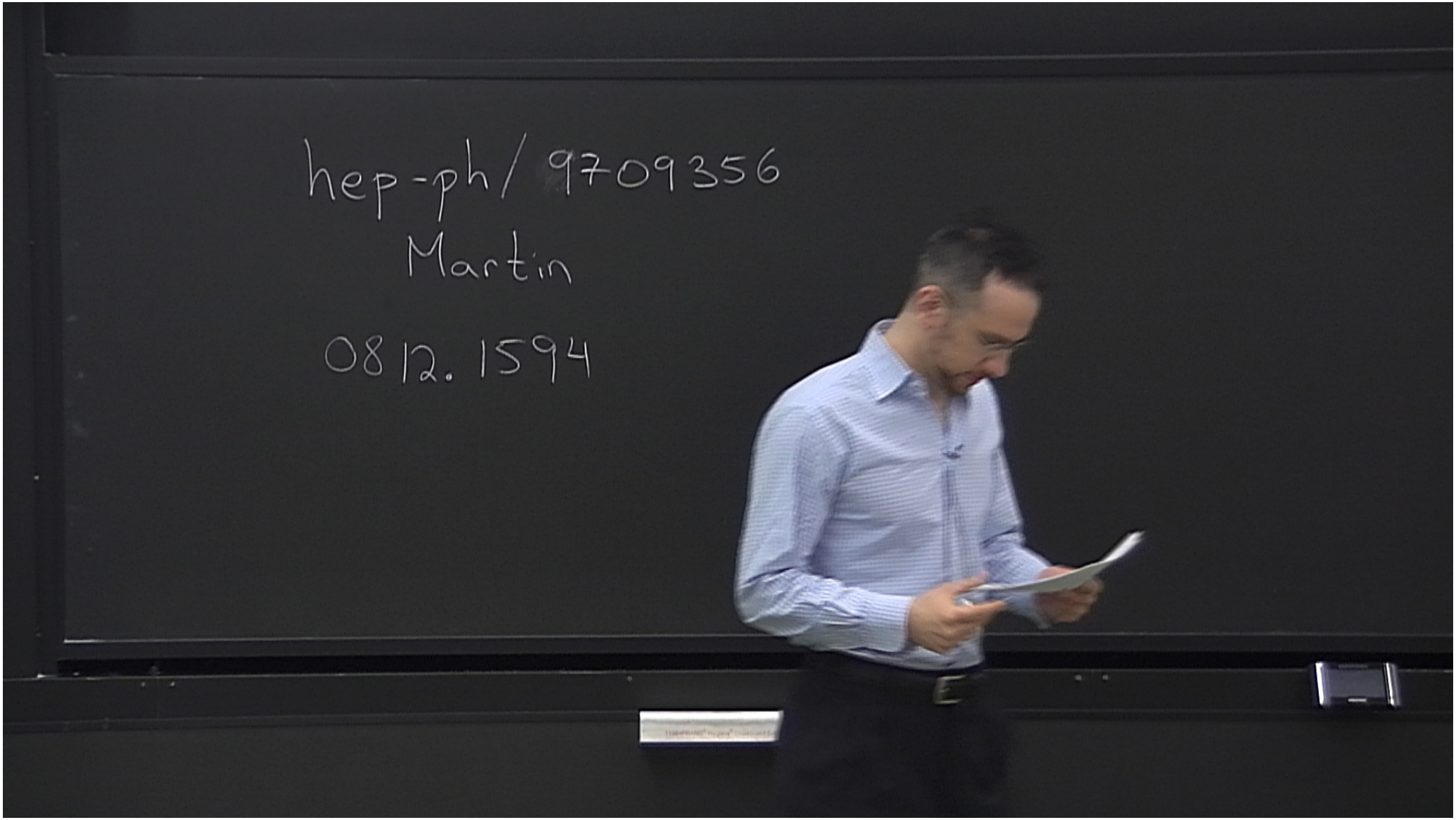
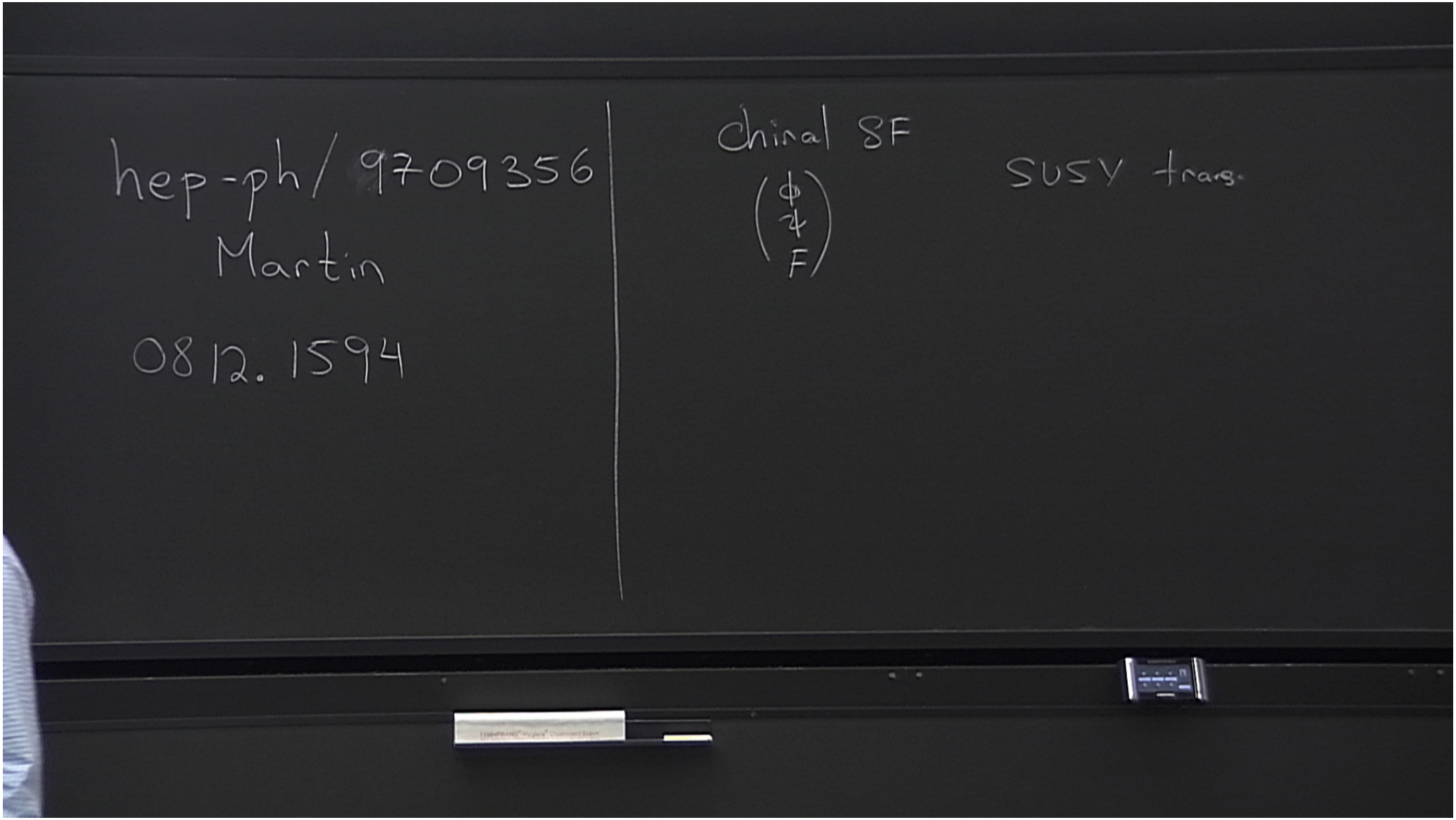
Title: 12/13 PSI - Beyond the Standard Model Lecture 6

Date: Feb 26, 2013 09:00 AM

URL: http://www.pirsa.org/13020096

Abstract:


hep-ph/9709356
Martin
0812.1594


hep-ph/ 9709356
Martin
0812.1594
Chiral SF
$\begin{pmatrix} \phi \\ \psi \\ F \end{pmatrix}$
SUSY trans.

$1 + i\theta$

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

$\boxed{\delta\phi \to \phi \, i\theta}$

$= \phi_{new} - \phi_{old} = e^{i\theta}\phi_{old} - \phi_{old}$

356

Chiral SF

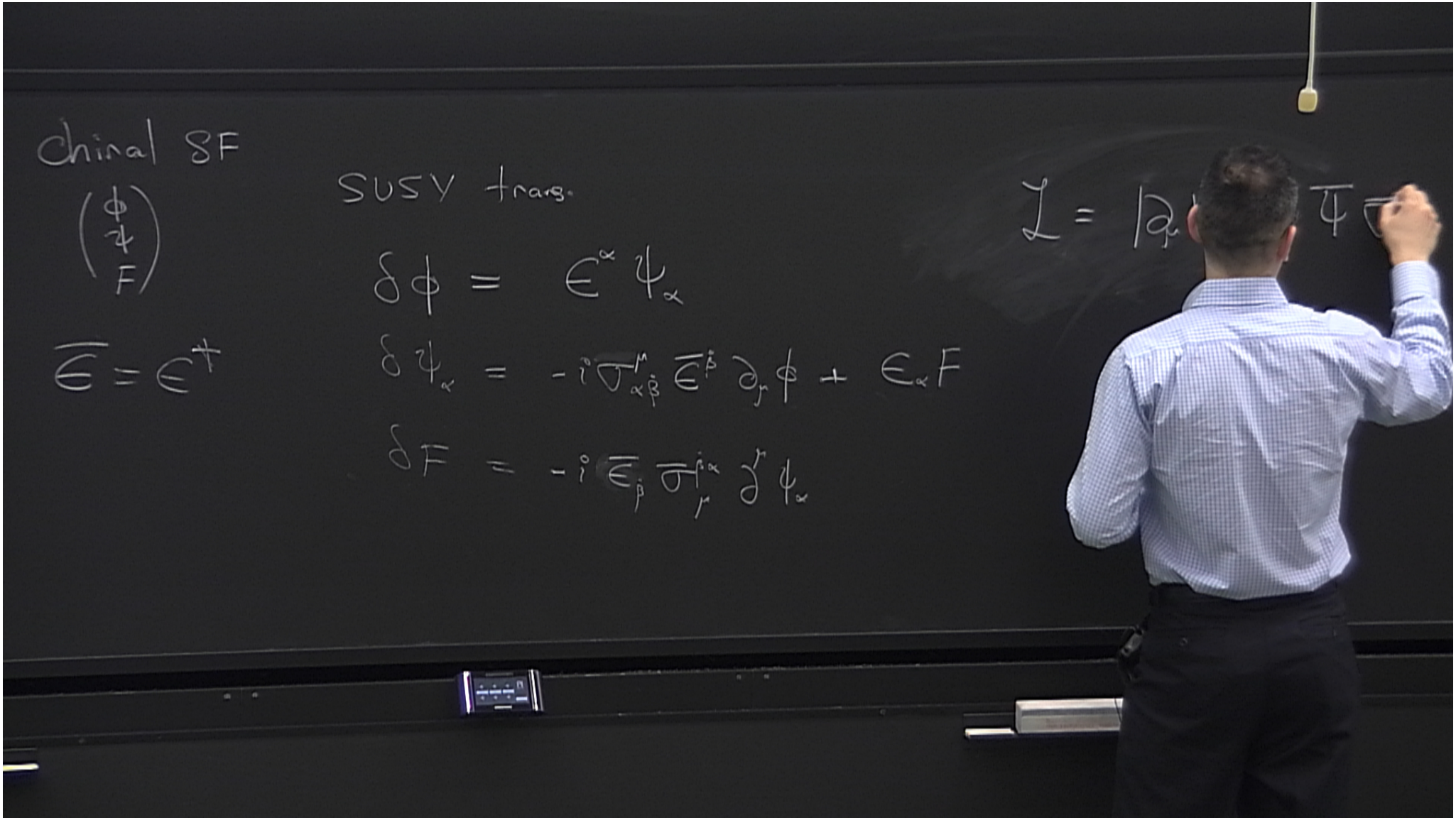
$\begin{pmatrix} \phi \\ \psi \\ F \end{pmatrix}$

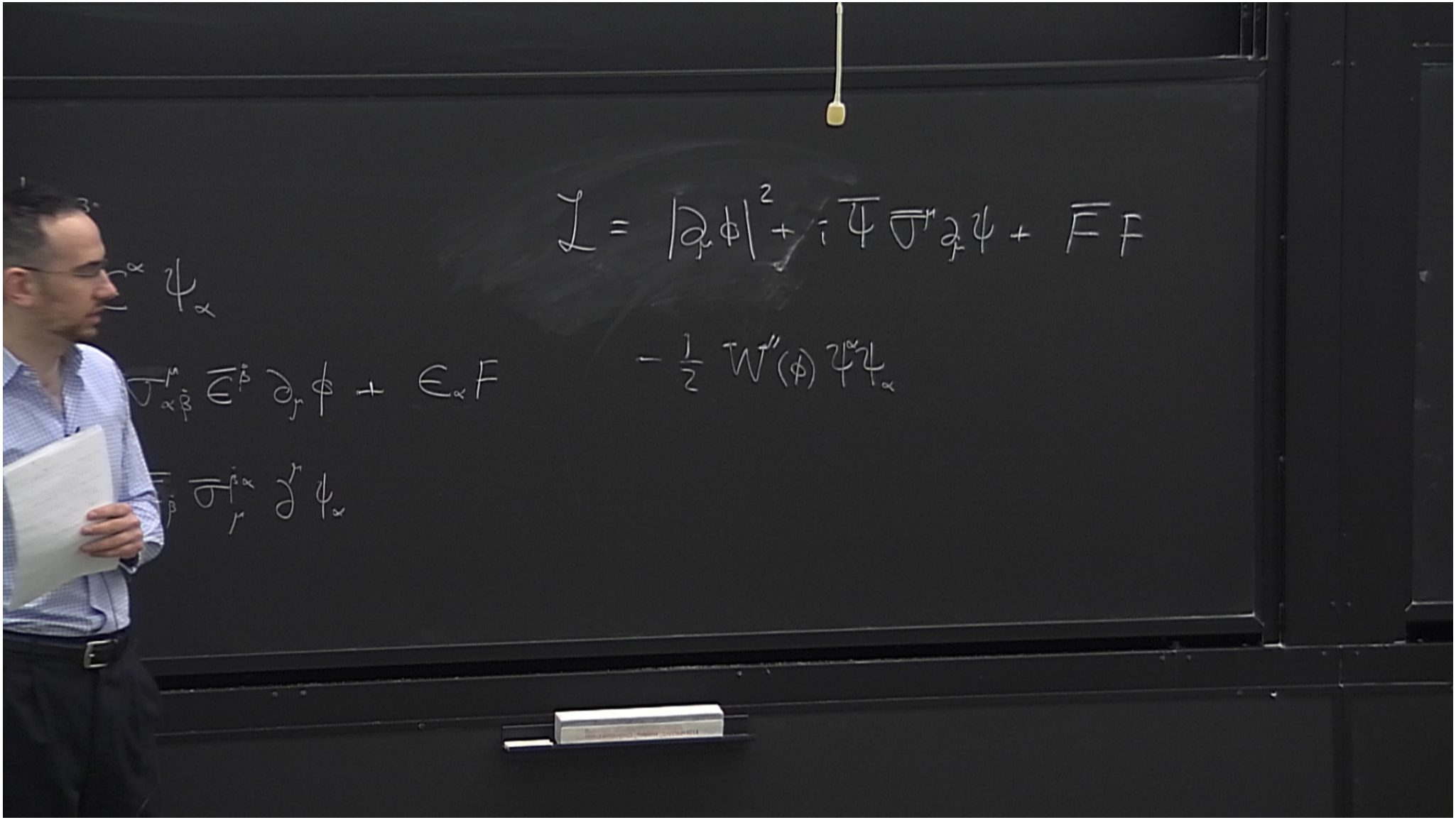
SUSY trans.

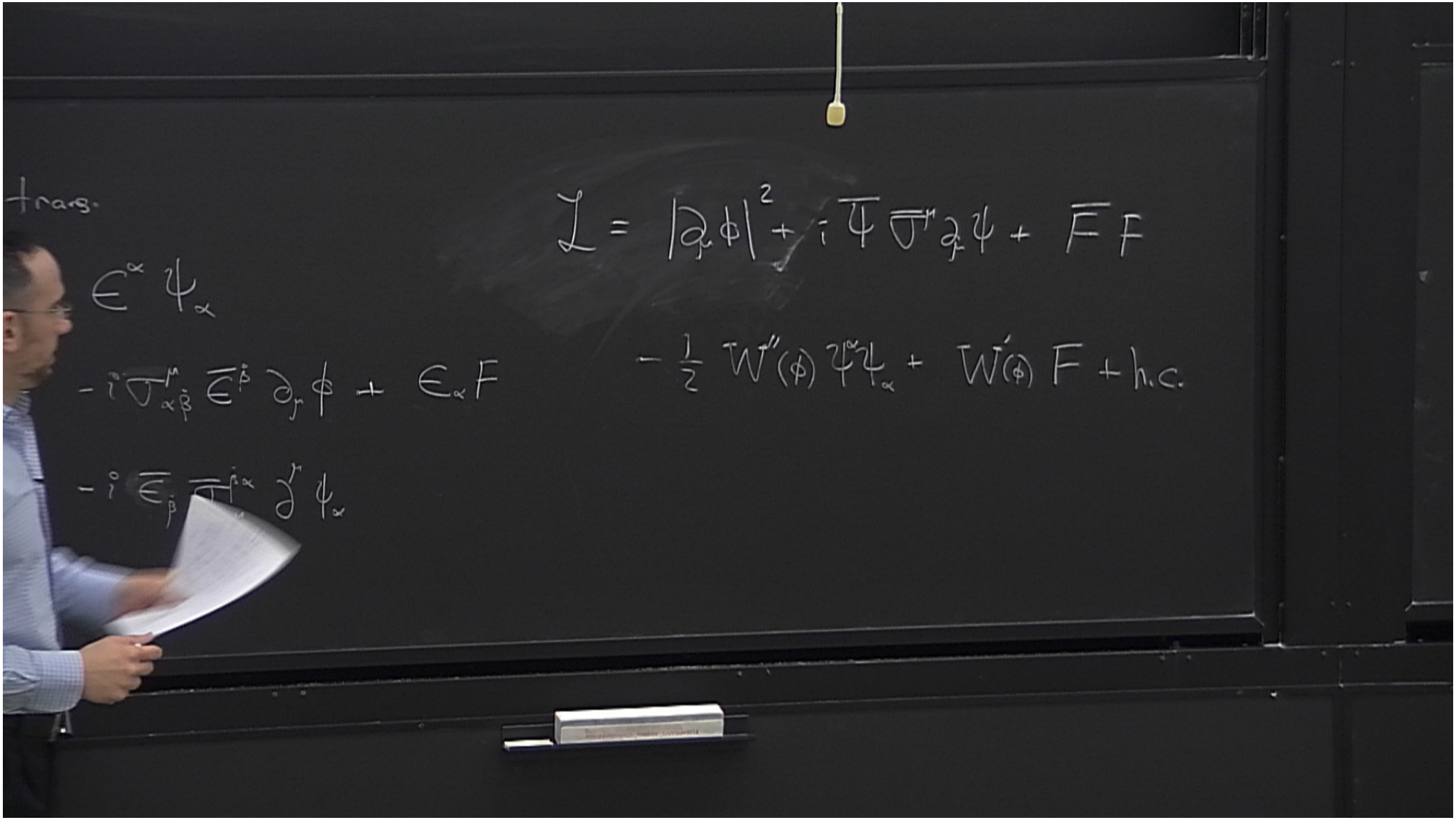
$$\delta\phi = \epsilon^\alpha \psi_\alpha$$

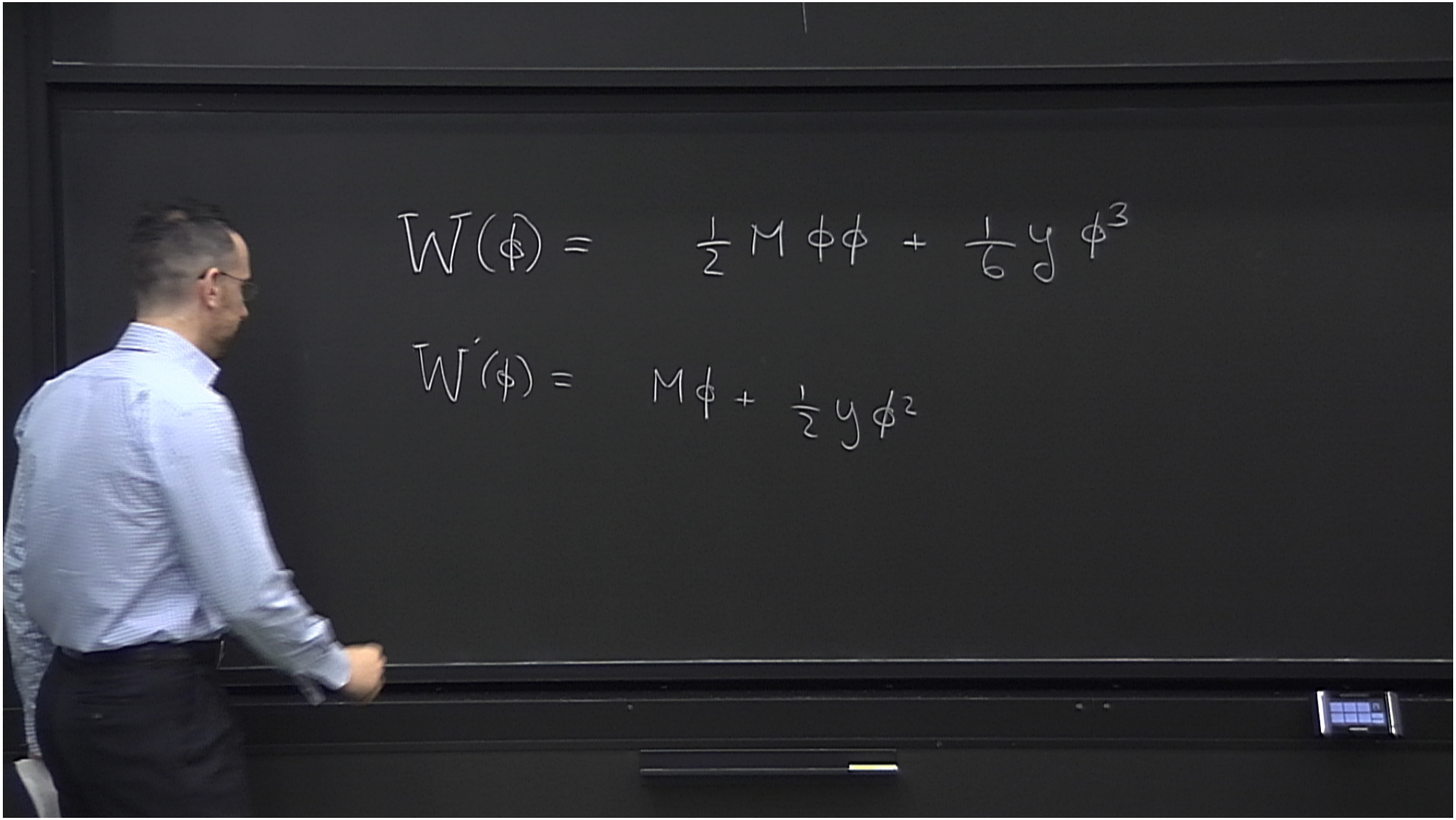
$$\delta\psi_\alpha = -i\sigma^\mu_{\alpha\dot\beta}\bar\epsilon^{\dot\beta}\partial_\mu\phi + \epsilon_\alpha F$$

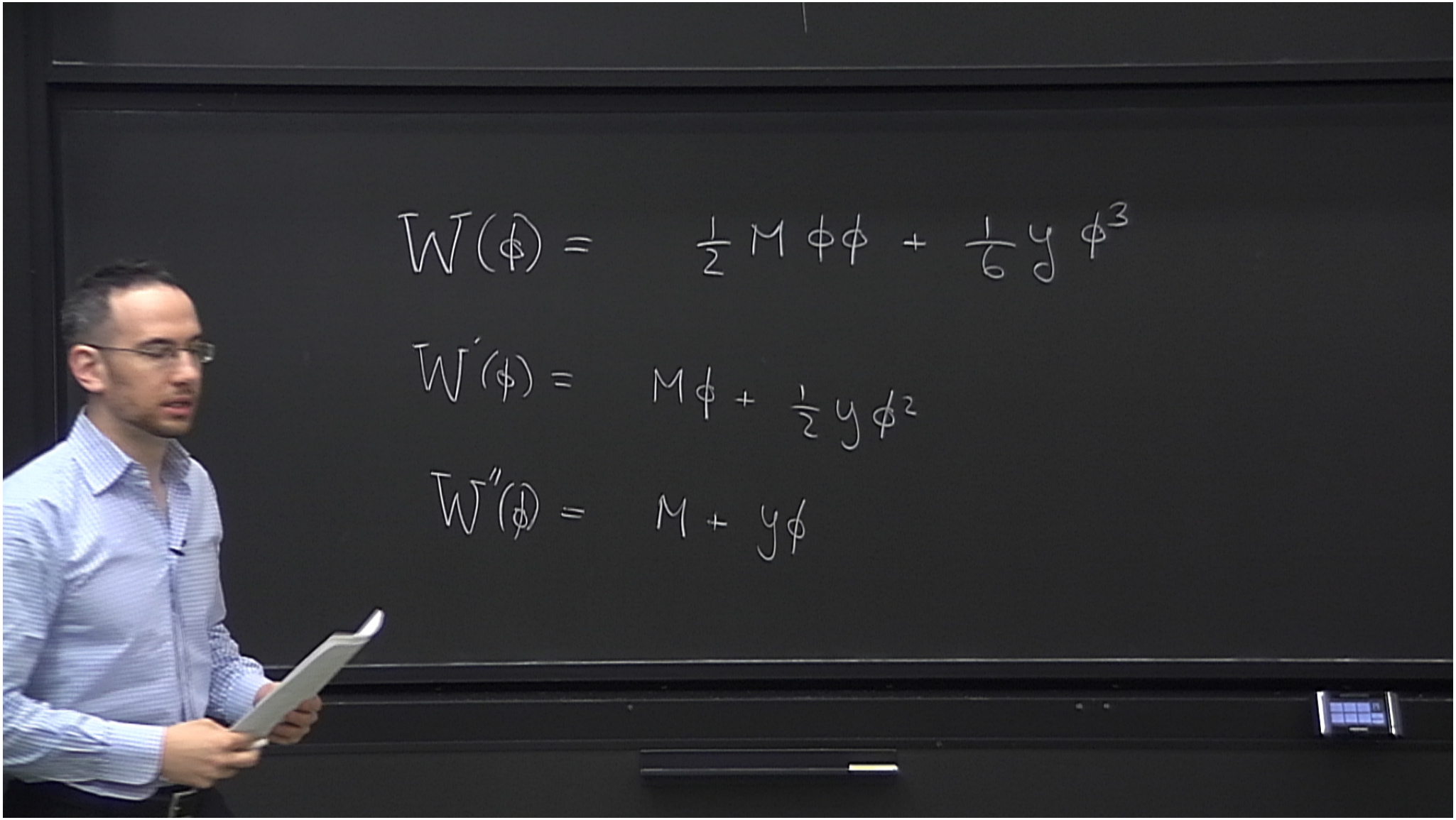
$$\delta F = -i\bar\epsilon_{\dot\beta}\bar\sigma^{\dot\beta\alpha}_{\mu}\partial^\mu\psi_\alpha$$


Chiral SF
$\begin{pmatrix} \phi \\ \psi \\ F \end{pmatrix}$
$\bar{\epsilon} = \epsilon^\dagger$
SUSY trans.
$\delta\phi = \epsilon^\alpha \psi_\alpha$
$\delta\psi_\alpha = -i\sigma^\mu_{\alpha\dot{\beta}} \bar{\epsilon}^{\dot{\beta}} \partial_\mu \phi + \epsilon_\alpha F$
$\delta F = -i \bar{\epsilon}_{\dot{\beta}} \bar{\sigma}^{\dot{\beta}\alpha}_{\mu} \partial^\mu \psi_\alpha$
$\mathcal{L} = |\partial$
ψ


$\mathcal{L} = |\partial_\mu \phi|^2 + i\bar{\psi}\bar{\sigma}^\mu \partial_\mu \psi + \bar{F}F$
ψ_α
$\epsilon_\alpha F$
$-\frac{1}{2} W''(\phi)\psi\psi$


trans.
$\mathcal{L} = |\partial_\mu \phi|^2 + i\bar{\psi}\bar{\sigma}^\mu \partial_\mu \psi + \bar{F}F$
$\epsilon^\alpha \psi_\alpha$
$-i\sigma^\mu_{\alpha\dot{\beta}} \bar{\epsilon}^{\dot{\beta}} \partial_\mu \phi + \epsilon_\alpha F$
$-\frac{1}{2} W''(\phi) \psi^\alpha \psi_\alpha + W'(\phi) F + h.c.$
$-i \epsilon_\beta \bar{\sigma}^{\mu\dot{\alpha}} \partial_\mu \psi_\alpha$

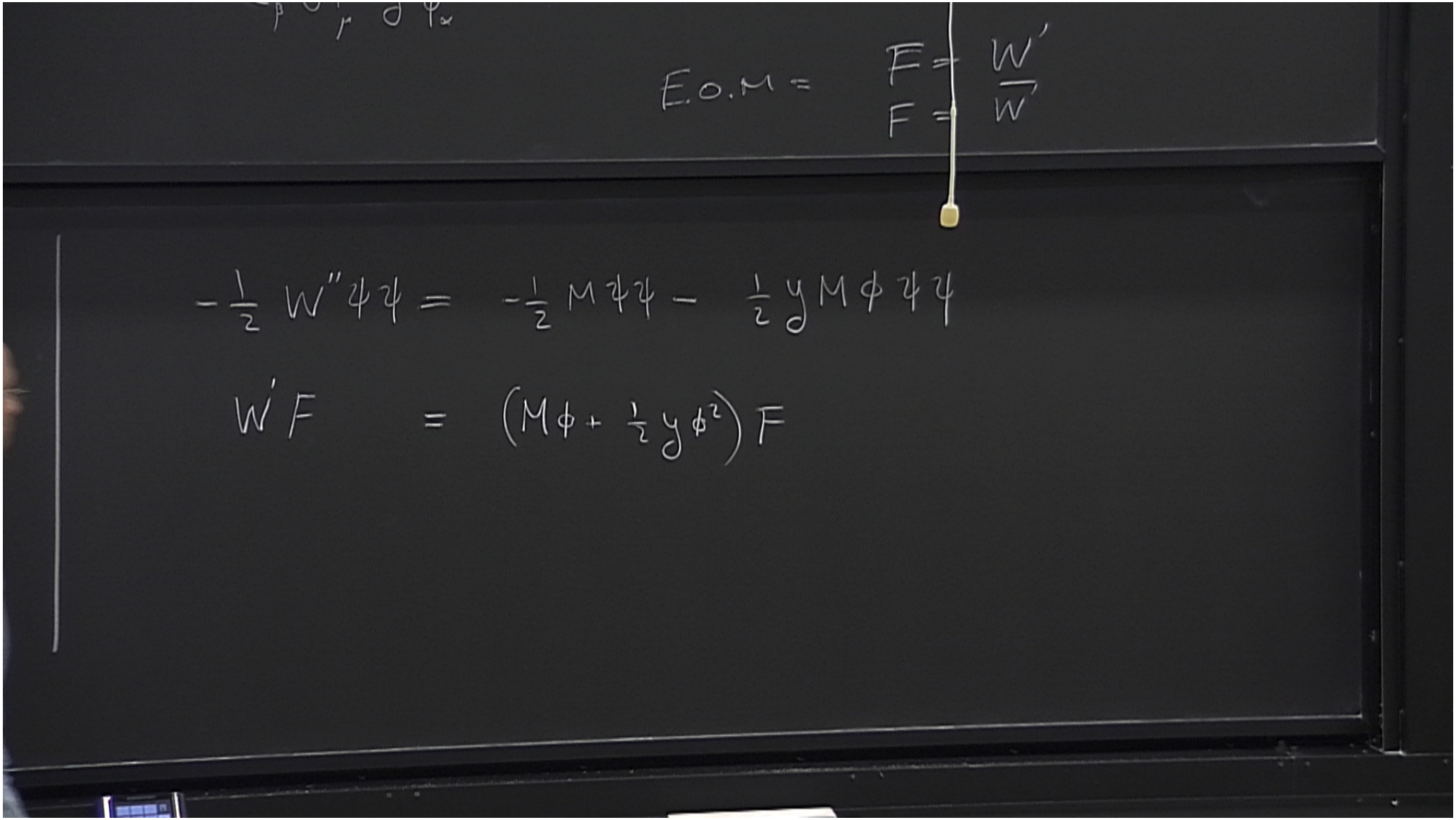

$W(\phi) = \frac{1}{2} M \phi\phi + \frac{1}{6} y \phi^3$
$W'(\phi) = M\phi + \frac{1}{2} y \phi^2$

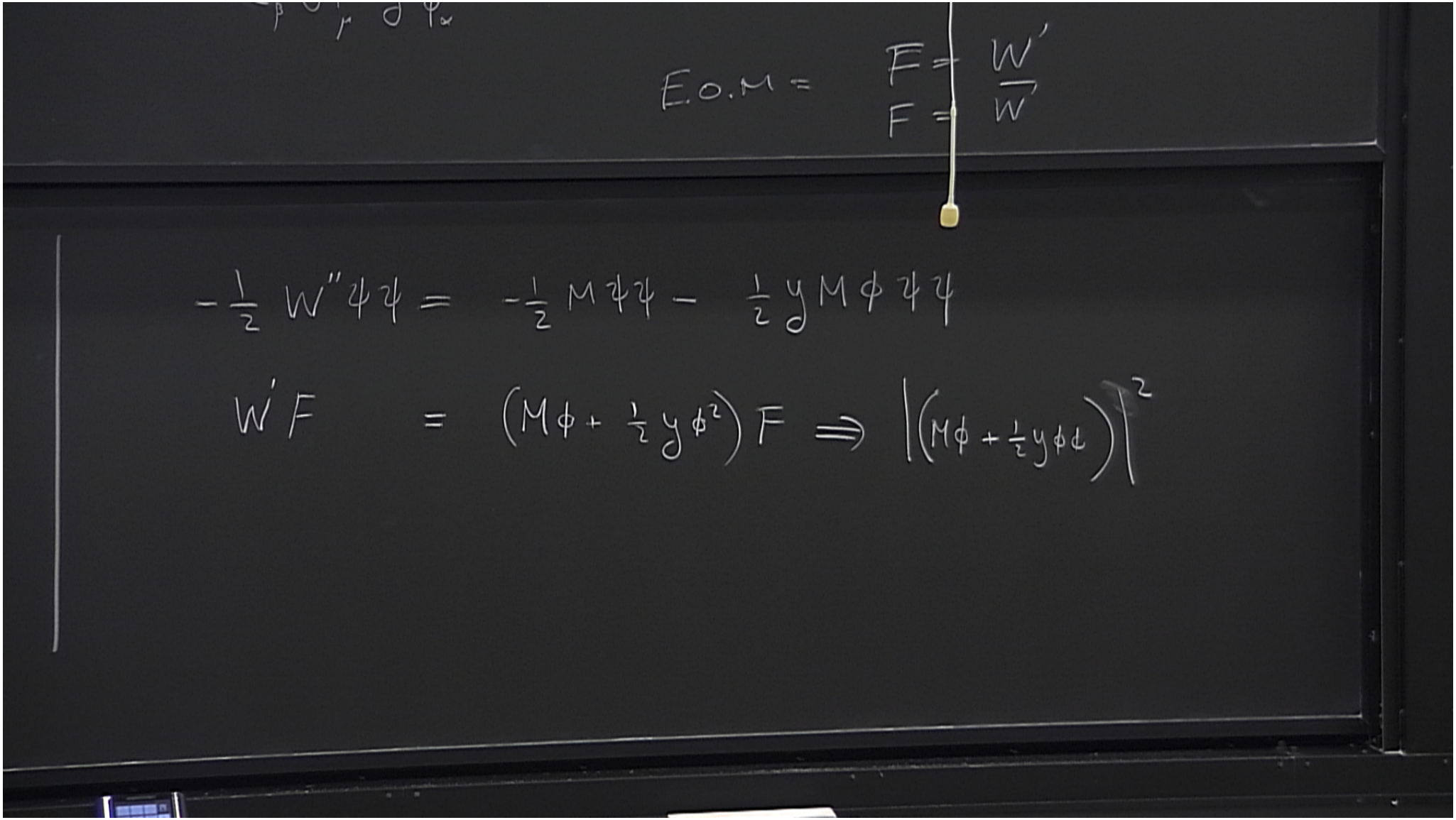

$W(\phi) = \frac{1}{2} M \phi\phi + \frac{1}{6} y \phi^3$
$W'(\phi) = M\phi + \frac{1}{2} y \phi^2$
$W''(\phi) = M + y\phi$

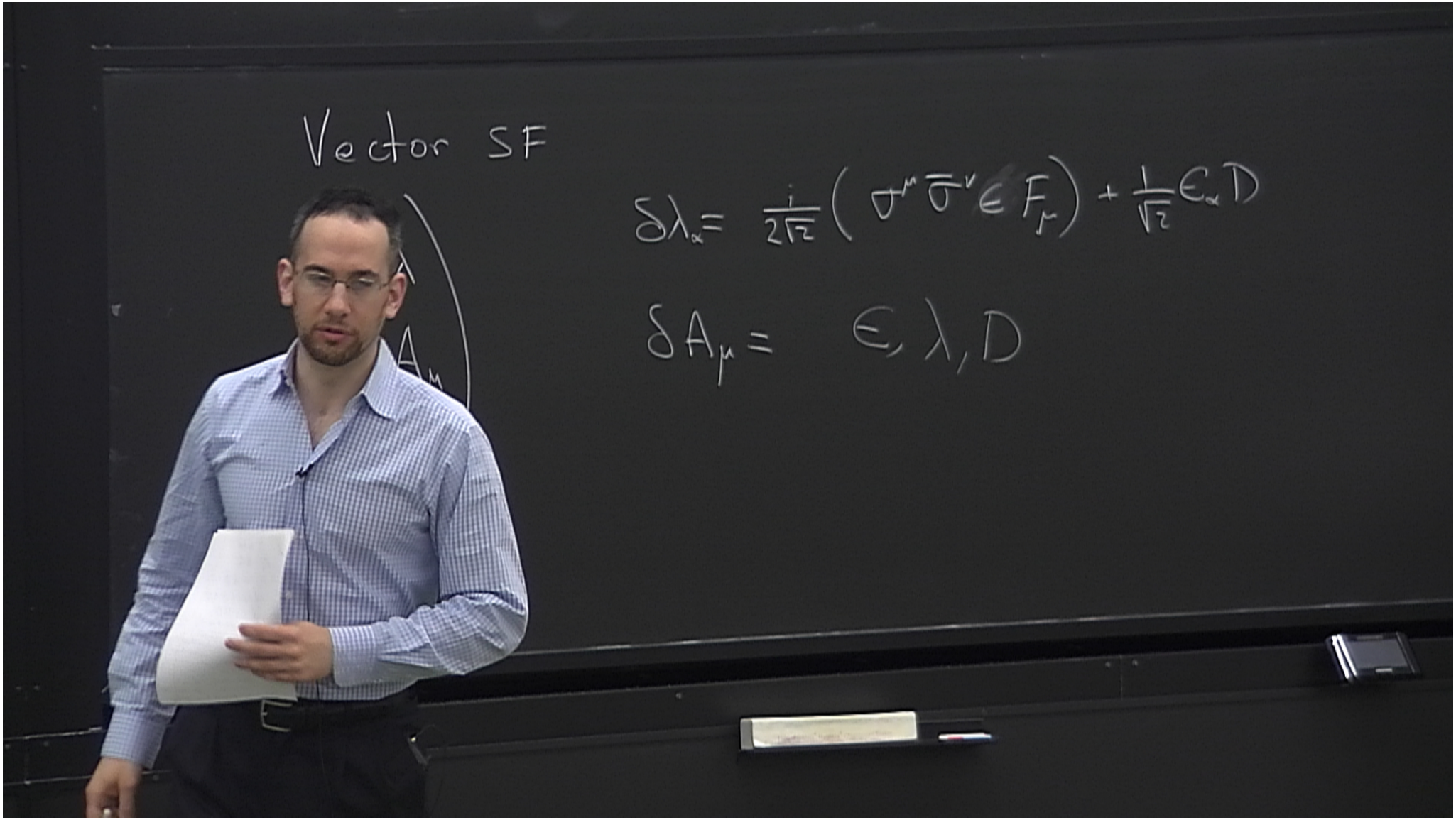
$\frac{1}{6} y \phi^3$

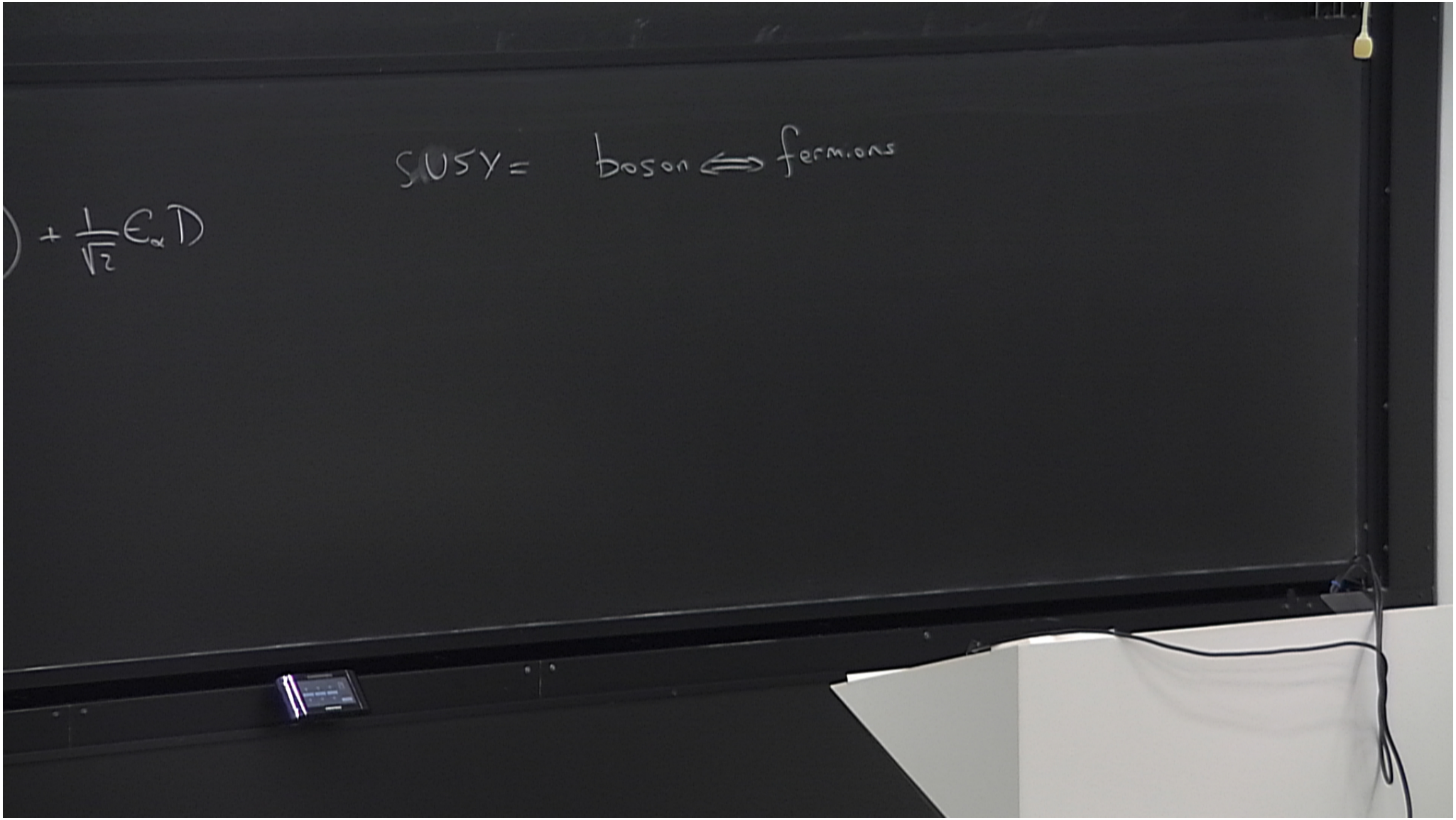
$$-\frac{1}{2} W'' \psi\psi = -\frac{1}{2} M \psi\psi - \frac{1}{2} y M \phi \psi\psi$$

$$W' F = \left(M\phi + \frac{1}{2} y \phi^2\right) F$$


E.O.M =
F = W'
F = W'
$-\frac{1}{2} W'' \psi\psi = -\frac{1}{2} M \psi\psi - \frac{1}{2} y M \phi \psi\psi$
$W' F = \left(M\phi + \frac{1}{2} y \phi^2\right) F$


E.O.M =
F = W'
F = W'
$-\frac{1}{2} W'' \psi\psi = -\frac{1}{2} M \psi\psi - \frac{1}{2} y M \phi \psi\psi$
$W' F = (M\phi + \frac{1}{2} y \phi^2) F \Rightarrow |(M\phi + \frac{1}{2} y \phi^2)|^2$


Vector SF
$\delta\lambda_\alpha = \frac{i}{2\sqrt{2}}(\sigma^\mu\bar{\sigma}^\nu\epsilon F_{\mu\nu}) + \frac{1}{\sqrt{2}}\epsilon_\alpha D$
$\delta A_\mu = \epsilon\lambda, D$


SUSY = boson ⟺ fermions
$+\frac{1}{\sqrt{2}}\epsilon_\alpha D$

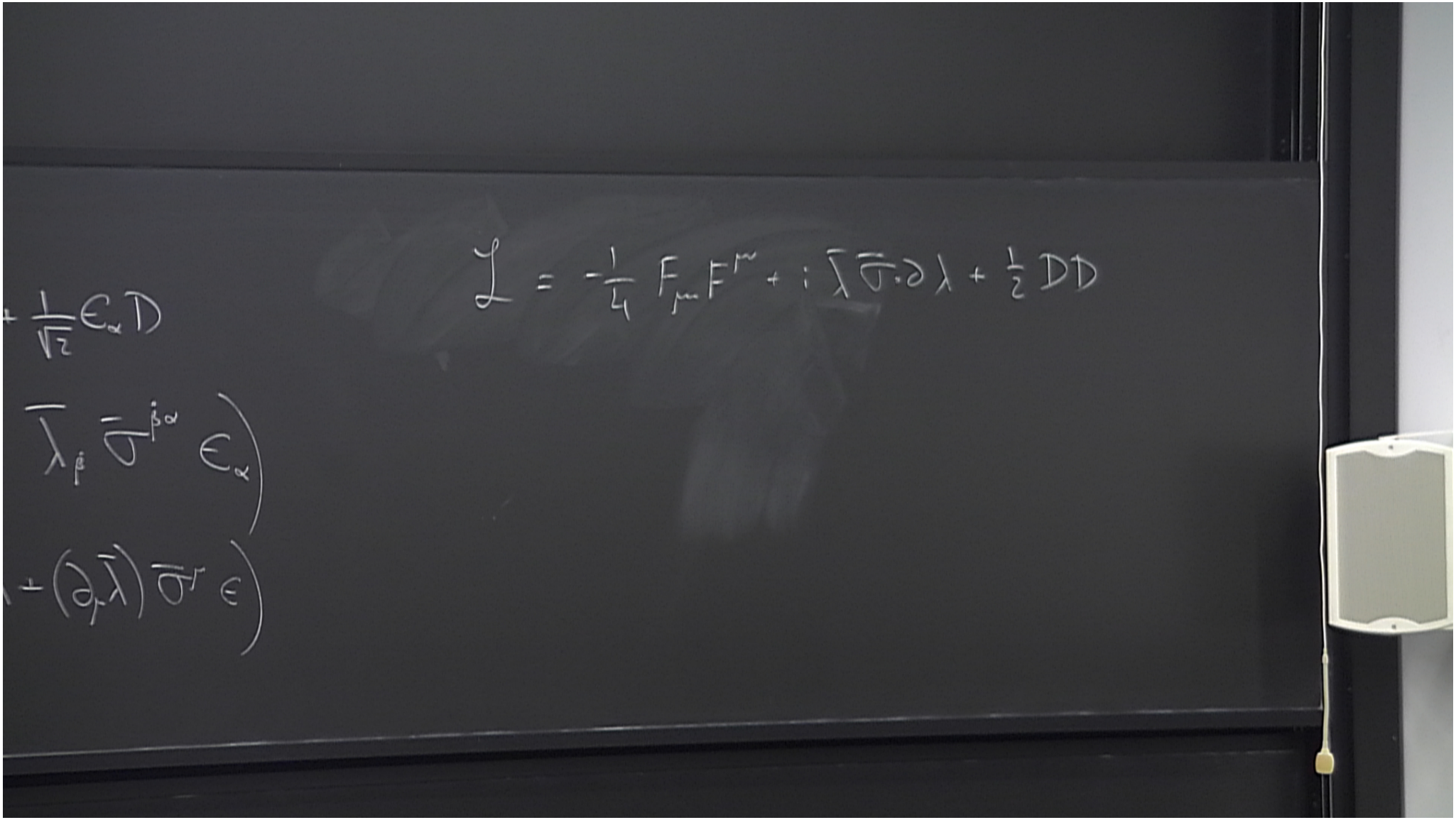
Vector SF

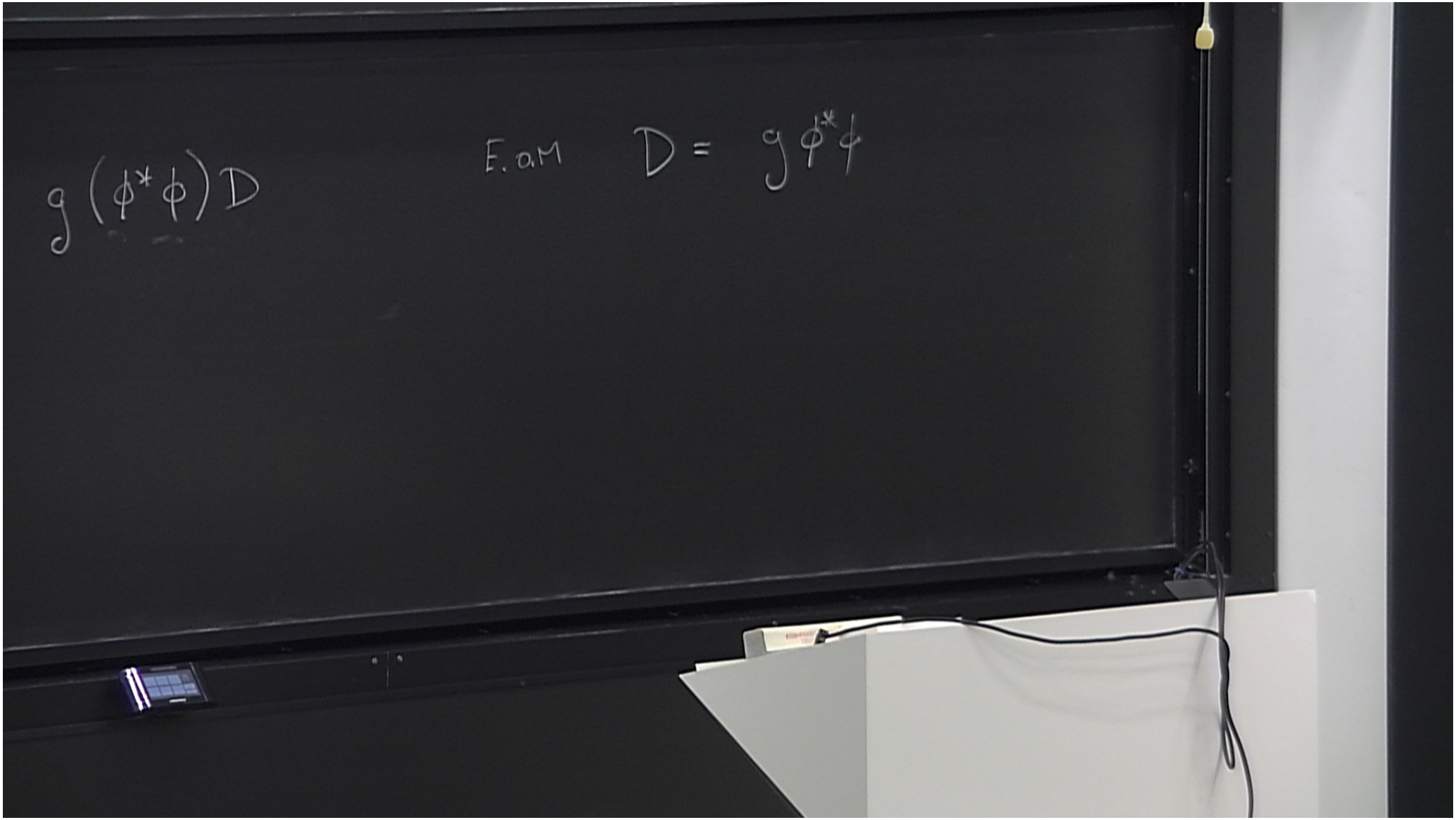
$$\begin{pmatrix} \lambda \\ A_\mu \\ D \end{pmatrix}$$

$$\delta\lambda_\alpha = \frac{i}{2\sqrt{2}}\left(\sigma^\mu\bar{\sigma}^\nu\epsilon F_{\mu\nu}\right) + \frac{1}{\sqrt{2}}\epsilon_\alpha D$$

$$\delta A_\mu = \frac{1}{\sqrt{2}}\left(\bar{\epsilon}_{\dot{\beta}}\bar{\sigma}_\mu^{\dot{\beta}\alpha}\lambda_\alpha + \bar{\lambda}_{\dot{\beta}}\bar{\sigma}^{\dot{\beta}\alpha}\epsilon_\alpha\right)$$

$$\delta D = \frac{i}{\sqrt{2}}\left(-\bar{\epsilon}\bar{\sigma}^\mu\partial_\mu\lambda + (\partial_\mu\bar{\lambda})\bar{\sigma}^\mu\epsilon\right)$$

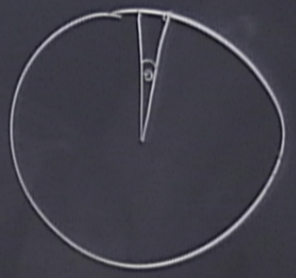

$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + i \bar{\lambda} \bar{\sigma} \cdot \partial \lambda + \frac{1}{2} DD$
$+ \frac{1}{\sqrt{2}} \epsilon_\alpha D$
$\bar{\lambda}_{\dot{\beta}} \bar{\sigma}^{\dot{\beta}\alpha} \epsilon_\alpha$
$+ (\partial_\nu \bar{\lambda}) \bar{\sigma}^\nu \epsilon$


$g(\phi^*\phi)D$
E.o.M
$D = g\phi^*\phi$

$[\phi] = 1$ $[F] = 2$

$[\psi] = 3/2$ $[D] = 2$

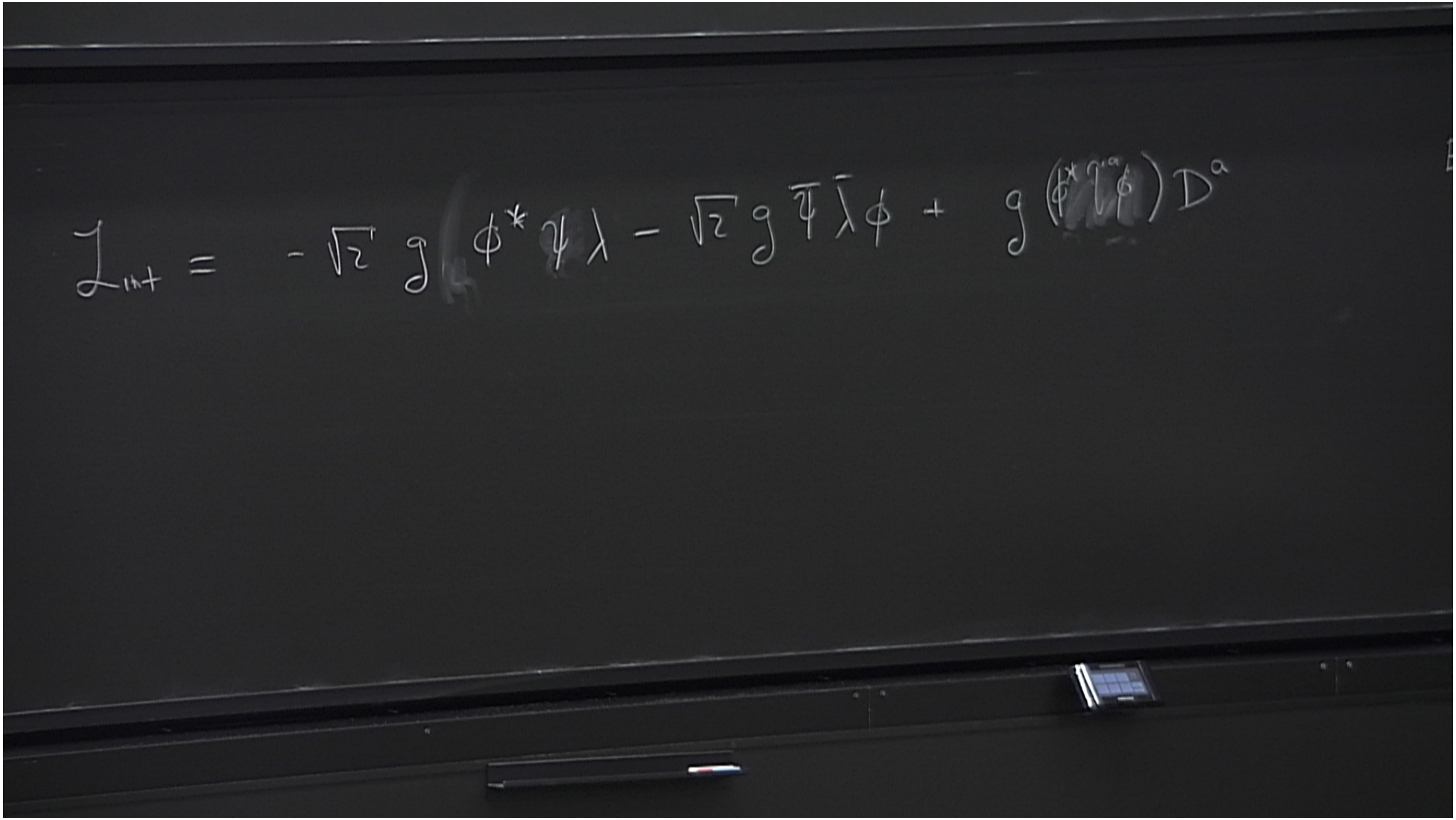
$[A] = 1$ $[\epsilon] = -1/2$

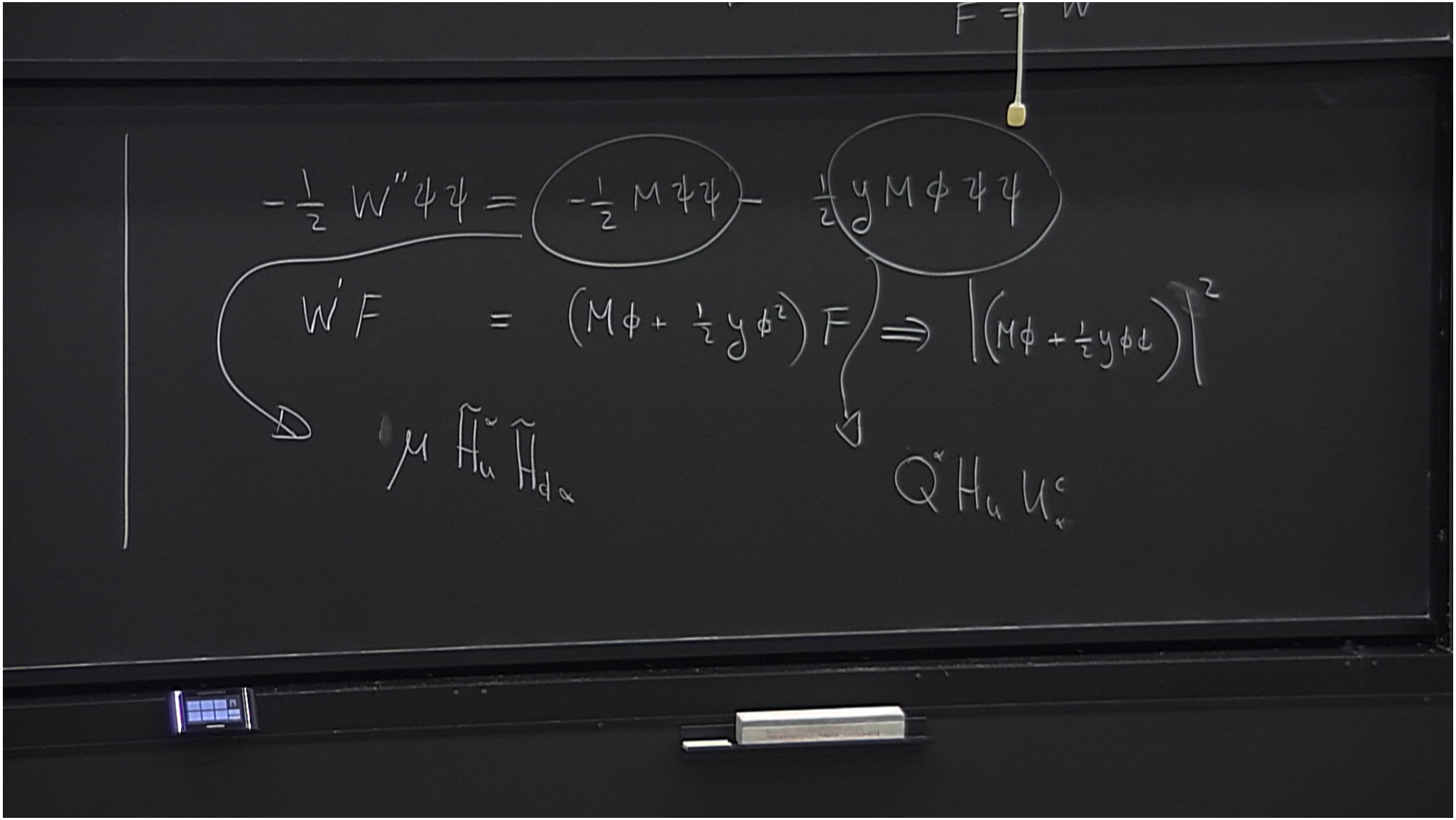


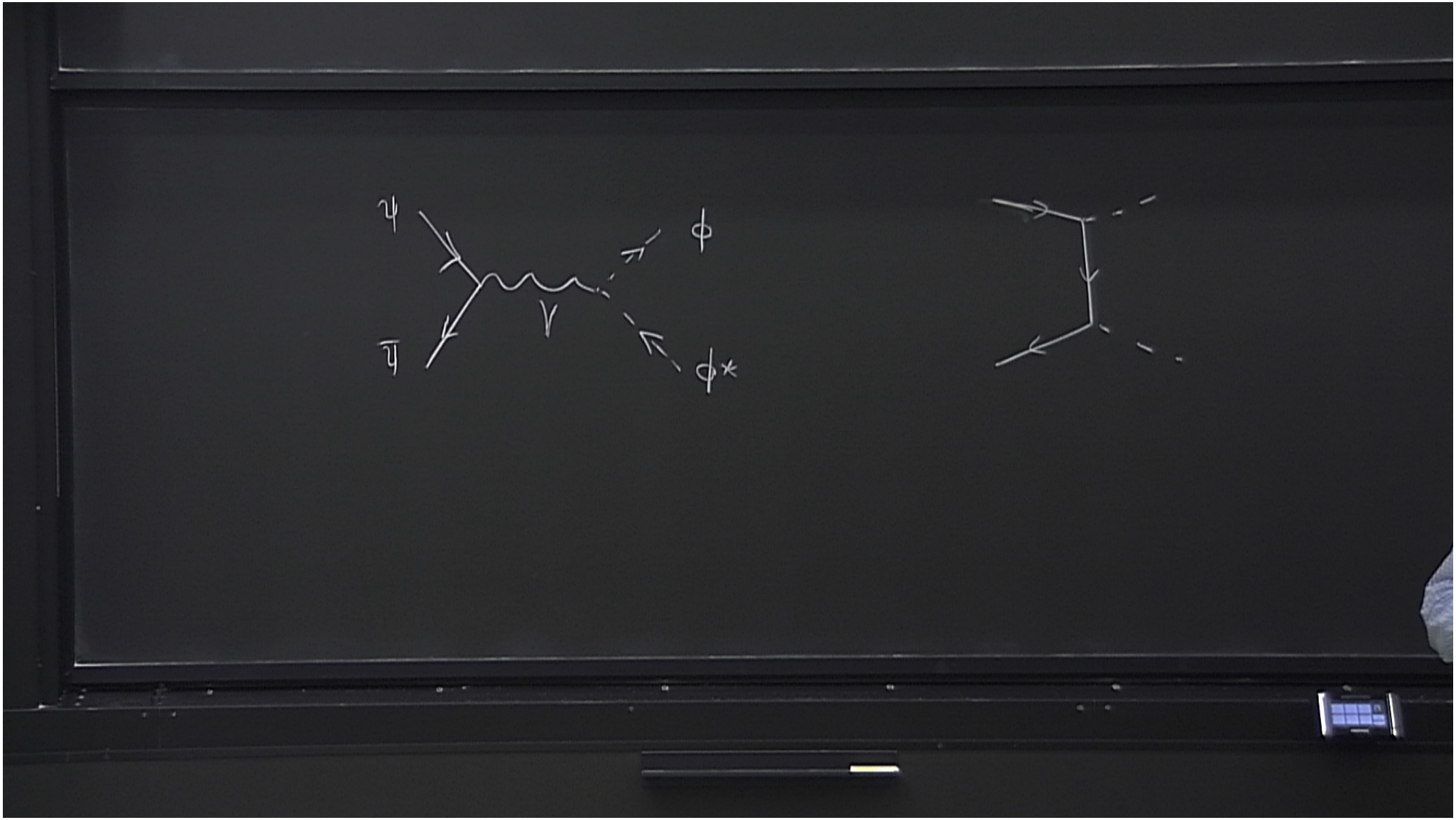
$\phi -$

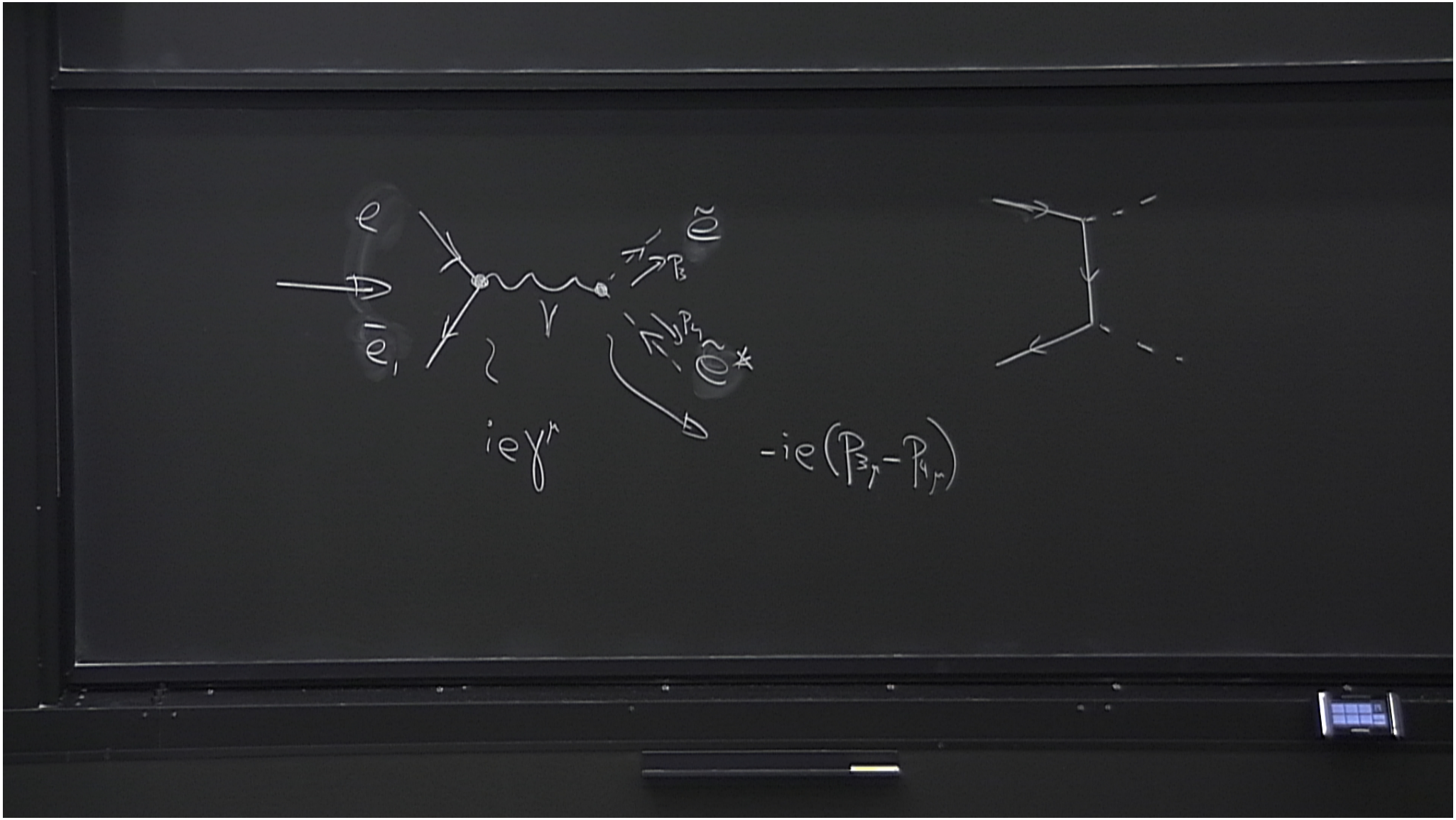
$S\phi$

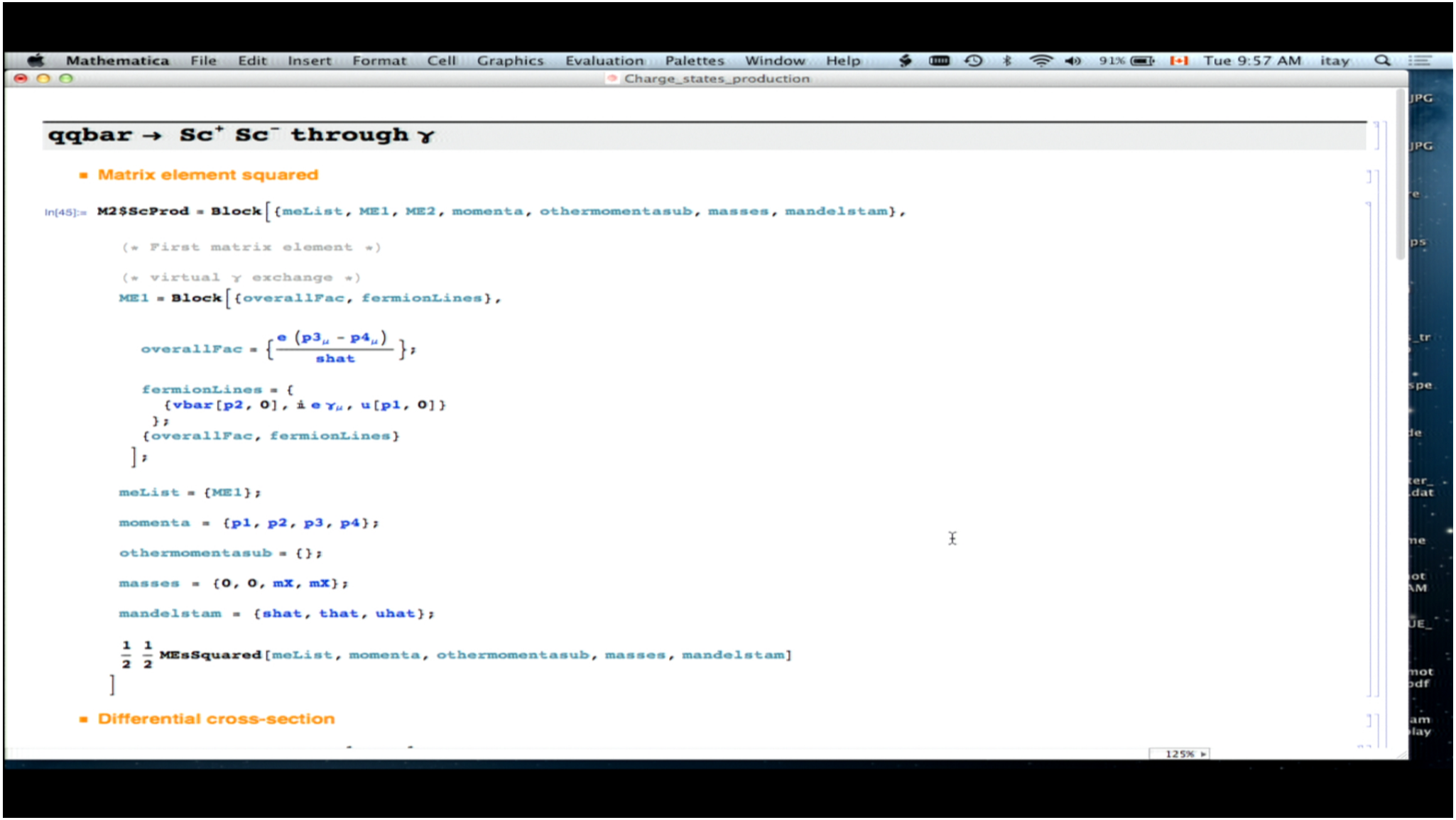
$= \phi$

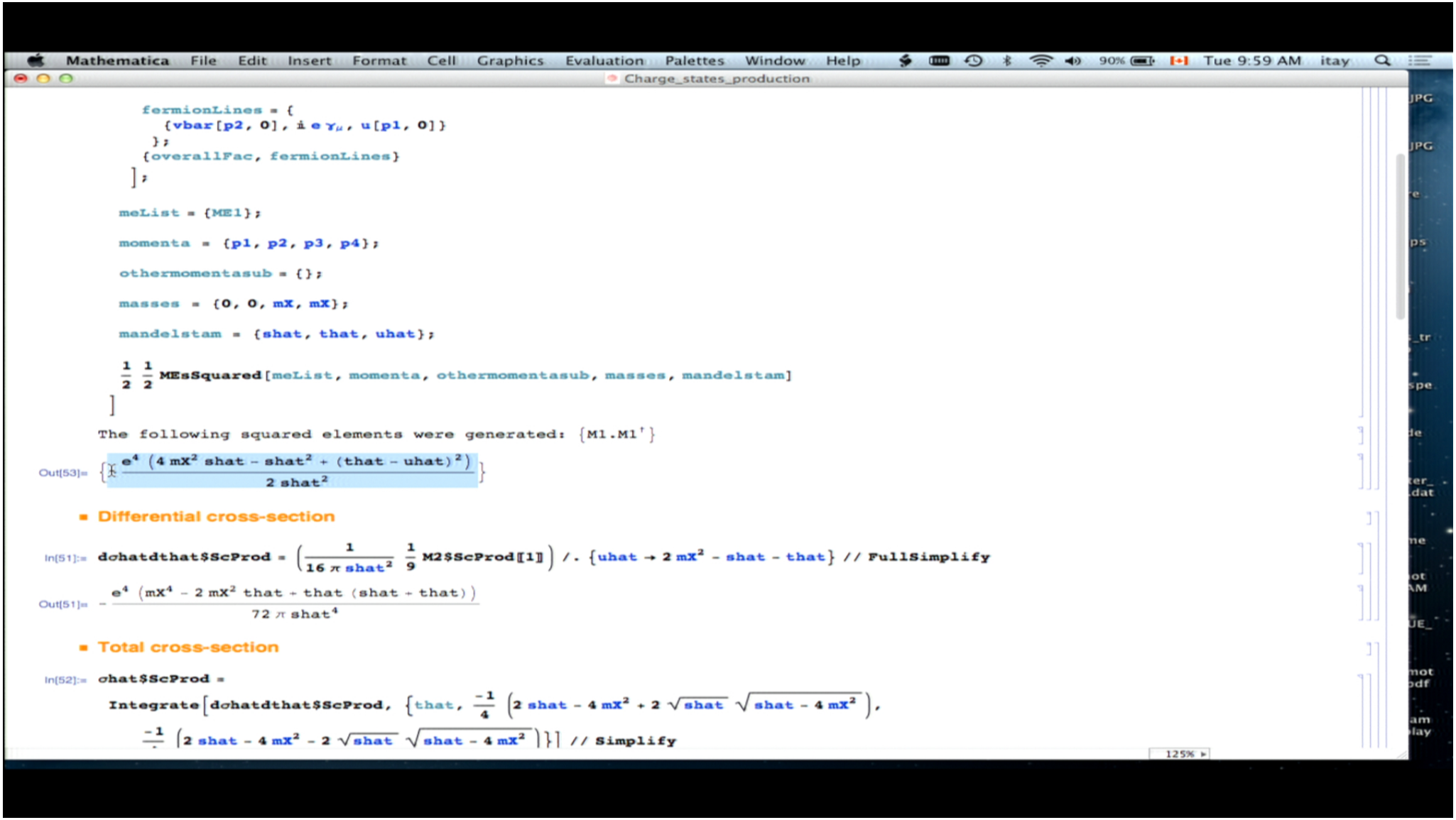

$\mathcal{L}_{int} = -\sqrt{2}\, g\, \phi^* \psi \lambda - \sqrt{2}\, g\, \bar{\psi} \bar{\lambda} \phi + g (\phi^* T^a \phi) D^a$

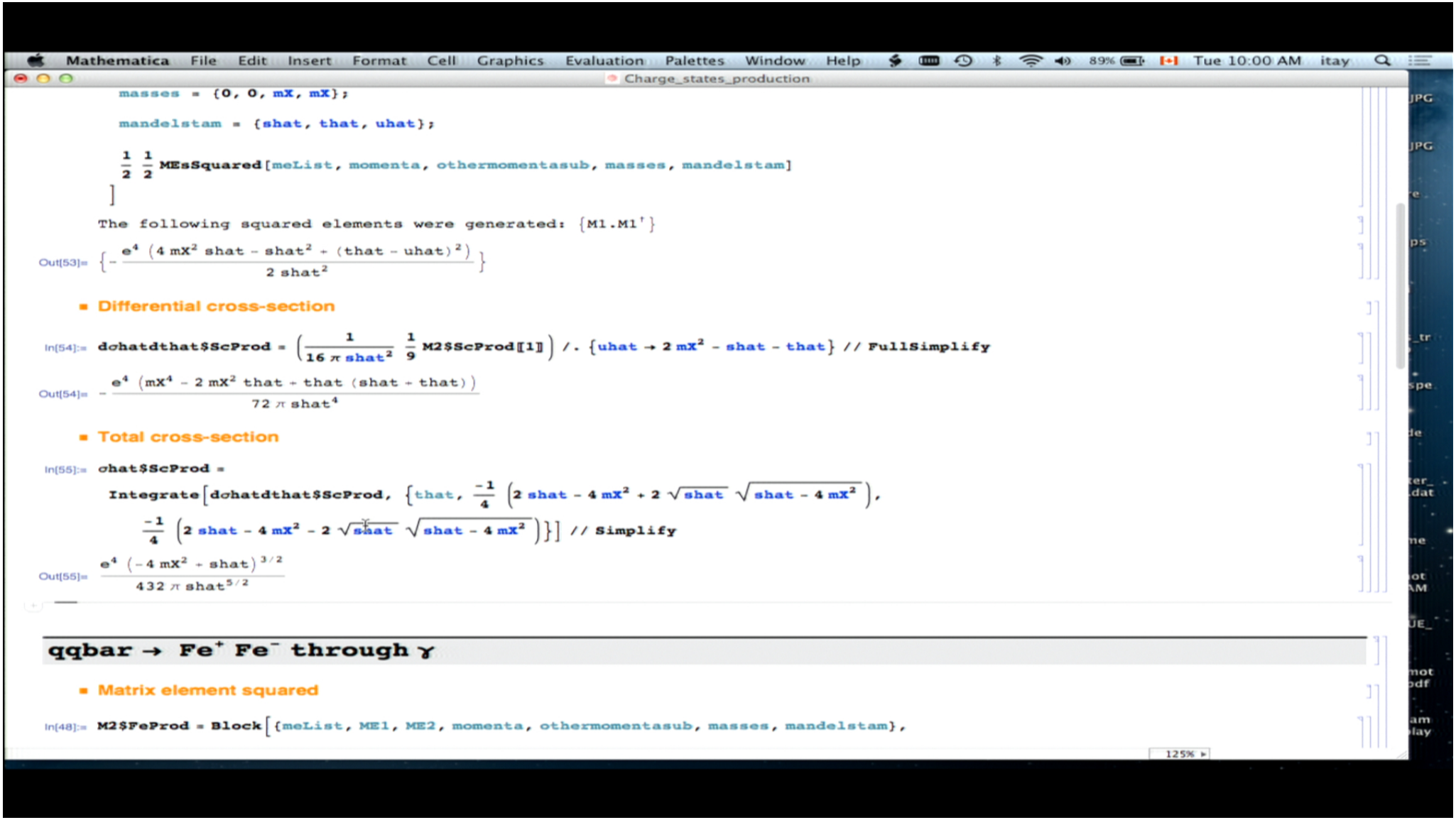

$-\frac{1}{2} W'' \psi\psi = -\frac{1}{2} M \psi\psi - \frac{1}{2} y M \phi \psi\psi$
$W' F = (M\phi + \frac{1}{2} y \phi^2) F \Rightarrow |(M\phi + \frac{1}{2} y \phi\phi)|^2$
$M \tilde{H}_u \tilde{H}_d$
$Q H_u U^c$

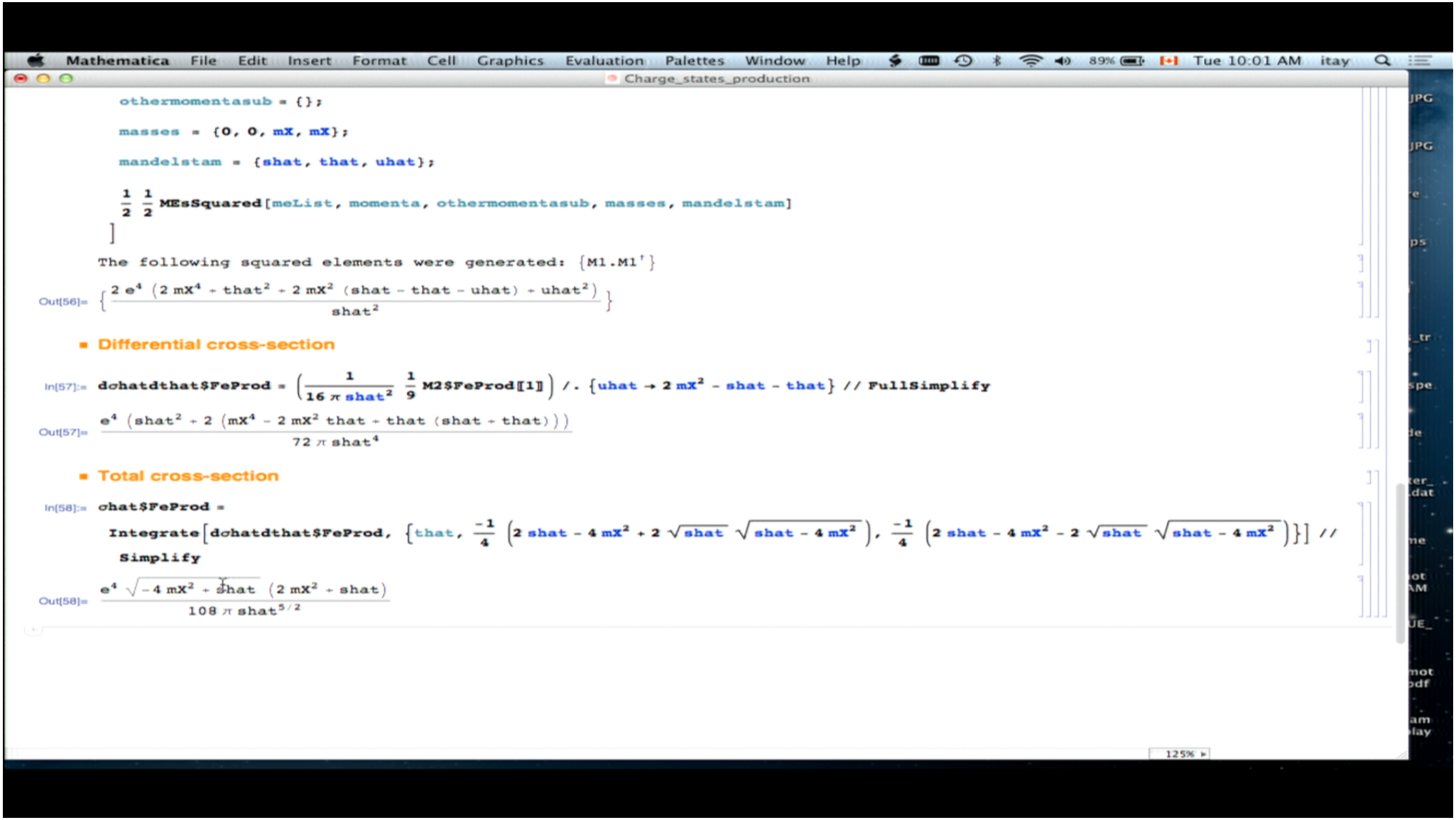

ψ
ψ̄
γ
φ
φ*


e
e
γ
$\tilde{e}$
$\tilde{e}^*$
p_3
p_4
$ie\gamma^\mu$
$-ie(p_{3\mu} - p_{4\mu})$


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Tue 9:57 AM itay
Charge_states_production
qqbar → Sc+ Sc− through γ
Matrix element squared
In[45]:= M2$ScProd = Block[{meList, ME1, ME2, momenta, othermomentasub, masses, mandelstam},
(* First matrix element *)
(* virtual γ exchange *)
ME1 = Block[{overallFac, fermionLines},
overallFac = {e (p3μ - p4μ) / shat};
fermionLines = {
{vbar[p2, 0], i e γμ, u[p1, 0]}
};
{overallFac, fermionLines}
];
meList = {ME1};
momenta = {p1, p2, p3, p4};
othermomentasub = {};
masses = {0, 0, mX, mX};
mandelstam = {shat, that, uhat};
1/2 1/2 MEsSquared[meList, momenta, othermomentasub, masses, mandelstam]
]
Differential cross-section
125%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Tue 9:59 AM itay
Charge_states_production
fermionLines = {
{vbar[p2, 0], I e γμ, u[p1, 0]}
};
{overallFac, fermionLines}
];
meList = {ME1};
momenta = {p1, p2, p3, p4};
othermomentasub = {};
masses = {0, 0, mX, mX};
mandelstam = {shat, that, uhat};
1/2 1/2 MEsSquared[meList, momenta, othermomentasub, masses, mandelstam]
]
The following squared elements were generated: {M1.M1*}
Out[53]= {e^4 (4 mX^2 shat - shat^2 + (that - uhat)^2) / (2 shat^2)}
Differential cross-section
In[51]:= dσhatdthat$ScProd = (1/(16 π shat^2) 1/9 M2$ScProd[[1]]) /. {uhat → 2 mX^2 - shat - that} // FullSimplify
Out[51]= -e^4 (mX^4 - 2 mX^2 that + that (shat + that)) / (72 π shat^4)
Total cross-section
In[52]:= σhat$ScProd =
Integrate[dσhatdthat$ScProd, {that, -1/4 (2 shat - 4 mX^2 + 2 √shat √(shat - 4 mX^2)),
-1/4 (2 shat - 4 mX^2 - 2 √shat √(shat - 4 mX^2))}] // Simplify
125%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Tue 10:00 AM itay
Charge_states_production
masses = {0, 0, mX, mX};
mandelstam = {shat, that, uhat};
1/2 1/2 MEsSquared[meList, momenta, othermomentasub, masses, mandelstam]
The following squared elements were generated: {M1.M1'}
Out[53]= {-e^4 (4 mX^2 shat - shat^2 + (that - uhat)^2) / (2 shat^2)}
Differential cross-section
In[54]:= dσhatdthat$ScProd = (1/(16 π shat^2) 1/9 M2$ScProd[[1]]) /. {uhat → 2 mX^2 - shat - that} // FullSimplify
Out[54]= -e^4 (mX^4 - 2 mX^2 that + that (shat + that)) / (72 π shat^4)
Total cross-section
In[55]:= σhat$ScProd = Integrate[dσhatdthat$ScProd, {that, -1/4 (2 shat - 4 mX^2 + 2 √shat √(shat - 4 mX^2)), -1/4 (2 shat - 4 mX^2 - 2 √shat √(shat - 4 mX^2))}] // Simplify
Out[55]= e^4 (-4 mX^2 + shat)^(3/2) / (432 π shat^(5/2))
qqbar → Fe+ Fe- through γ
Matrix element squared
In[48]:= M2$FeProd = Block[{meList, ME1, ME2, momenta, othermomentasub, masses, mandelstam},
125%


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help
Tue 10:01 AM itay
Charge_states_production
othermomentasub = {};
masses = {0, 0, mX, mX};
mandelstam = {shat, that, uhat};
1/2 1/2 MEsSquared[meList, momenta, othermomentasub, masses, mandelstam]
]
The following squared elements were generated: {M1.M1'}
Out[56]= {2 e^4 (2 mX^4 + that^2 + 2 mX^2 (shat - that - uhat) + uhat^2) / shat^2}
Differential cross-section
In[57]:= dσhatdthat$FeProd = (1/(16 π shat^2) 1/9 M2$FeProd[[1]]) /. {uhat → 2 mX^2 - shat - that} // FullSimplify
Out[57]= e^4 (shat^2 + 2 (mX^4 - 2 mX^2 that + that (shat + that))) / (72 π shat^4)
Total cross-section
In[58]:= σhat$FeProd = Integrate[dσhatdthat$FeProd, {that, -1/4 (2 shat - 4 mX^2 + 2 √shat √(shat - 4 mX^2)), -1/4 (2 shat - 4 mX^2 - 2 √shat √(shat - 4 mX^2))}] // Simplify
Out[58]= e^4 √(-4 mX^2 + shat) (2 mX^2 + shat) / (108 π shat^(5/2))
125%