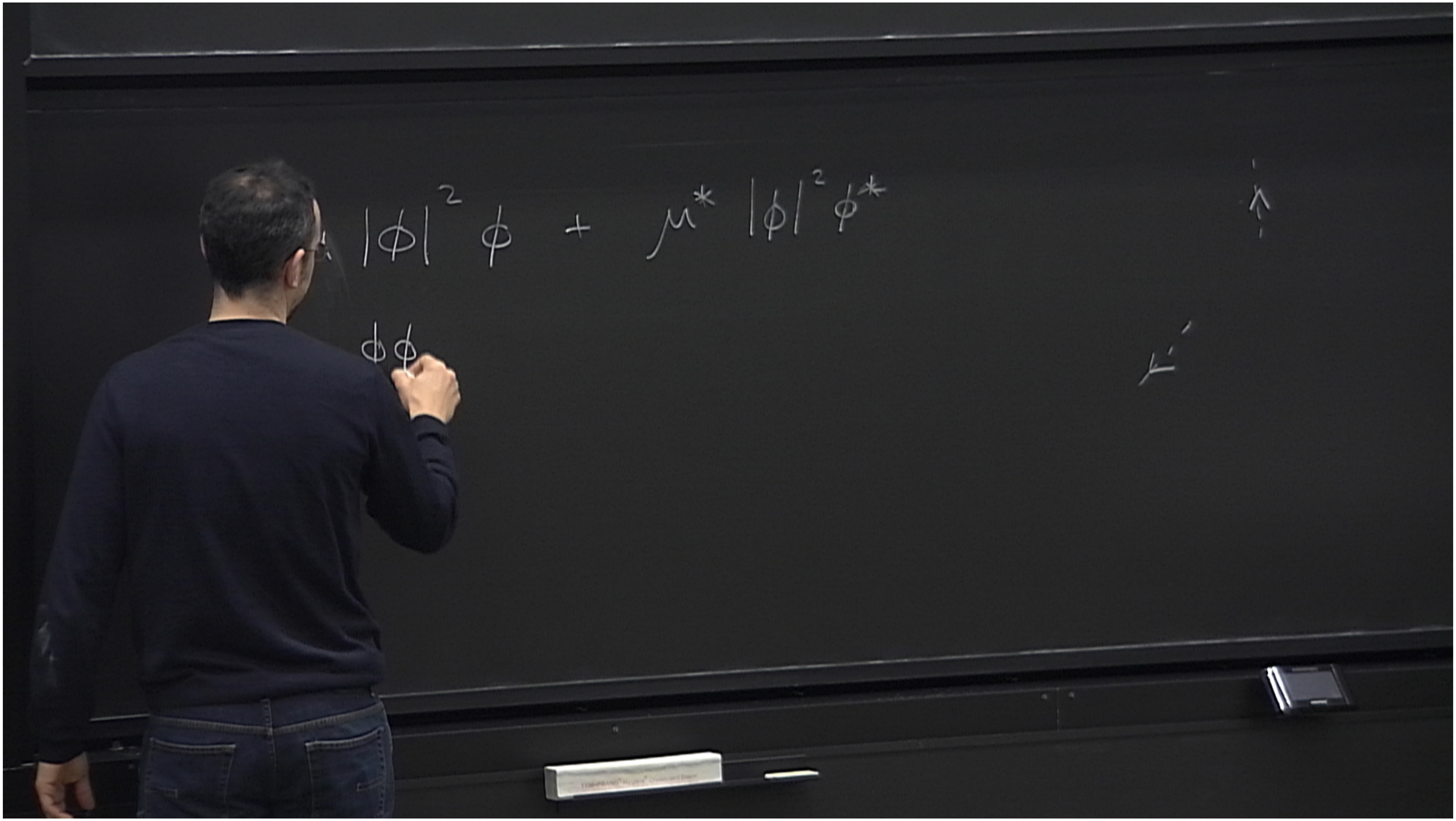

k.T. + ½ y ψψφ* + h.c.
M ψψ + λ/4 |φφ*|²


$|\phi|^2 \phi$

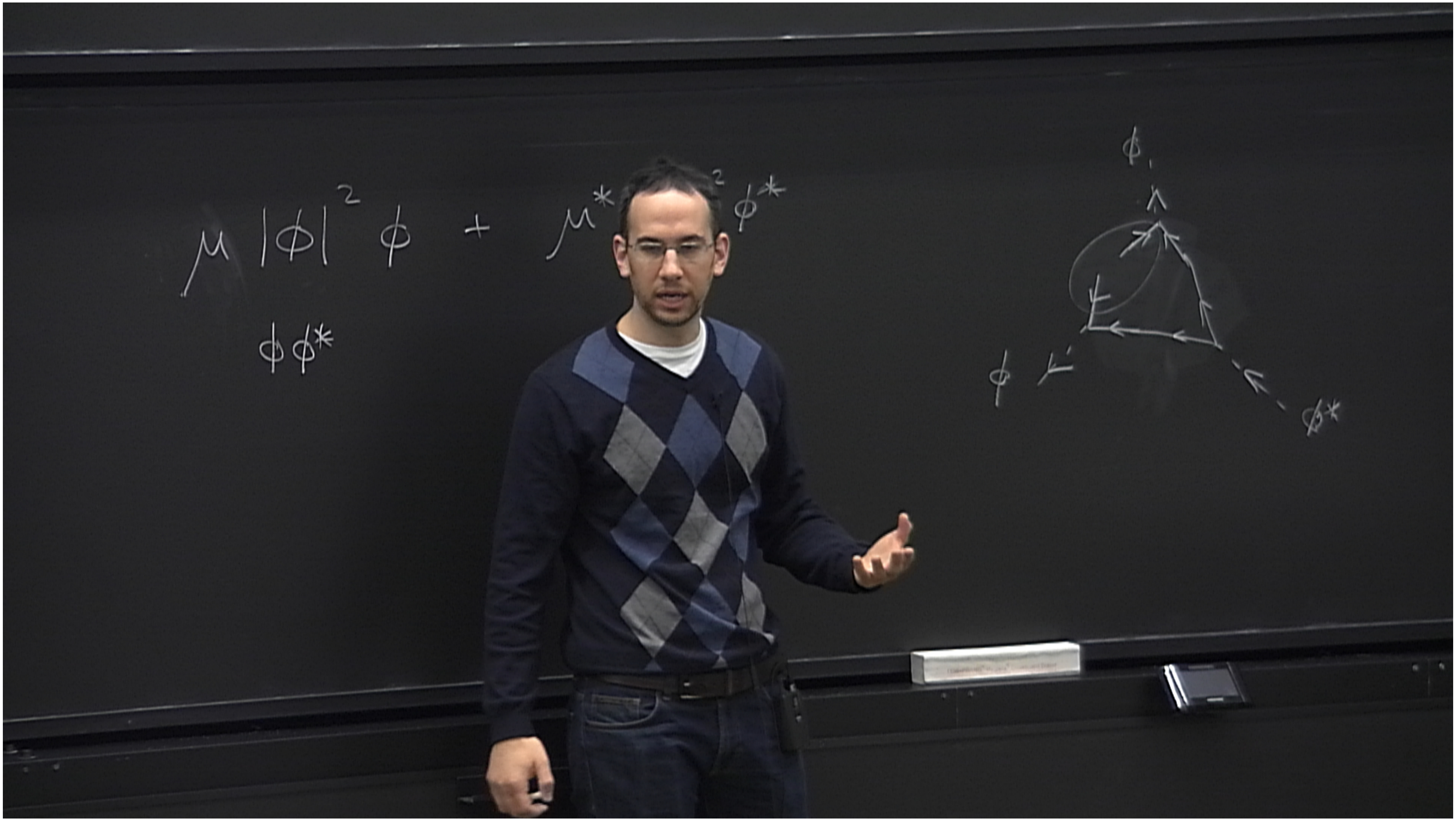

$\mu |\phi|^2 \phi$

$$\mu |\phi|^2 \phi + \mu^* |\phi|^2 \phi^*$$


$\mu |\phi|^2 \phi + \mu^* |\phi|^2 \phi^*$

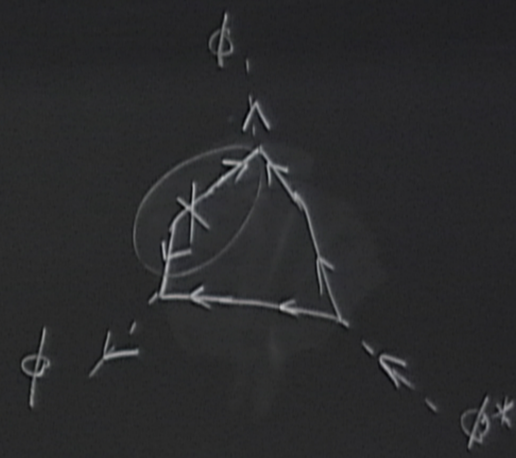


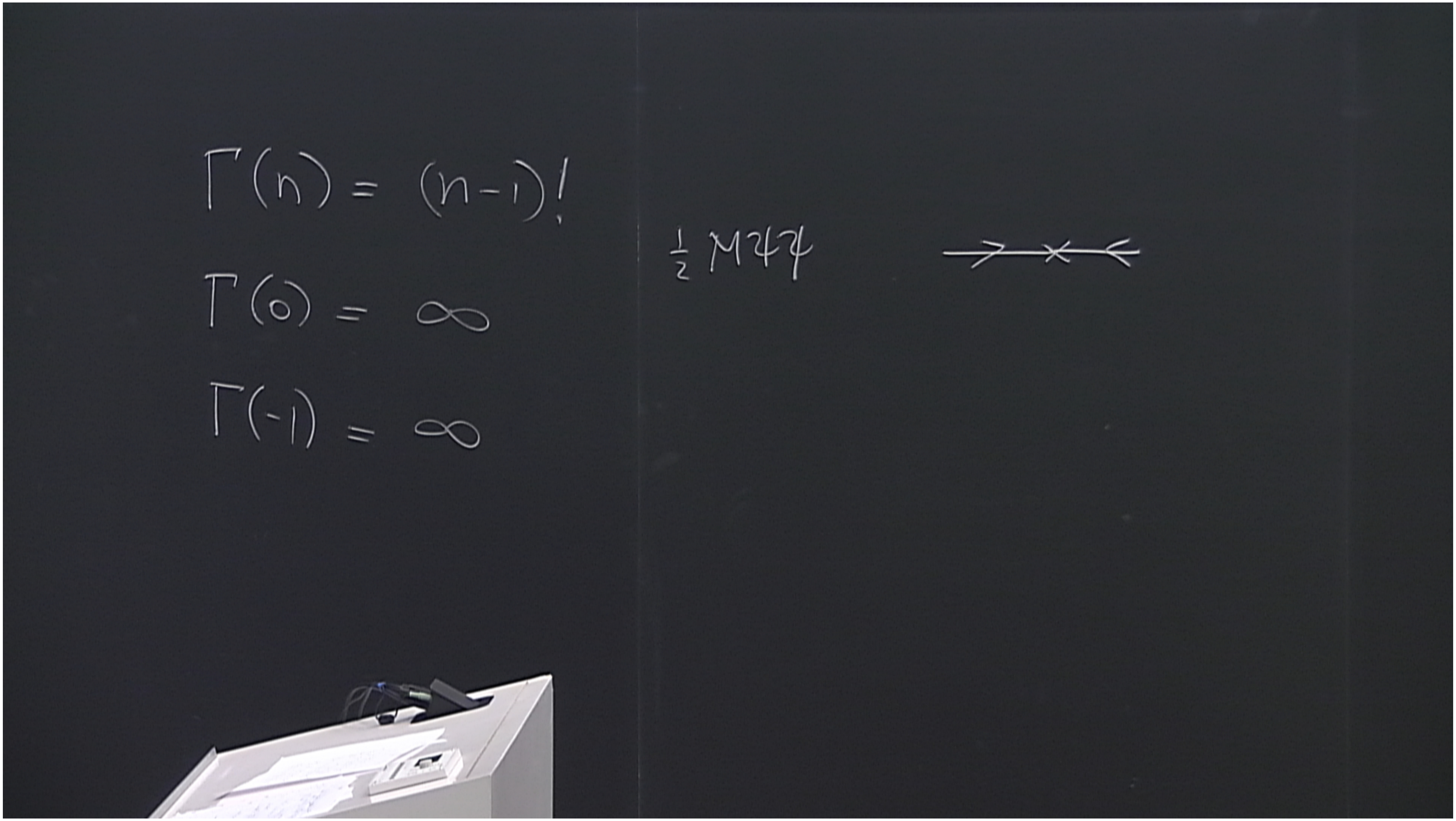
$|\phi|^2 \phi + \mu^* |\phi|^2 \phi^*$
$\phi\phi$


$\mu |\phi|^2 \phi + \mu^*$
ϕ^*
$\phi\phi^*$
ϕ
ϕ
ϕ^*

$$\mu\,|\phi|^2\phi + \mu^*\,|\phi|^2\phi^*$$

$$\phi\phi^*$$




$\Gamma(n) = (n-1)!$
$\Gamma(0) = \infty$
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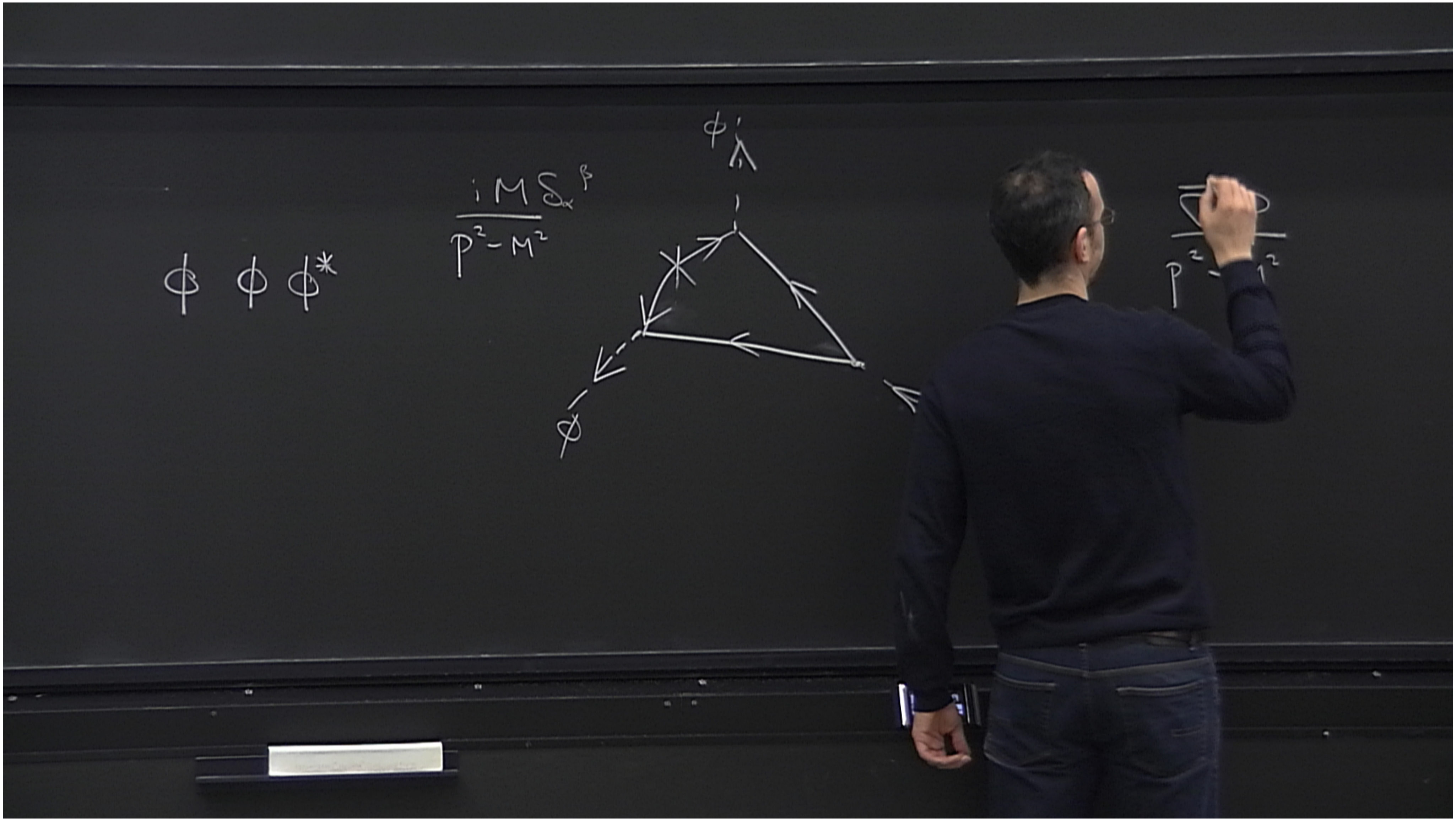
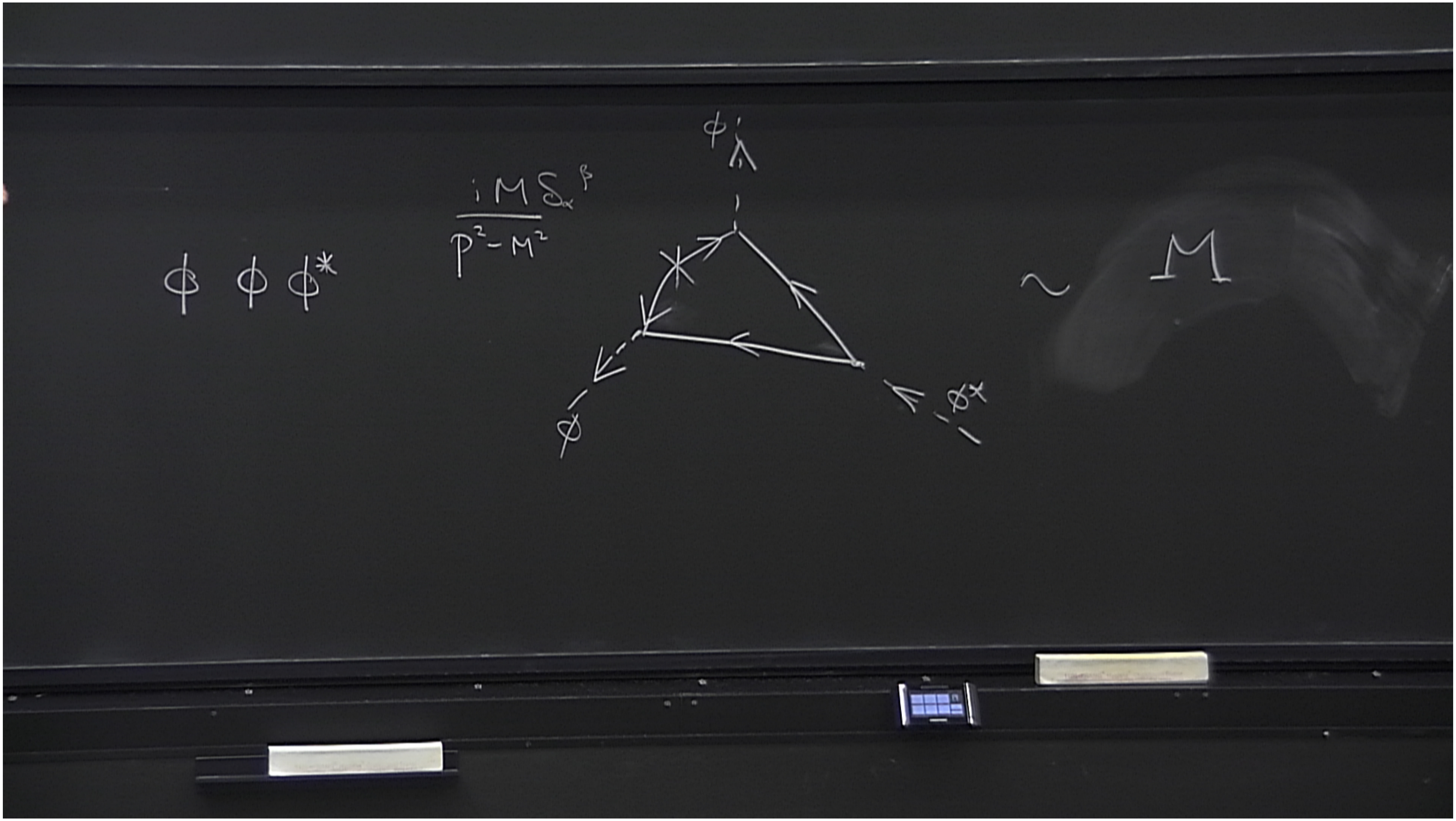
$\frac{1}{2} M \psi \psi$



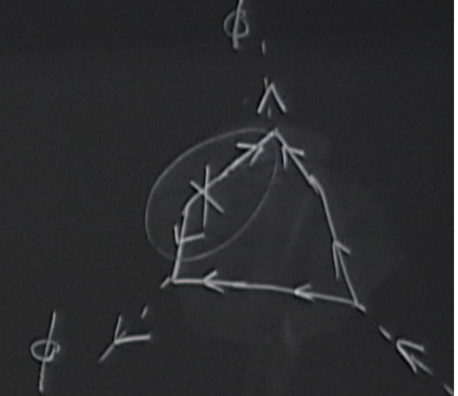
$\phi \quad \phi \quad \phi^*$
$\frac{iM\delta_\alpha^\beta}{p^2-M^2}$
ϕ'
ϕ


$\phi \ \phi \ \phi^*$
$\frac{iM\delta_\alpha{}^\beta}{p^2 - M^2}$
ϕ'
ϕ
ϕ^*
$\sim M$

$$\mu |\phi|^2 \phi + \mu^* |\phi|^2 \phi^*$$

$$\phi \phi^*$$

$$\phi \to e^{2i\theta} \phi$$



$$\mathcal{L} = \underset{\underset{\frac{1}{2} M \psi\psi}{\parallel}}{k.T.} + \frac{1}{2} y \overset{e^{i\theta}}{\psi}\overset{e^{i\theta}}{\psi}\overset{e^{-2i\theta}}{\phi^*} + h.c.$$

$$\frac{1}{2} M \psi\psi \qquad + \frac{\lambda}{4} |\phi\phi^*|^2$$

$$e^{i\theta} e^{i\theta}$$

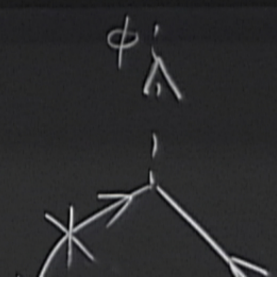
$$\psi \to e^{i\theta}\psi$$

$$\phi \to e^{2i\theta}\phi$$

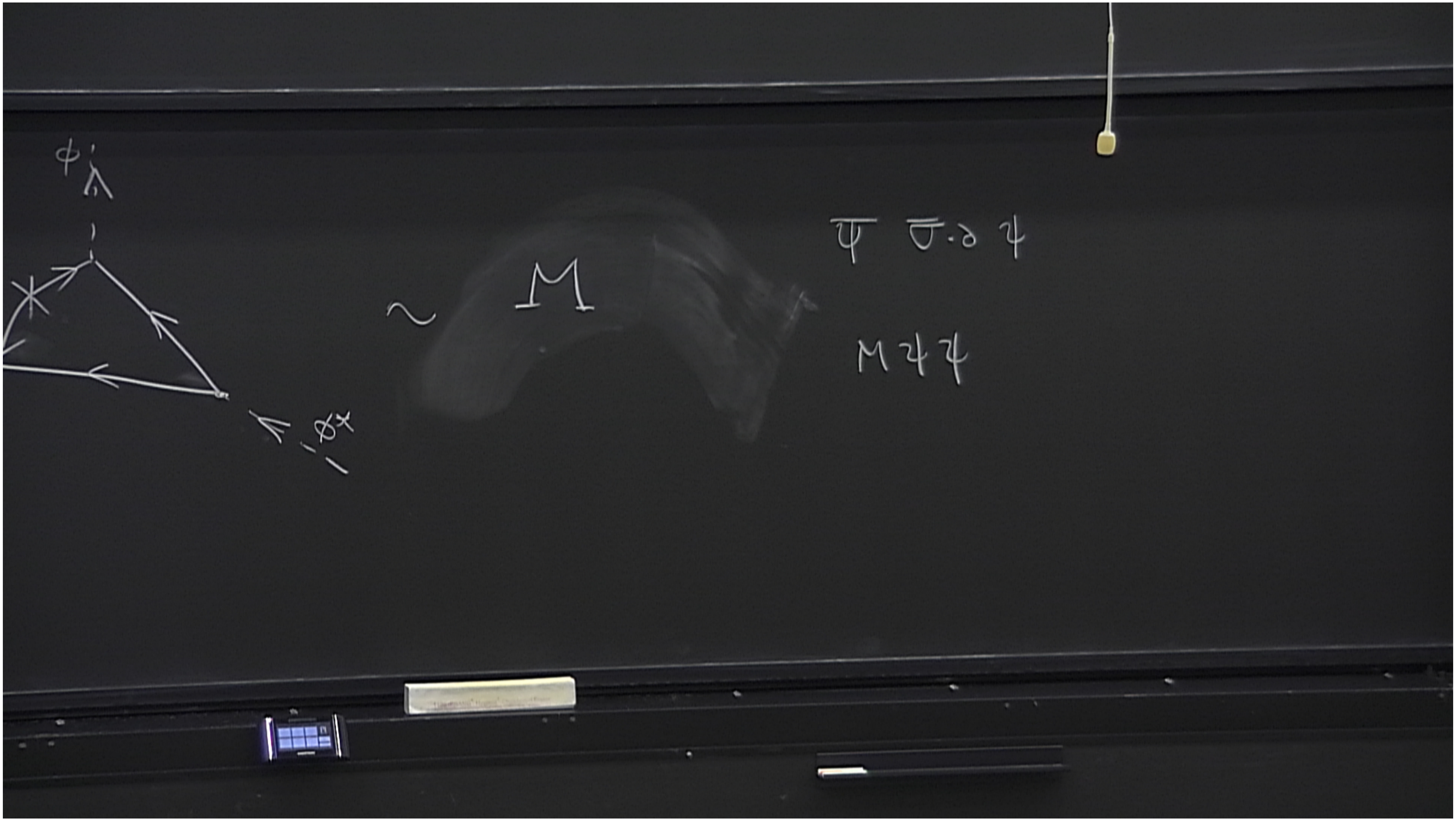
$$\psi \not\to \text{anything}$$

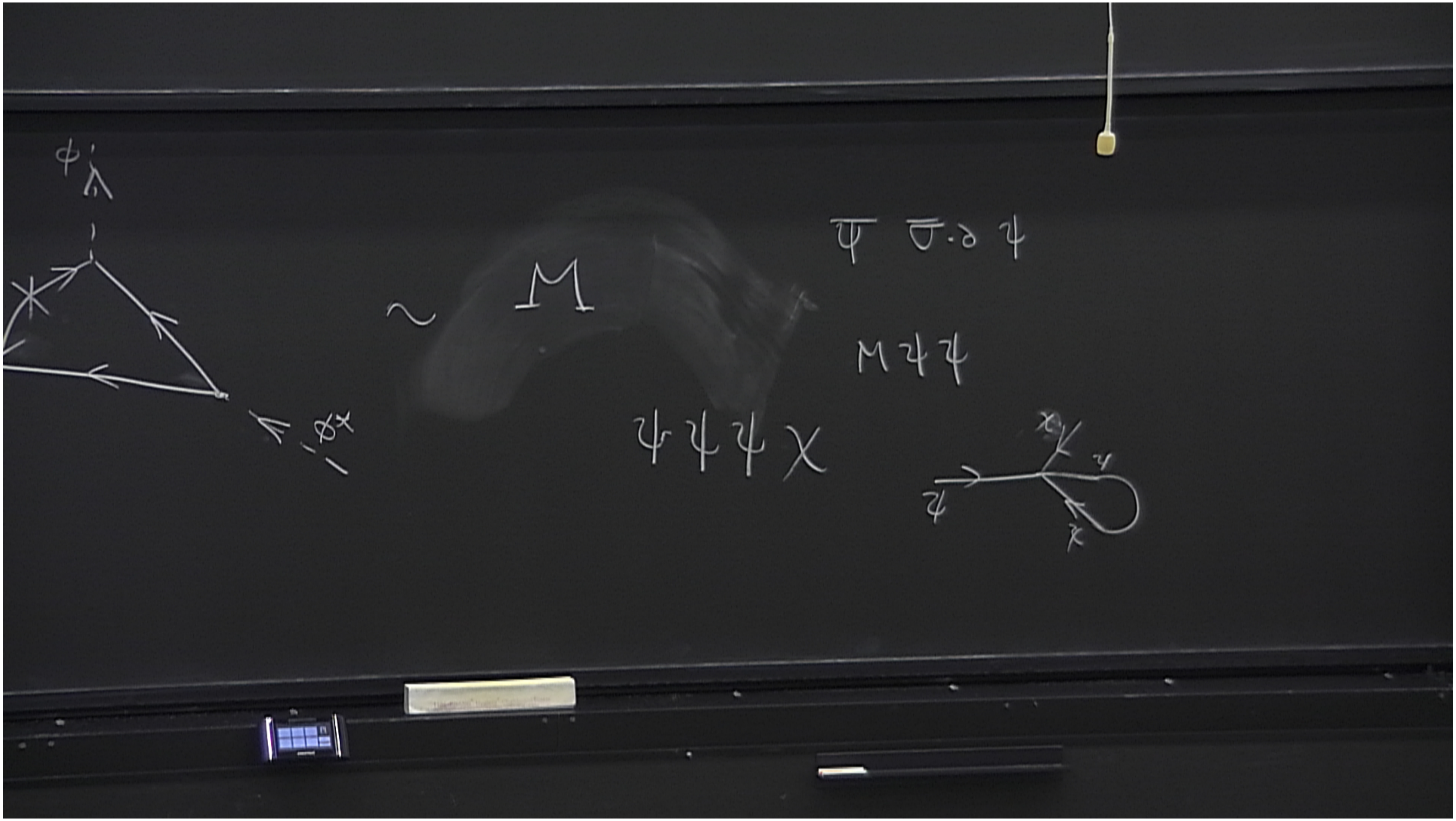
ϕ^*

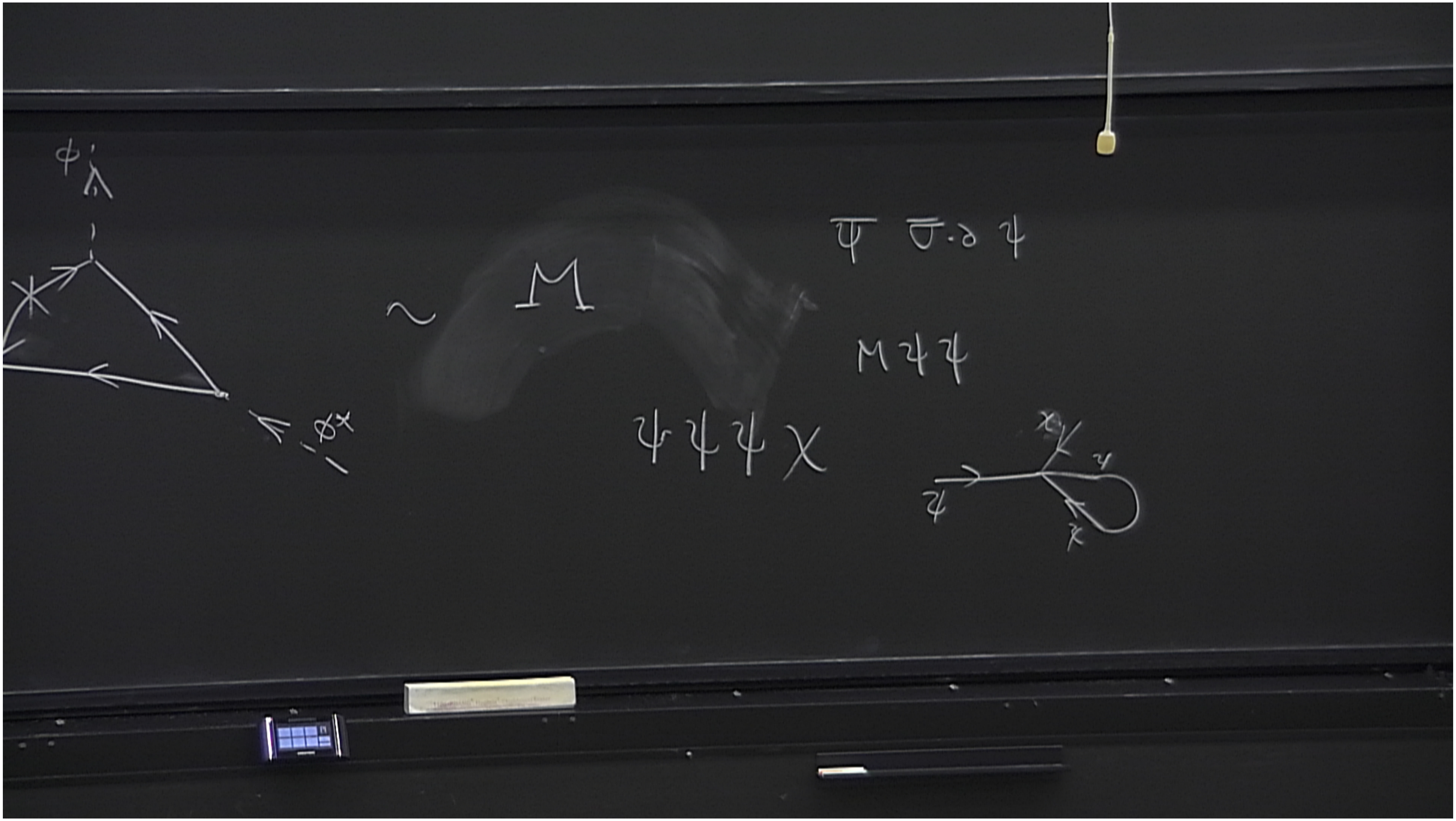
$$\frac{iM\delta_\alpha{}^\beta}{p^2 - M^2}$$



$\sim M$


$\sim M$
$\bar{\psi}\,\bar{\sigma}\cdot\partial\,\psi$
$M\psi\psi$


~ M
$\bar{\Psi}\,\bar{\sigma}\cdot\partial\,\psi$
$M\psi\psi$
$\psi\psi\psi\chi$


~ M
ψ̄ σ̄·∂ ψ
M ψ ψ
ψ ψ ψ χ