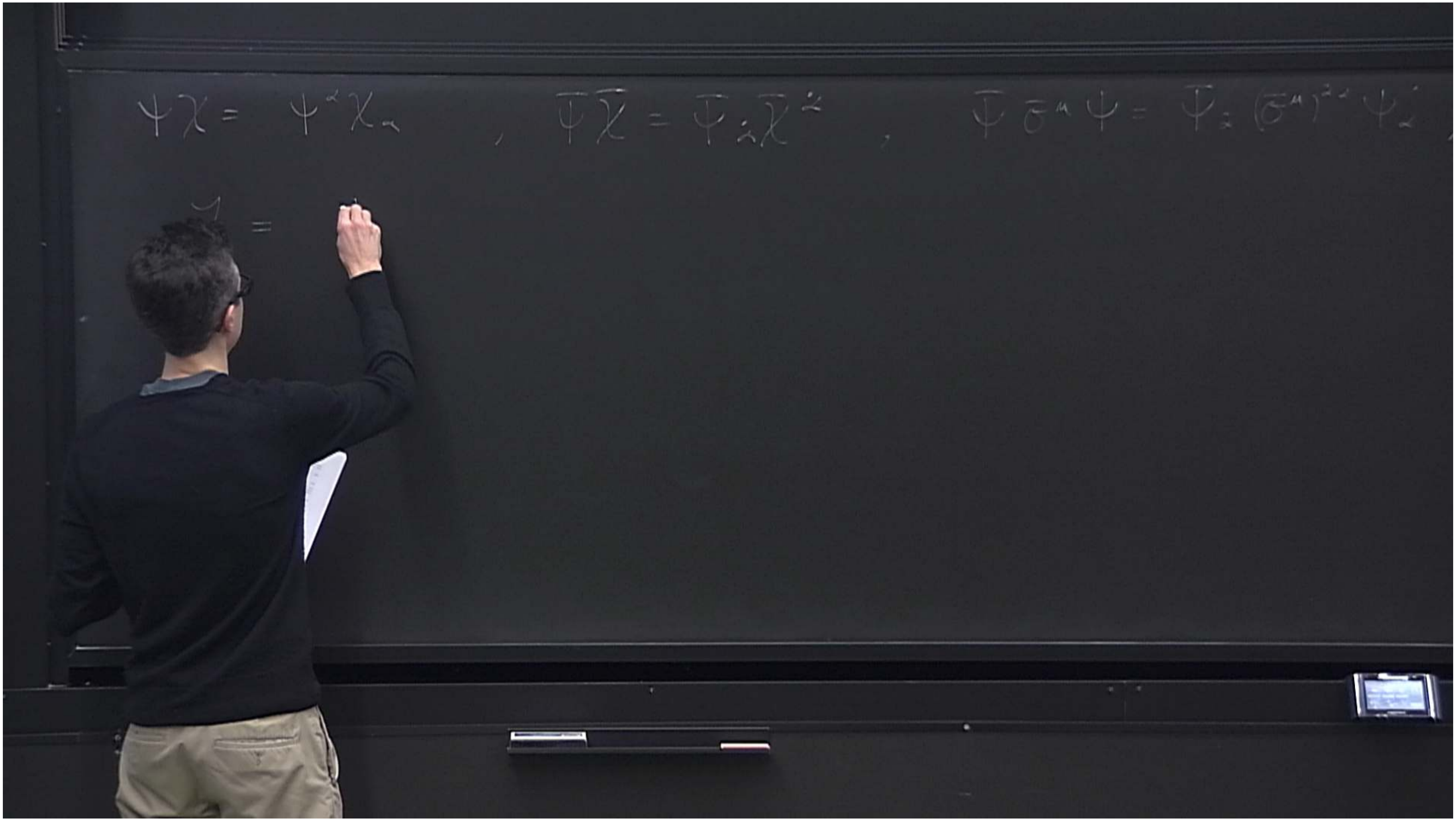
Title: PSI 2015/2016 More/Beyond Standard Model - Lecture 7

Date: Mar 01, 2016 09:00 AM

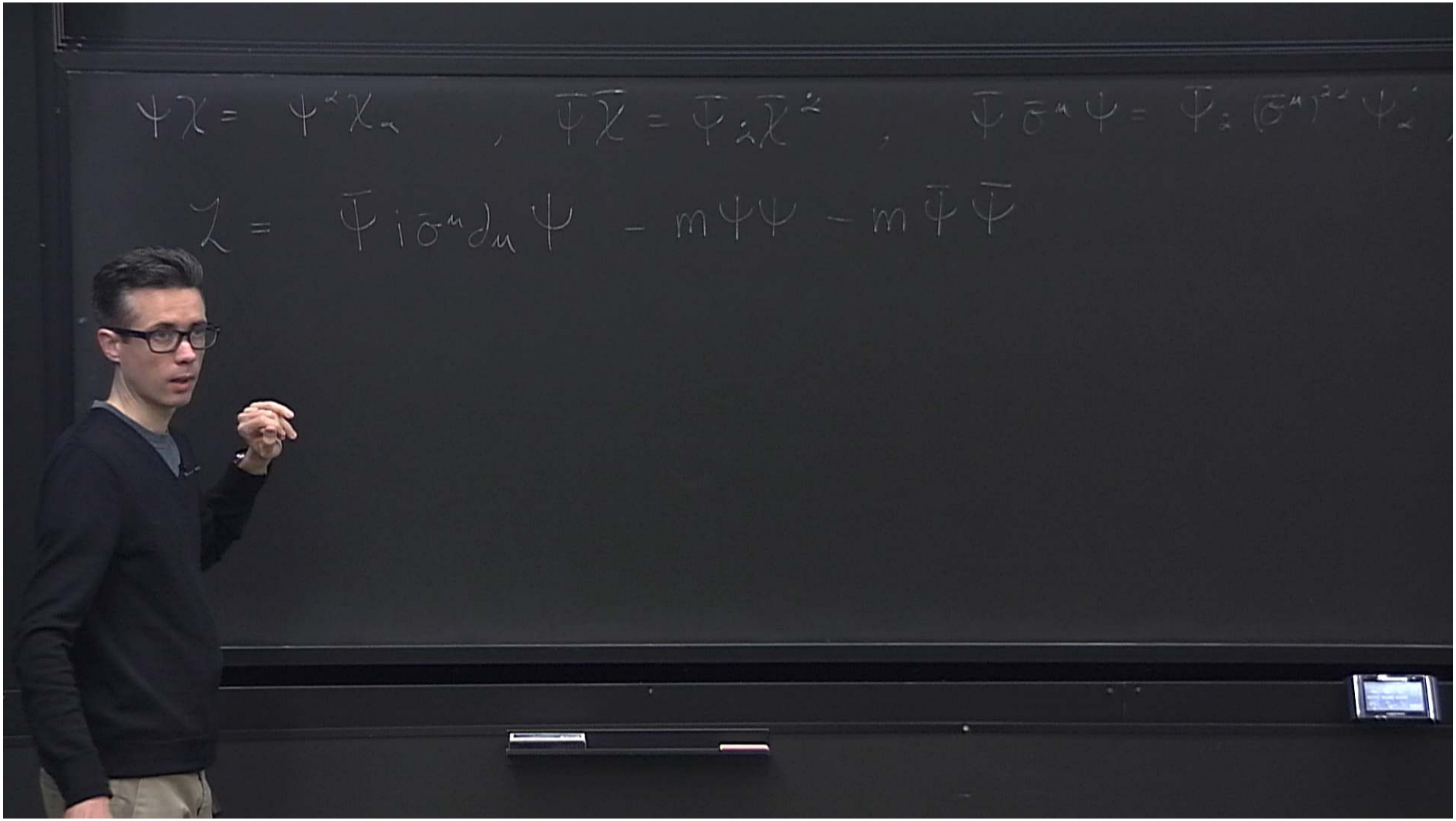
URL: http://pirsa.org/16030036

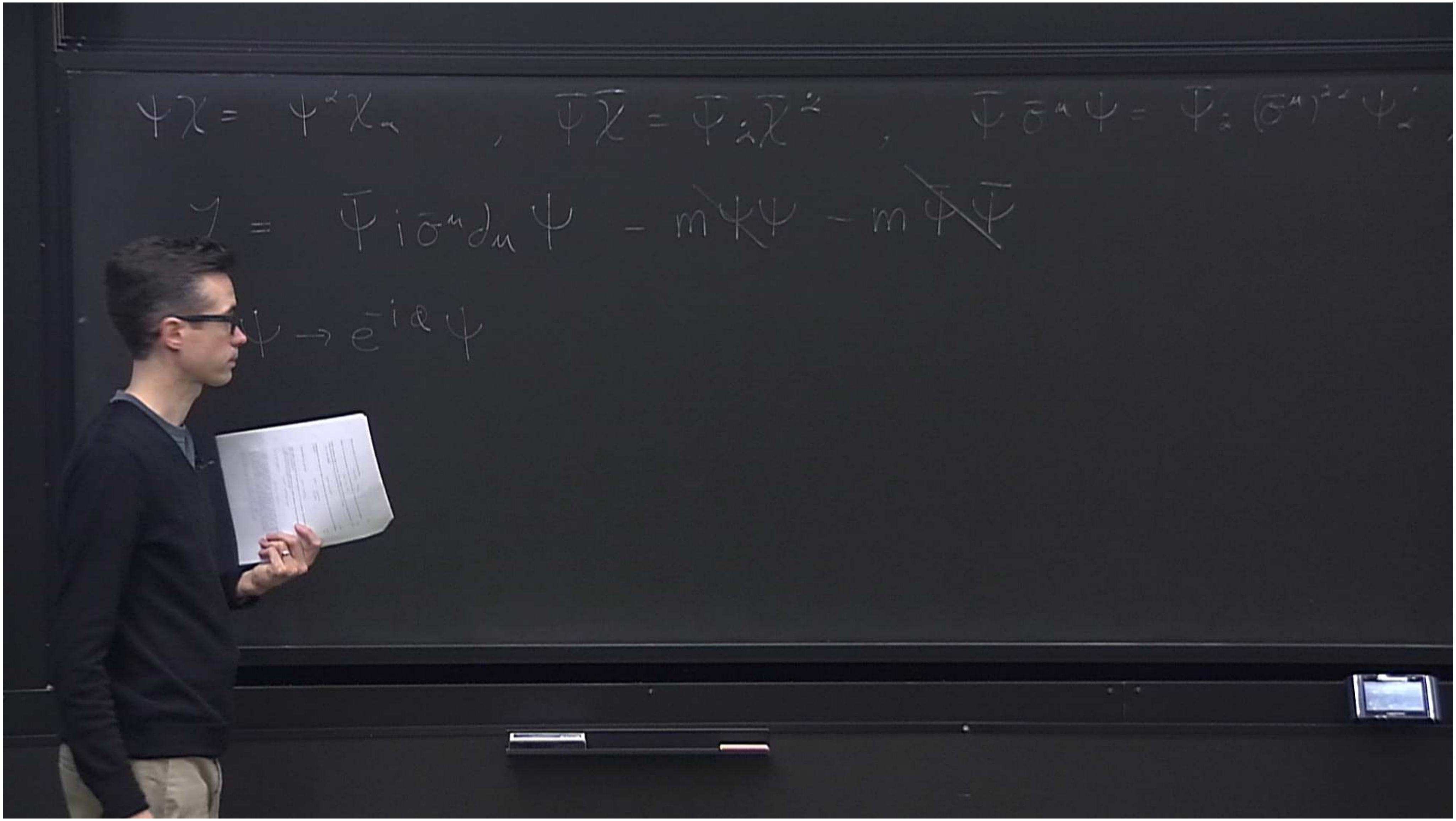
Abstract:

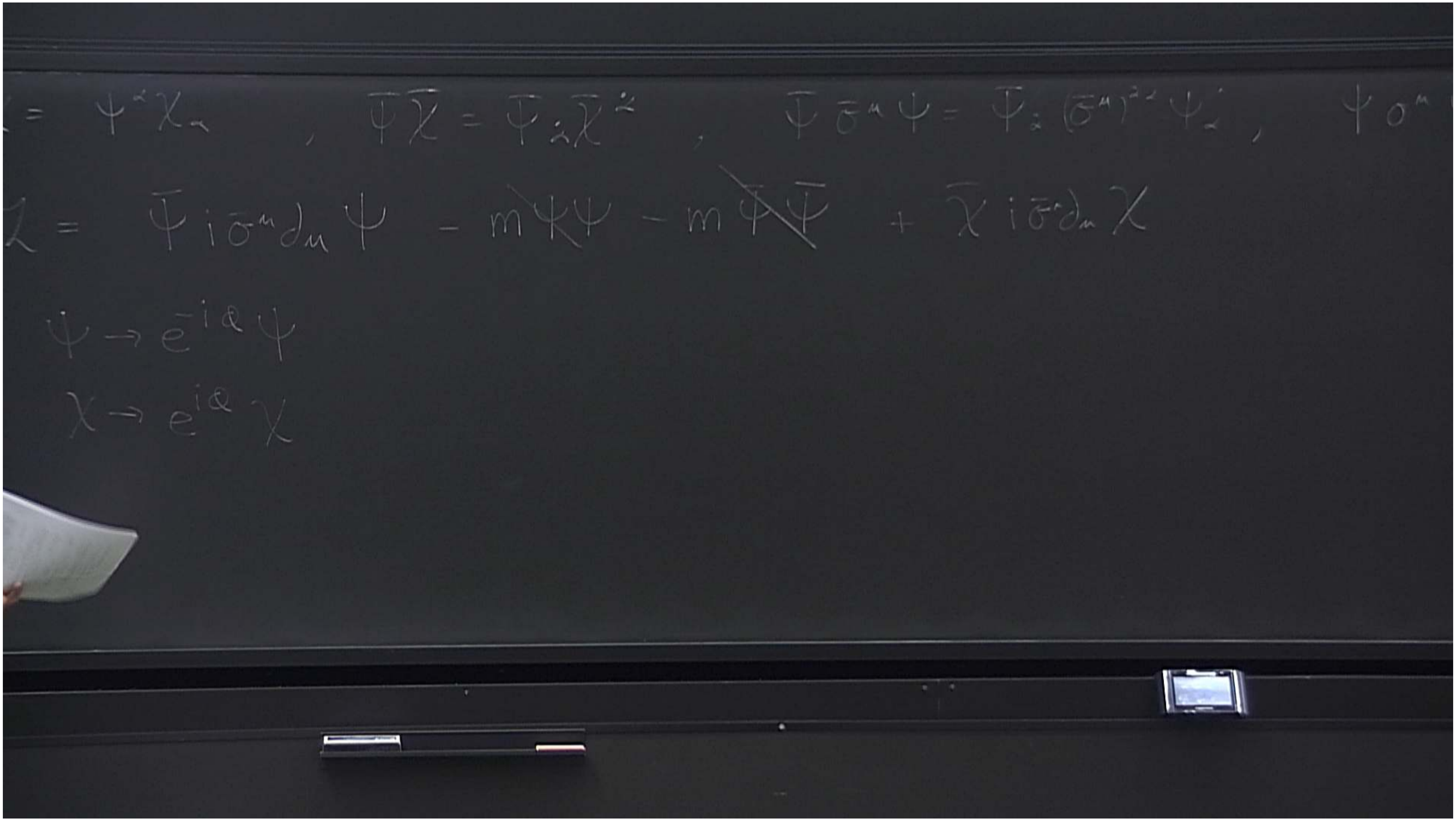

$\psi\chi = \psi^\alpha \chi_\alpha$, $\bar\psi\bar\chi = \bar\psi_{\dot\alpha}\bar\chi^{\dot\alpha}$, $\bar\psi\bar\sigma^\mu\psi = \bar\psi_{\dot\alpha}(\bar\sigma^\mu)^{\dot\alpha\alpha}\psi_\alpha$

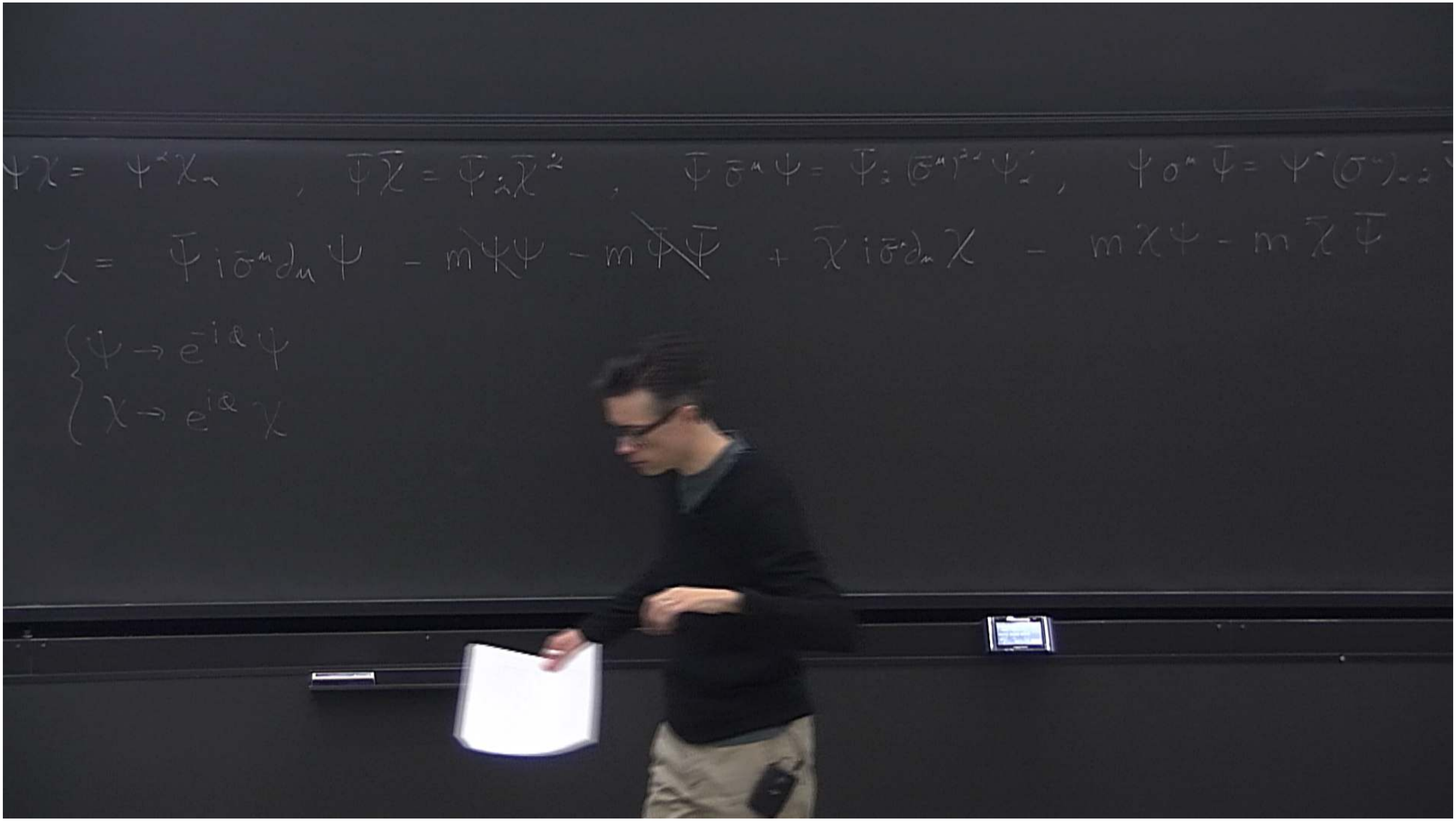
$$\ldots)^{\dot{\alpha}\alpha}\psi_\alpha \,, \qquad \psi\sigma^\mu\bar{\psi} = \psi^\alpha(\sigma^\mu)_{\alpha\dot{\alpha}}\bar{\psi}^{\dot{\alpha}} \,, \qquad \bar{\psi}^{\dot{\alpha}} = (\epsilon^{\alpha\beta}\psi_\beta)^*$$

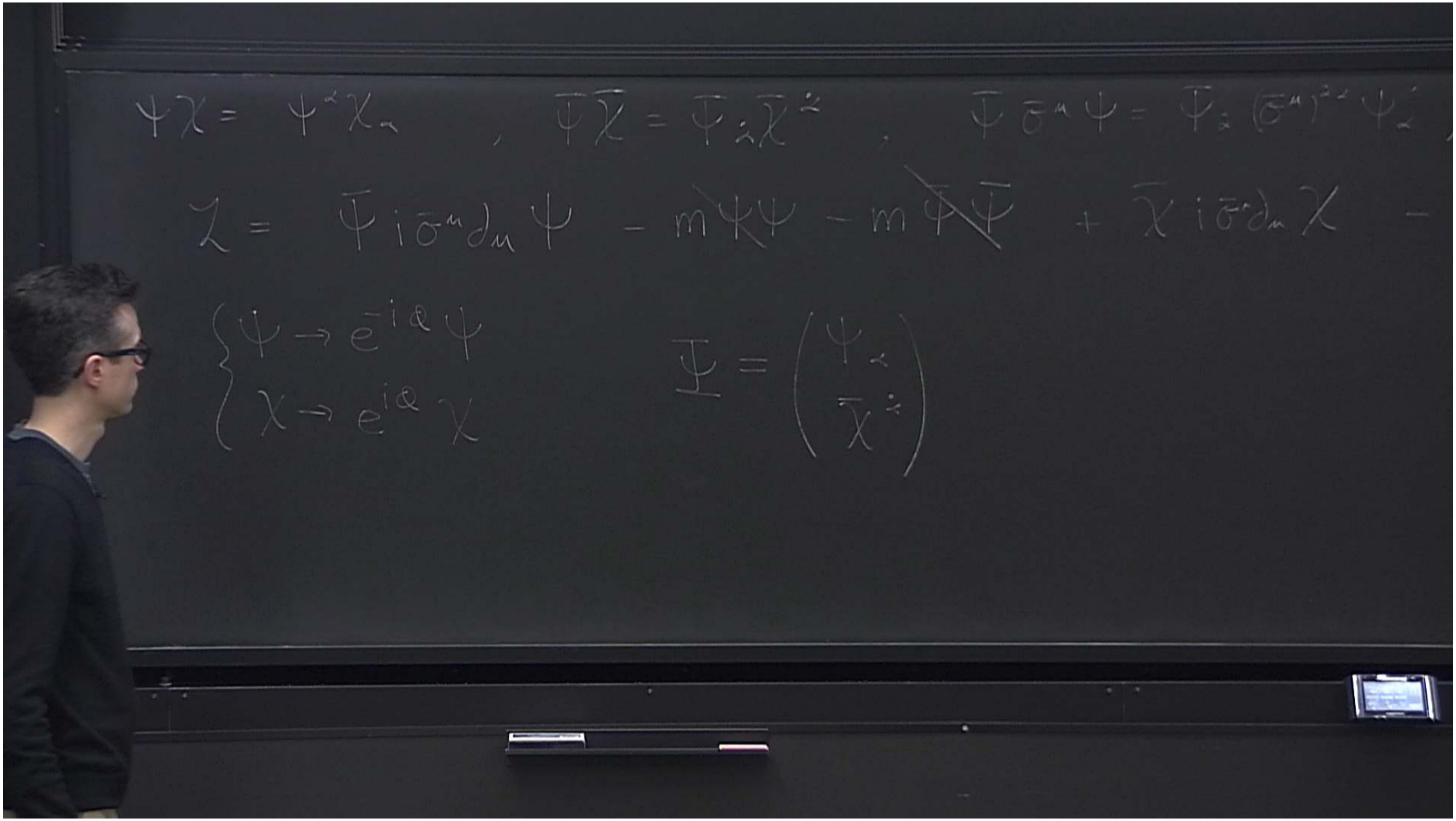

$\psi\chi = \psi^\alpha \chi_\alpha$, $\bar\psi\bar\chi = \bar\psi_{\dot\alpha}\bar\chi^{\dot\alpha}$, $\bar\psi\bar\sigma^\mu\psi = \bar\psi_{\dot\alpha}(\bar\sigma^\mu)^{\dot\alpha\alpha}\psi_\alpha$, $\psi\sigma^\mu\bar\psi = \psi^\alpha(\sigma^\mu)_{\alpha\dot\alpha}\bar\psi^{\dot\alpha}$
$\bar\psi^{\dot\alpha} = (\epsilon^{\alpha\beta}\psi_\beta)^*$
$\mathcal{L} = \bar\psi i\bar\sigma^\mu\partial_\mu\psi$

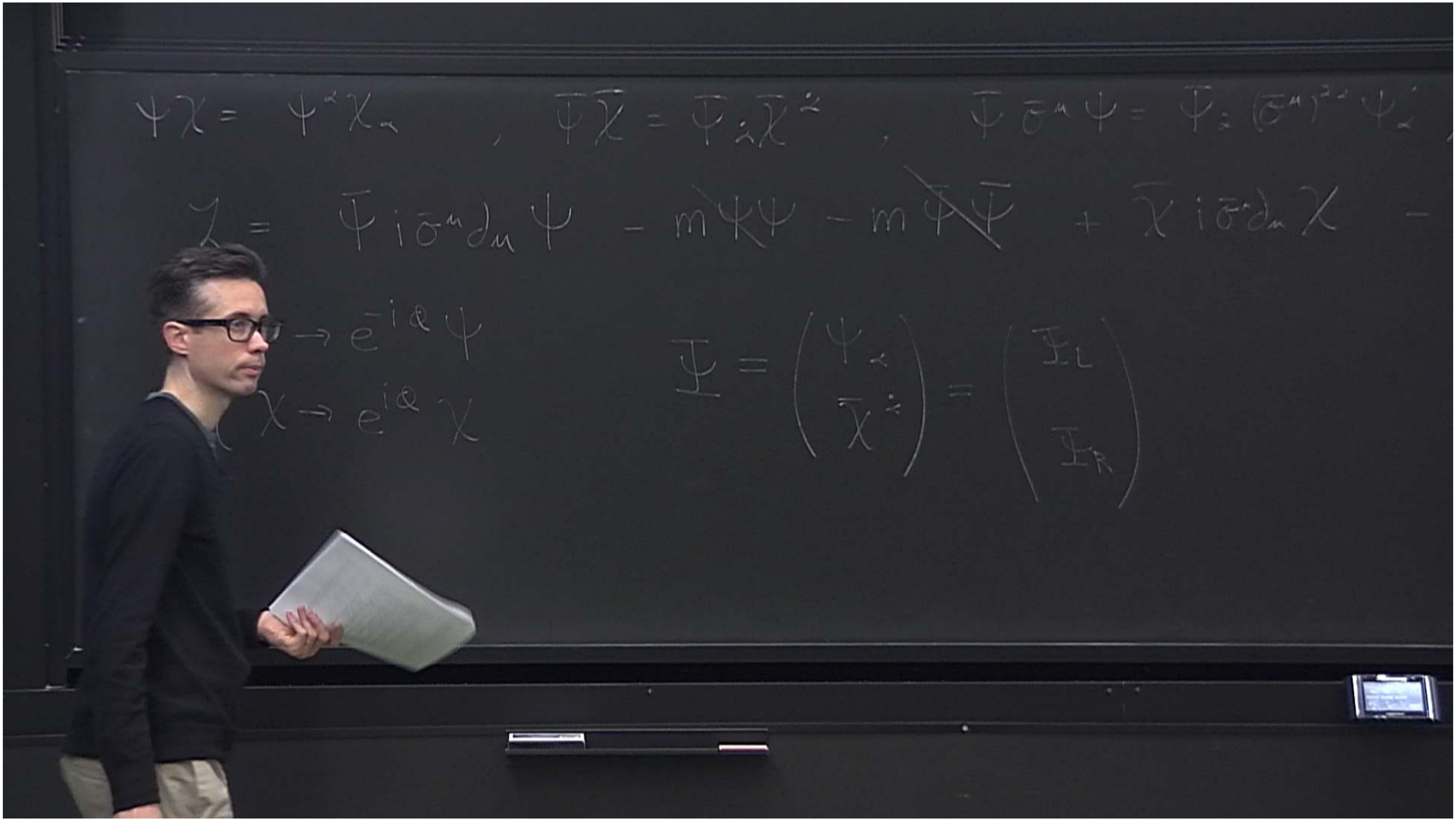

$\psi\chi = \psi^{\alpha}\chi_{\alpha}$, $\bar{\psi}\bar{\chi} = \bar{\psi}_{\dot{\alpha}}\bar{\chi}^{\dot{\alpha}}$, $\bar{\psi}\bar{\sigma}^{\mu}\psi = \bar{\psi}_{\dot{\alpha}}(\bar{\sigma}^{\mu})^{\dot{\alpha}\alpha}\psi_{\alpha}$,
$\mathcal{L} = \bar{\psi}\, i\bar{\sigma}^{\mu}\partial_{\mu}\psi - m\psi\psi - m\bar{\psi}\bar{\psi}$


$\psi\chi = \psi^\alpha \chi_\alpha$, $\bar\psi\bar\chi = \bar\psi_{\dot\alpha}\bar\chi^{\dot\alpha}$, $\bar\psi\bar\sigma^\mu\psi = \bar\psi_{\dot\alpha}(\bar\sigma^\mu)^{\dot\alpha\alpha}\psi_\alpha$
$\mathcal{L} = \bar\psi i\bar\sigma^\mu\partial_\mu\psi - m\cancel{\psi\psi} - m\cancel{\bar\psi\bar\psi}$
$\psi \to e^{-i\alpha}\psi$


$\chi = \psi^\alpha \chi_\alpha$, $\bar\psi\bar\chi = \bar\psi_{\dot\alpha}\bar\chi^{\dot\alpha}$, $\bar\psi\bar\sigma^\mu\psi = \bar\psi_{\dot\alpha}(\bar\sigma^\mu)^{\dot\alpha\alpha}\psi_\alpha$, $\psi\sigma^\mu$
$\mathcal{L} = \bar\psi i\bar\sigma^\mu\partial_\mu\psi - m\cancel{\psi\psi} - m\cancel{\bar\psi\bar\psi} + \bar\chi i\bar\sigma^\mu\partial_\mu\chi$
$\psi \to e^{-i\alpha}\psi$
$\chi \to e^{i\alpha}\chi$


$\psi\chi = \psi^\alpha \chi_\alpha \; , \; \bar\psi\bar\chi = \bar\psi_{\dot\alpha}\bar\chi^{\dot\alpha} \; , \; \bar\psi\bar\sigma^\mu\psi = \bar\psi_{\dot\alpha}(\bar\sigma^\mu)^{\dot\alpha\alpha}\psi_\alpha \; , \; \psi\sigma^\mu\bar\psi = \psi^\alpha(\sigma^\mu)_{\alpha\dot\alpha}\bar\psi^{\dot\alpha}$
$\mathcal{L} = \bar\psi i\bar\sigma^\mu\partial_\mu\psi - m\cancel{\psi\psi} - m\cancel{\bar\psi\bar\psi} + \bar\chi i\bar\sigma^\mu\partial_\mu\chi - m\chi\psi - m\bar\chi\bar\psi$
$\psi \to e^{-i\alpha}\psi$
$\chi \to e^{i\alpha}\chi$


$\psi\chi = \psi^{\alpha}\chi_{\alpha}$, $\bar{\psi}\bar{\chi} = \bar{\psi}_{\dot\alpha}\bar{\chi}^{\dot\alpha}$, $\bar{\psi}\bar{\sigma}^{\mu}\psi = \bar{\psi}_{\dot\alpha}(\bar{\sigma}^{\mu})^{\dot\alpha\alpha}\psi_{\alpha}$,
$\mathcal{L} = \bar{\psi} i\bar{\sigma}^{\mu}\partial_{\mu}\psi - m\cancel{\psi\psi} - m\cancel{\bar{\psi}\bar{\psi}} + \bar{\chi} i\bar{\sigma}^{\mu}\partial_{\mu}\chi -$
$\begin{cases} \psi \to e^{-i\alpha}\psi \\ \chi \to e^{i\alpha}\chi \end{cases}$
$\Psi = \begin{pmatrix} \psi_{\alpha} \\ \bar{\chi}^{\dot\alpha} \end{pmatrix}$


$\psi\chi = \psi^\alpha \chi_\alpha$, $\bar\psi\bar\chi = \bar\psi_{\dot\alpha}\bar\chi^{\dot\alpha}$, $\bar\psi\bar\sigma^\mu\psi = \bar\psi_{\dot\alpha}(\bar\sigma^\mu)^{\dot\alpha\alpha}\psi_\alpha$
$\mathcal{L} = \bar\psi i\bar\sigma^\mu\partial_\mu\psi - m\cancel{\chi\psi} - m\cancel{\bar\psi\bar\chi} + \bar\chi i\bar\sigma^\mu\partial_\mu\chi -$
$\psi \to e^{-i\alpha}\psi$
$\chi \to e^{i\alpha}\chi$
$\Psi = \begin{pmatrix}\psi_\alpha \\ \bar\chi^{\dot\alpha}\end{pmatrix} = \begin{pmatrix}\Psi_L \\ \Psi_R\end{pmatrix}$

$$\bar\psi\bar\chi = \bar\psi_{\dot\alpha}\bar\chi^{\dot\alpha} \quad , \quad \bar\psi\bar\sigma^\mu\psi = \bar\psi_{\dot\alpha}(\bar\sigma^\mu)^{\dot\alpha\alpha}\psi_\alpha \; , \quad \psi\sigma^\mu\bar\psi = \psi^\alpha(\sigma^\mu)_{\alpha\dot\alpha}\bar\psi^{\dot\alpha}$$

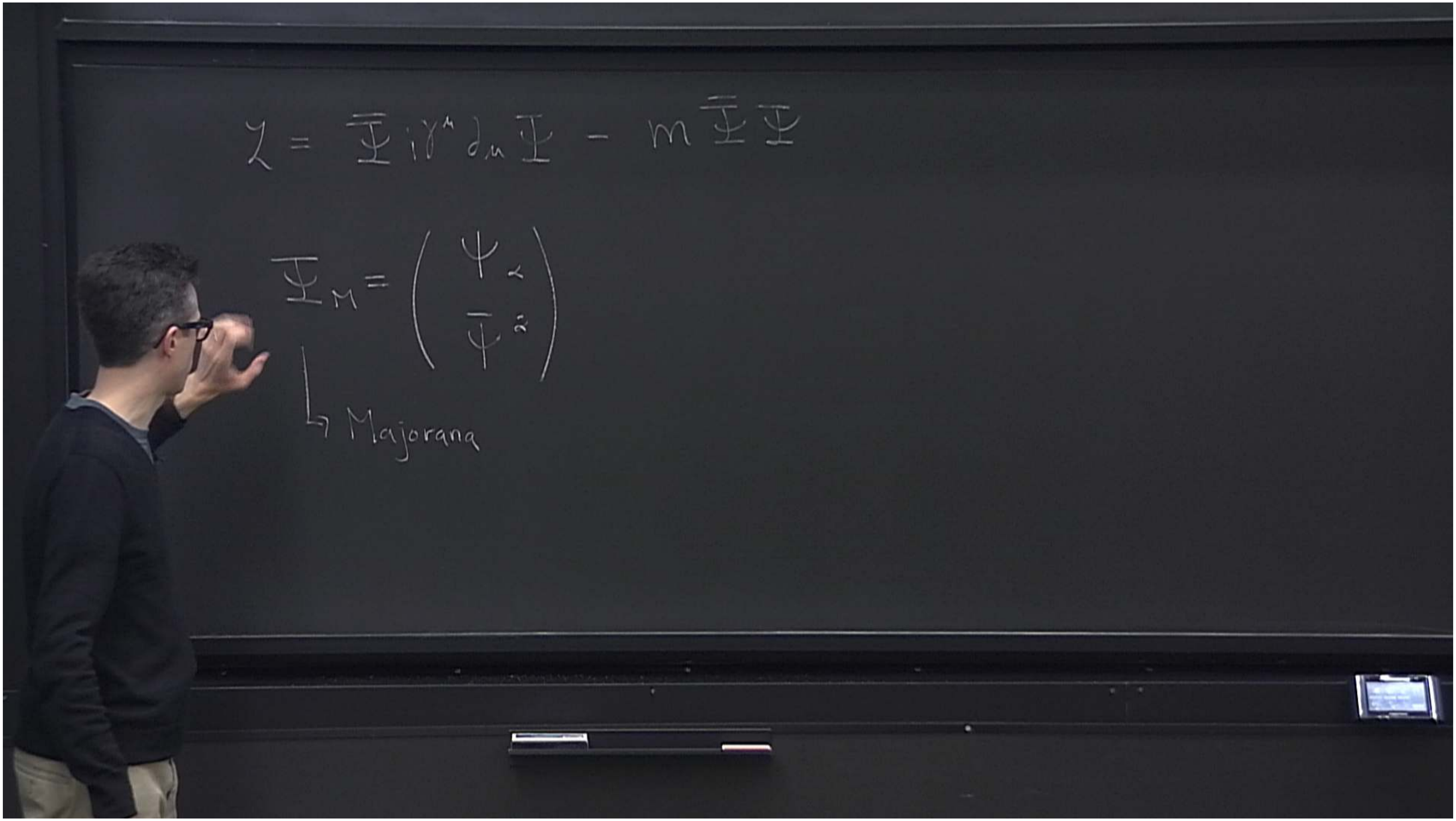
$$- m\cancel{\psi\psi} - m\cancel{\bar\psi\bar\psi} + \bar\chi i\bar\sigma^\mu\partial_\mu\chi - m\chi\psi - m\bar\chi\bar\psi$$

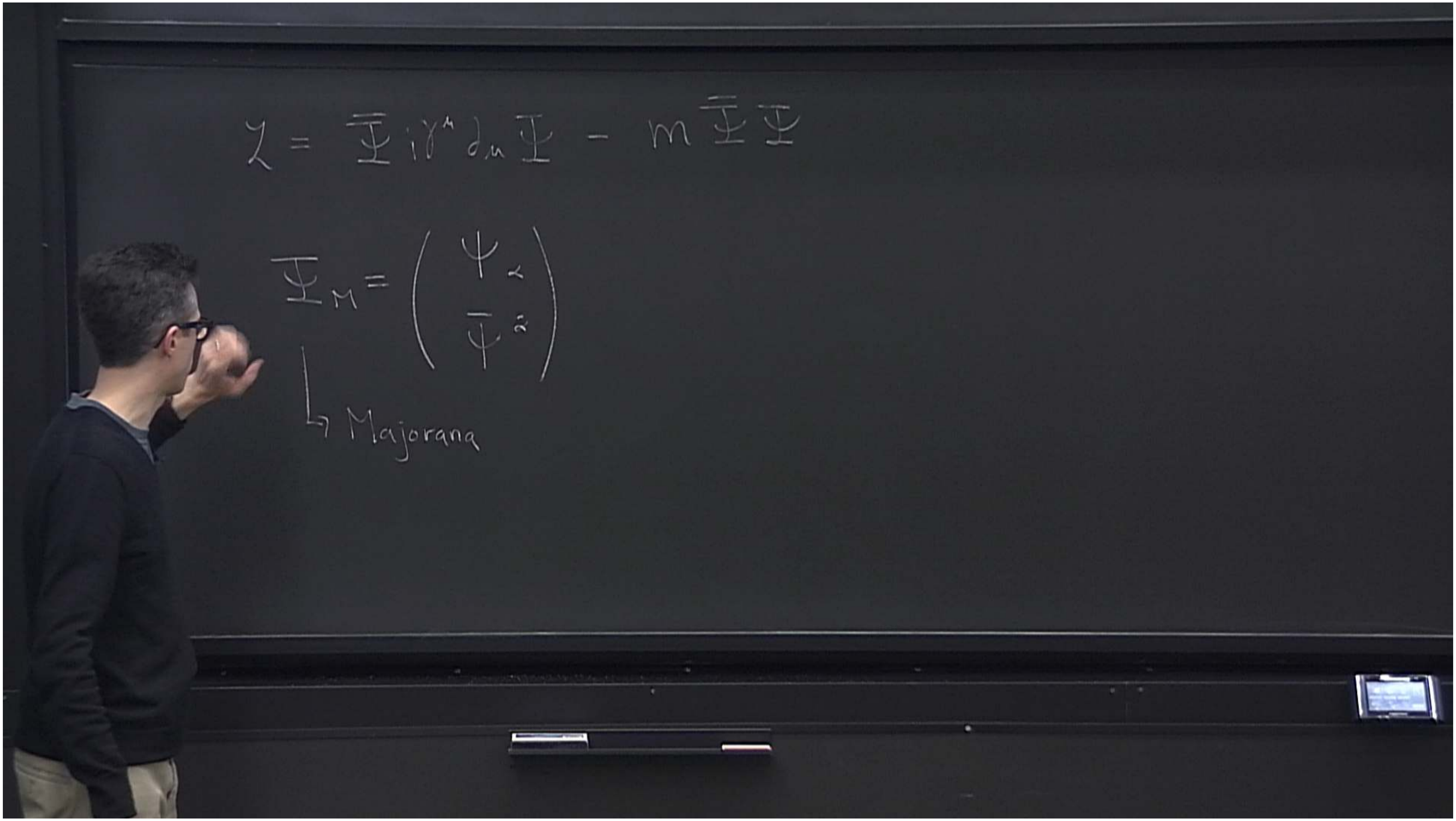
$$\underset{\substack{\uparrow \\ \text{Dirac}}}{\Psi} = \begin{pmatrix} \psi_\alpha \\ \bar\chi^{\dot\alpha} \end{pmatrix} = \begin{pmatrix} \Psi_L \\ \Psi_R \end{pmatrix} \Rightarrow \Psi^\dagger = (\bar\psi_{\dot\alpha}, \chi^\alpha)$$

$$\bar\psi_{\dot\alpha}(\bar\sigma^\mu)^{\dot\alpha\alpha}\psi_\alpha\ , \qquad \psi\sigma^\mu\bar\psi = \psi^\alpha(\sigma^\mu)_{\alpha\dot\alpha}\bar\psi^{\dot\alpha}\ , \qquad \bar\psi^{\dot\alpha} = (\epsilon^{\alpha\beta}\psi_\beta)^*$$

$$i\bar\sigma^\mu\partial_\mu\chi \;-\; m\chi\psi - m\bar\chi\bar\psi$$

$$\left.\begin{array}{l} \Rightarrow\ \Psi^T = (\bar\psi_{\dot\alpha}, \chi^\alpha) \\[2ex] \gamma^\mu = \begin{pmatrix} 0 & \sigma^\mu \\ \bar\sigma^\mu & 0 \end{pmatrix} \end{array}\right\} \to \bar\Psi = \Psi^\dagger\gamma^0 = (\chi^\alpha, \bar\psi_{\dot\alpha})$$


$\mathcal{L} = \bar{\Psi} i \gamma^\mu \partial_\mu \Psi - m \bar{\Psi} \Psi$
$\Psi_M = \begin{pmatrix} \psi_\alpha \\ \bar{\psi}^{\dot{\alpha}} \end{pmatrix}$
↳ Majorana


$\mathcal{L} = \bar{\Psi} i \gamma^\mu \partial_\mu \Psi - m \bar{\Psi} \Psi$
$\Psi_M = \begin{pmatrix} \psi_\alpha \\ \bar{\psi}^{\dot{\alpha}} \end{pmatrix}$
↳ Majorana

$$\mathcal{L} = \bar{\Psi} i \gamma^\mu \partial_\mu \Psi - m \bar{\Psi} \Psi$$

$$\Psi_M = \begin{pmatrix} \psi_\alpha \\ \bar{\psi}^{\dot{\alpha}} \end{pmatrix}$$

↳ Majorana

$$m\bar{e}e = m(\bar{e}_L e_R + \bar{e}_R e_L)$$

Supersymmetry

Supersymmetry

Generators of SUSY are $(\frac{1}{2},0)$, $(0,\frac{1}{2})$ fermion-valued objects.

$$Q^A_\alpha \, , \quad \bar{Q}^{\dot\beta}_B \, , \quad A,B = 1,2,\ldots,N .$$

Supersymmetry

Generators of SUSY are $(\frac{1}{2},0)$, $(0,\frac{1}{2})$ fermion-valued objects

$$Q^A_\alpha , \quad \bar{Q}^{\dot\beta}_B , \quad A,B = 1,2,\ldots,N$$

Supersymmetry

Generators of SUSY are $(\frac{1}{2},0)$, $(0,\frac{1}{2})$ fermion-valued objects.

$$Q^A_{\ \alpha}, \quad \bar{Q}^{\dot{\beta}}_{\ B}, \quad A,B = 1,2,\dots,N$$

$$\{Q^A_{\ \alpha}, \bar{Q}_{\dot{\beta}B}\} = 2(\sigma^\mu)_{\alpha\dot{\beta}} P_\mu \delta^A_{\ B}$$

Supersymmetry

Generators of SUSY are $(\frac{1}{2},0)$, $(0,\frac{1}{2})$ fermion-valued objects.

$$Q^A_\alpha \,, \quad \bar{Q}^{\dot\beta}_B \,, \quad A,B = 1,2,\dots,N$$

$$\{Q^A_\alpha , \bar{Q}_{\dot\beta B}\} = 2(\sigma^\mu)_{\alpha\dot\beta} P_\mu \delta^A{}_B$$

$$\{Q^A_\alpha , Q^A_\beta\} = 0 = \{\bar{Q}^{\dot\alpha}_A , \bar{Q}^{\dot\beta}_B\}$$

$$[P_\mu , Q^A_\alpha] = 0 = [P_\mu , \bar{Q}^{\dot\beta}_B]$$

Supersymmetry

Generators of SUSY are $(\frac{1}{2},0)$, $(0,\frac{1}{2})$ fermion-valued objects.

$$Q^A_\alpha \,, \quad \bar{Q}^{\dot\beta}_B \,, \quad A,B = 1,2,\ldots,N$$

$$\left\{ \begin{array}{l} \{Q^A_\alpha, \bar{Q}_{\dot\beta B}\} = 2(\sigma^\mu)_{\alpha\dot\beta} P_\mu \delta^A_B \\ \{Q^A_\alpha, Q^A_\beta\} = 0 = \{\bar{Q}^{\dot\alpha}_A, \bar{Q}^{\dot\beta}_B\} \\ [P_\mu, Q^A_\alpha] = 0 = [P_\mu, \bar{Q}^{\dot\beta}_B] \end{array} \right.$$

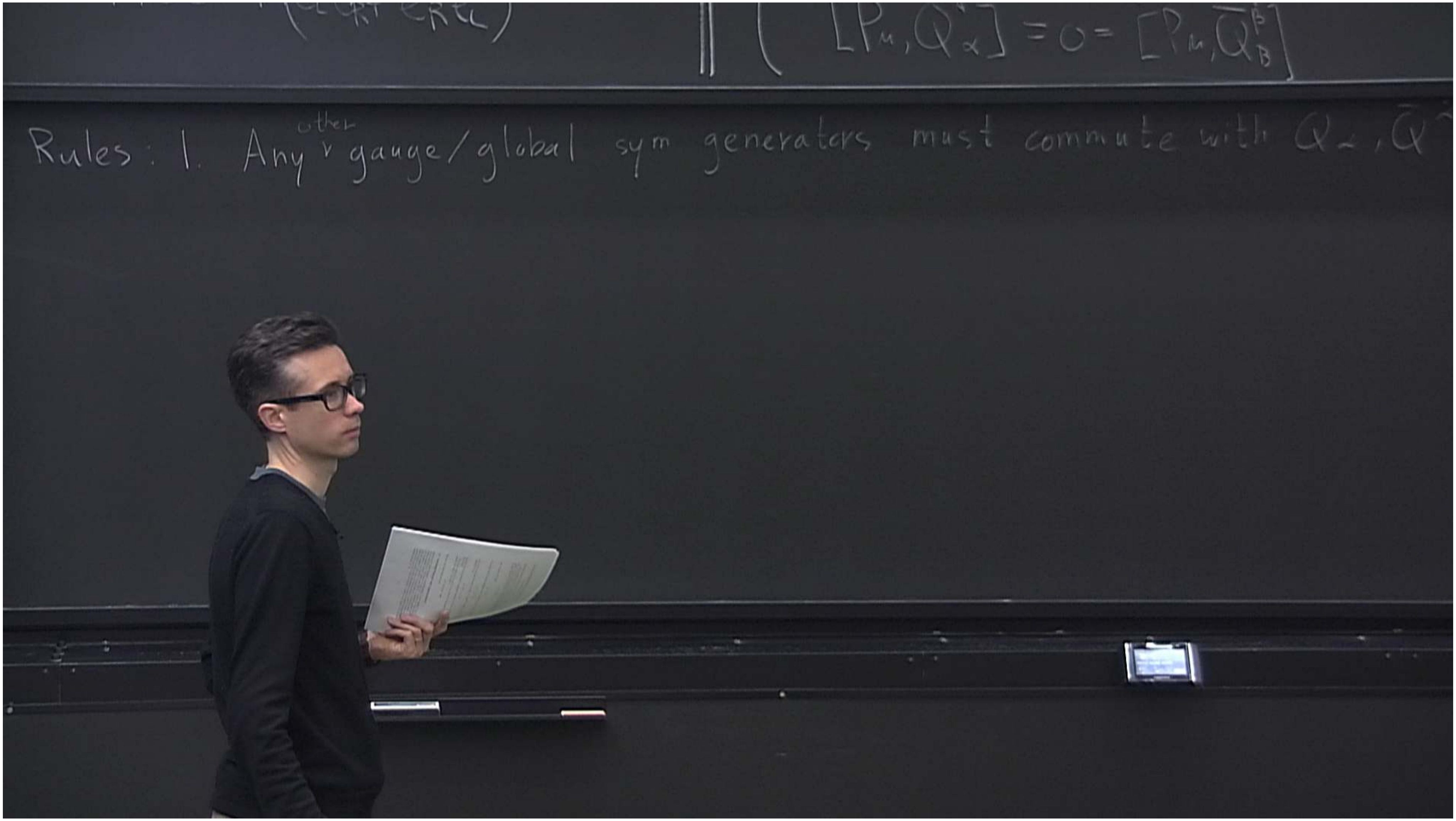
sy are $(\frac{1}{2},0), (0,\frac{1}{2})$ fermion-valued objects.

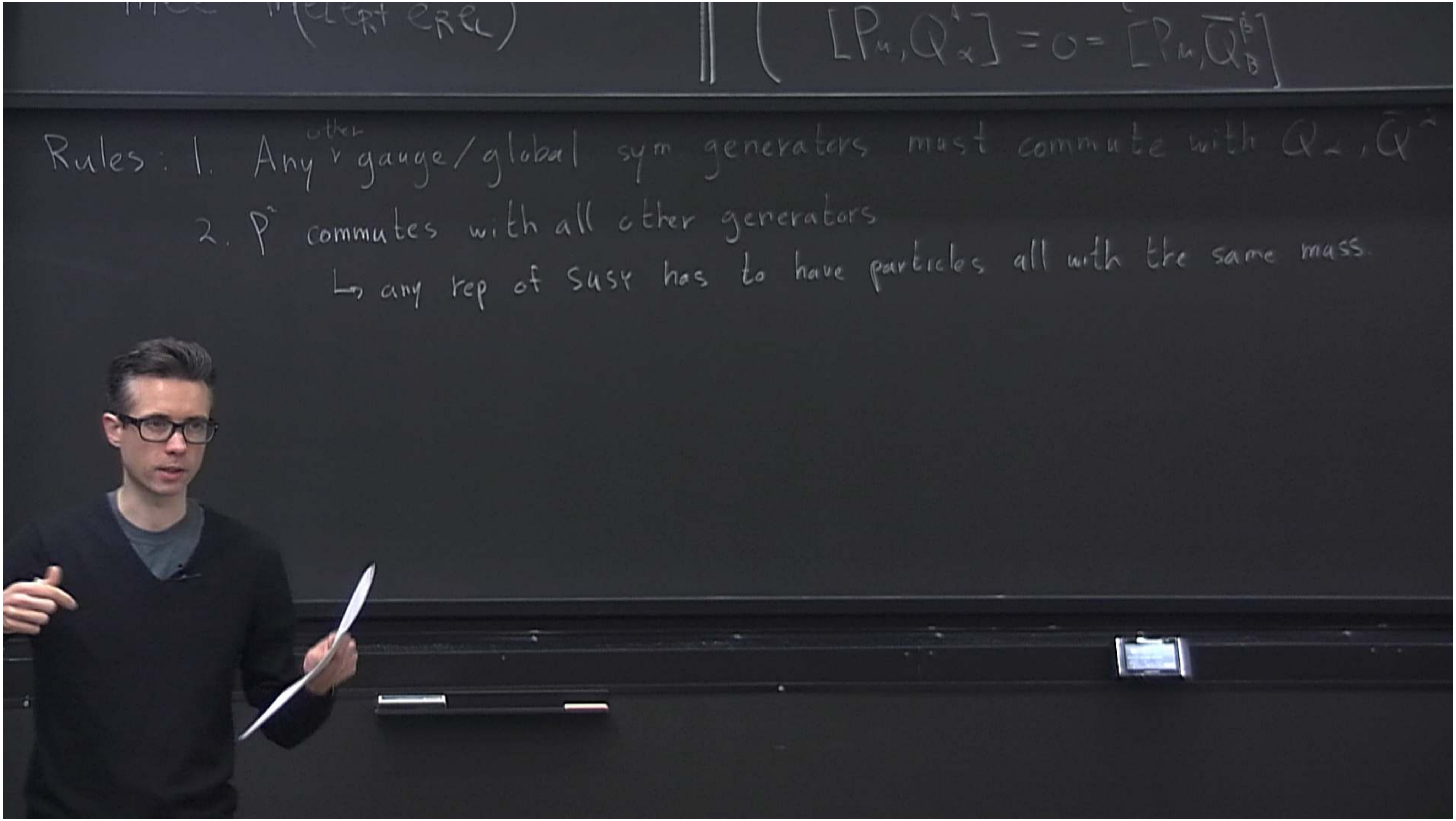
, $A,B = \underset{\sim}{1}, 2, \ldots, N$. $N=1,\ d=4$

$2(\sigma^{\mu})_{\alpha\dot{\beta}}\, P_{\underset{\sim}{\mu}}\, \delta^{A}{}_{B}$

$0 = \{ \bar{Q}^{\dot{\alpha}}_{A}, \bar{Q}^{\dot{\beta}}_{B} \}$

$0 = [P_{\mu}, \bar{Q}^{\dot{\beta}}_{B}]$


[Pμ, Qα] = 0 = [Pμ, Q̄β̇]
Rules: 1. Any other gauge/global sym generators must commute with Qα, Q̄


$[P_\mu, Q^A_\alpha] = 0 = [P_\mu, \bar{Q}^{\dot\beta}_B]$
Rules: 1. Any other gauge/global sym generators must commute with $Q_\alpha, \bar{Q}^{\dot\alpha}$
2. P^2 commutes with all other generators
↳ any rep of SUSY has to have particles all with the same mass.

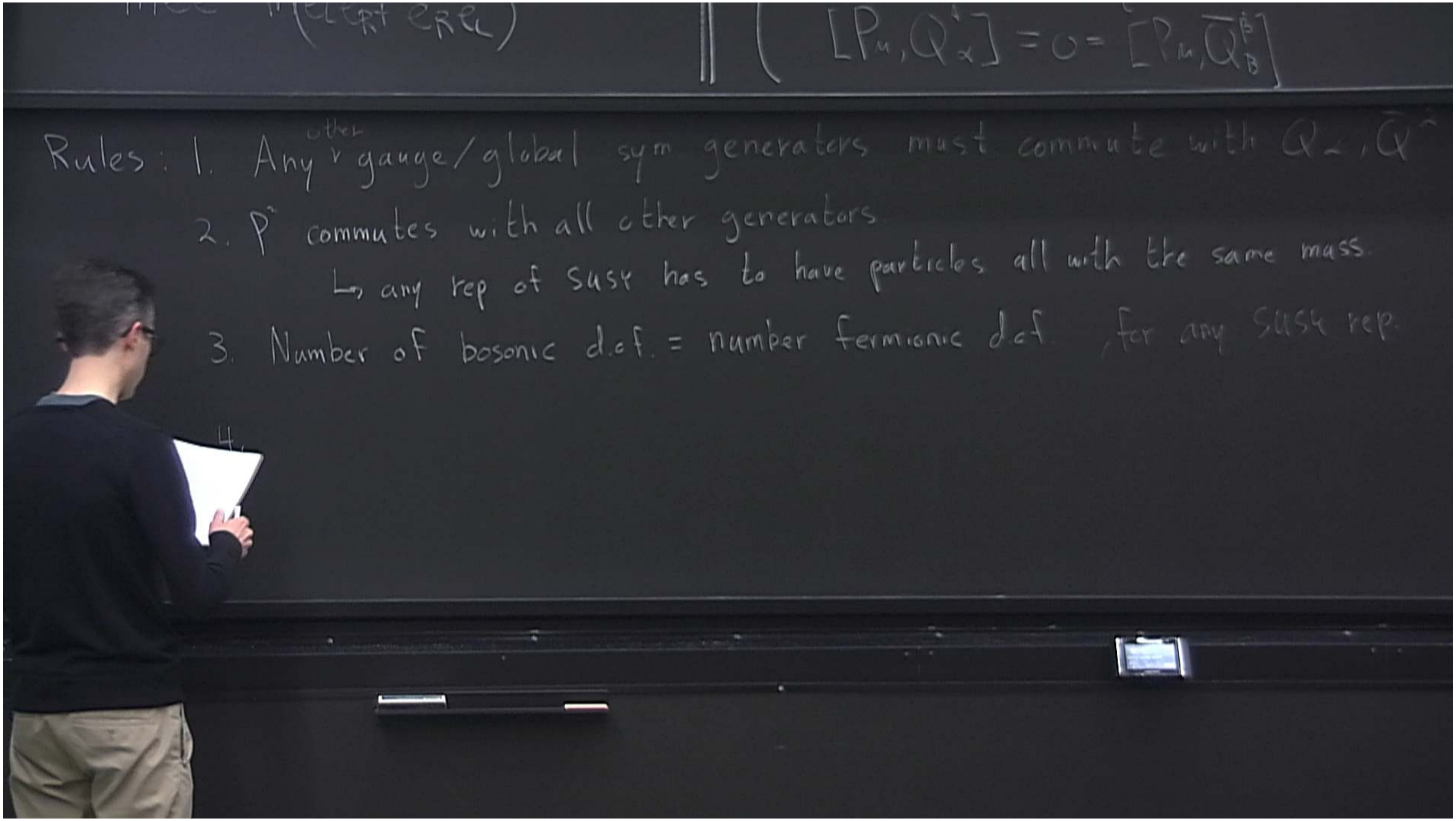
$$[P_\mu, Q^A_\alpha] = 0 = [P_\mu, \bar{Q}^{\dot\beta}_B]$$

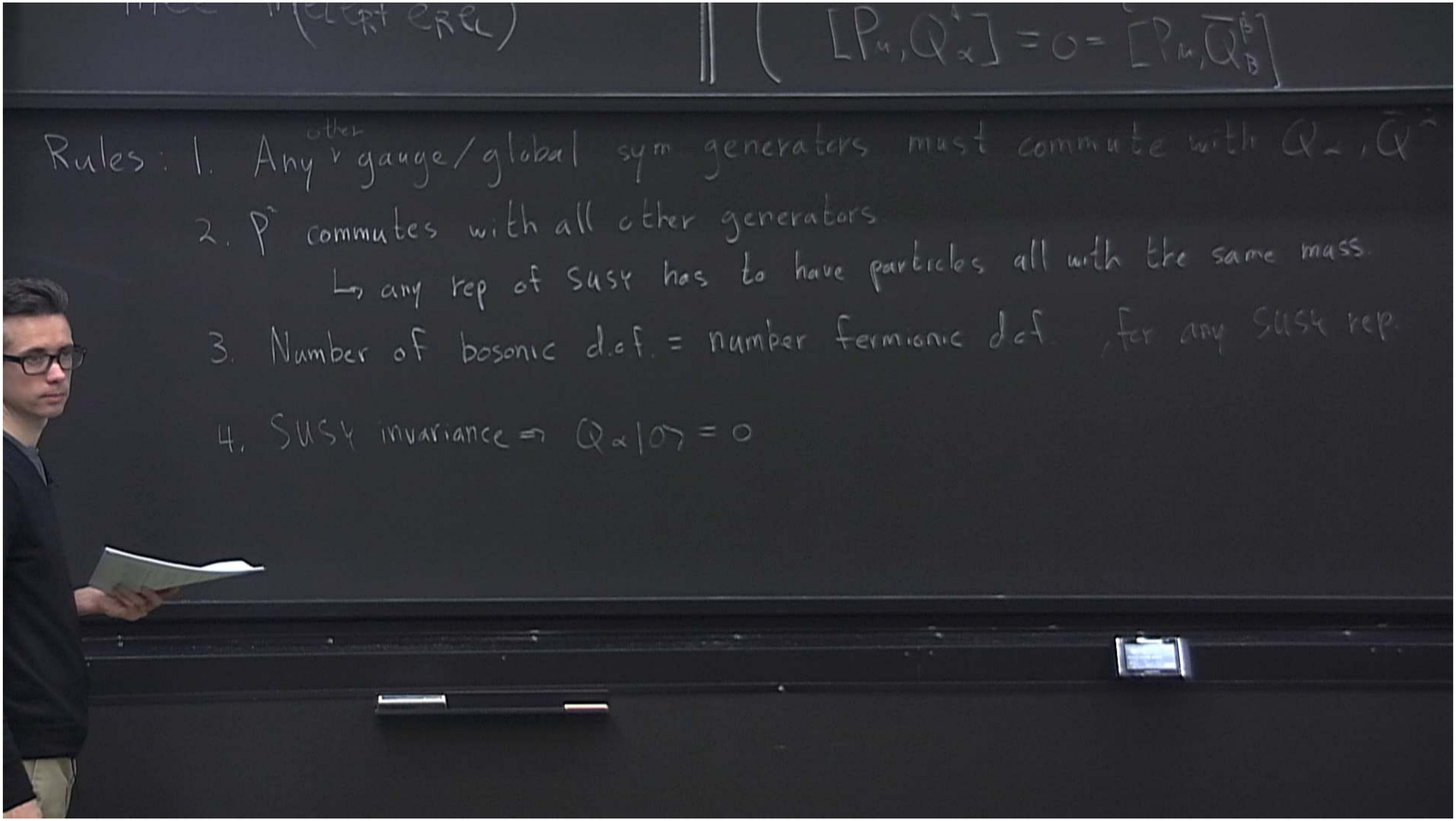
Rules: 1. Any other gauge/global sym generators must commute with $Q_\alpha, \bar{Q}^{\dot\alpha}$

2. P^2 commutes with all other generators.

↳ any rep of SUSY has to have particles all with the same mass.

3. Number of bosonic d.o.f. = number fermionic d.o.f.


[Pμ, Qα] = 0 = [Pμ, Q̄β]
Rules: 1. Any other gauge/global sym generators must commute with Qα, Q̄
2. P² commutes with all other generators.
↳ any rep of SUSY has to have particles all with the same mass.
3. Number of bosonic d.o.f. = number fermionic d.o.f. , for any SUSY rep.
4.


$[P_\mu, Q^A_\alpha] = 0 = [P_\mu, \bar{Q}^{\dot\beta}_B]$
Rules: 1. Any other gauge/global sym generators must commute with $Q_\alpha, \bar{Q}^{\dot\alpha}$
2. P^2 commutes with all other generators
↳ any rep of SUSY has to have particles all with the same mass.
3. Number of bosonic d.o.f. = number fermionic d.o.f. , for any SUSY rep.
4. SUSY invariance ⇒ $Q_\alpha|0\rangle = 0$

$$[P_\mu, Q^A_\alpha] = 0 = [P_\mu, \bar{Q}^{\dot\beta}_B]$$

Rules: 1. Any other gauge/global sym generators must commute with $Q_\alpha, \bar{Q}^{\dot\alpha}$

2. P^2 commutes with all other generators.

↳ any rep of SUSY has to have particles all with the same mass.

3. Number of bosonic d.o.f. = number fermionic d.o.f., for any SUSY rep.

4. SUSY invariance $\Rightarrow Q_\alpha|0\rangle = 0$

$$\{Q_\alpha, \bar{Q}_{\dot\beta}\} = 2\delta_{\alpha\dot\beta} P^0 \Rightarrow H|0\rangle = 0$$

$$\| \left(\quad [P_\mu, Q_\alpha] = 0 = [P_\mu, \bar{Q}^{\dot\beta}_{B}] \right.$$

sym generators must commute with $Q_\alpha, \bar{Q}^{\dot\alpha}$.

l other generators.

usy has to have particles all with the same mass.

d.o.f. = number fermionic d.o.f. , for any susy rep.

$Q_\alpha |0\rangle = 0$

$\delta_{\alpha\dot\beta} P^0 \Rightarrow H|0\rangle = 0$

$Q\,|\text{boson}\rangle \sim |\text{fermion}\rangle$

$Q\,|\text{fermion}\rangle \sim |\text{boson}\rangle$

Φ = chiral multiplet = (ϕ, ψ, F)

complex scalar (ϕ), Weyl ferm (ψ), auxilliary field (F)

$$S = \int d^4x \left(|\partial\phi|^2 + \bar{\psi}\, i\bar{\sigma}\cdot\partial\psi + F^\dagger F \right)$$

Φ = chiral multiplet = (ϕ, ψ, F)

auxilliary field

complex scalar

Weyl ferm

$$e^{-i\zeta Q}$$

$$S = \int d^4x \left(|\partial\phi|^2 + \bar{\psi}\, i\bar{\sigma}\cdot\partial\psi + F^\dagger F \right)$$

$$\delta\phi \sim$$

$$\Phi = \text{chiral multiplet} = (\underbrace{\phi}_{\text{complex scalar}}, \underbrace{\psi}_{\text{Weyl ferm}}, \overbrace{F}^{\text{auxilliary field}})$$

$$e^{-i\underbrace{\xi Q}} \sim e^{-i\alpha^a t^a}$$

$$S = \int d^4x \left(|\partial\phi|^2 + \bar{\psi}\, i\bar{\sigma}\cdot\partial\psi + F^\dagger F \right)$$

$$\delta\phi \sim \xi\psi$$

auxilliary field

erm

$F^\dagger F\Big)$

$$e^{-i\underbrace{\xi Q}} \sim \underbrace{e^{-i\alpha^a t^a} N}_{\hookrightarrow \left(1 - i\alpha^a t^a \underbrace{v}_{\delta v}\right)}$$

$$\Phi = \text{chiral multiplet} = (\underset{\text{complex scalar}}{\phi}, \underset{\text{Weyl ferm}}{\psi}, \overset{\text{auxilliary field}}{F})$$

$$e^{-i\underbrace{\xi Q}} \sim e^{-i\alpha^a t^a}$$

$$S = \int d^4x \left(|\partial\phi|^2 + \bar{\psi} i \bar{\sigma}\cdot\partial\psi + F^\dagger F \right)$$

$$\delta\phi \sim \xi\psi$$

$$\delta\psi \sim \sigma^\mu \bar{\xi} \partial_\mu \phi$$

Φ = chiral multiplet = (ϕ, ψ, F)

auxilliary field

complex scalar

Weyl ferm

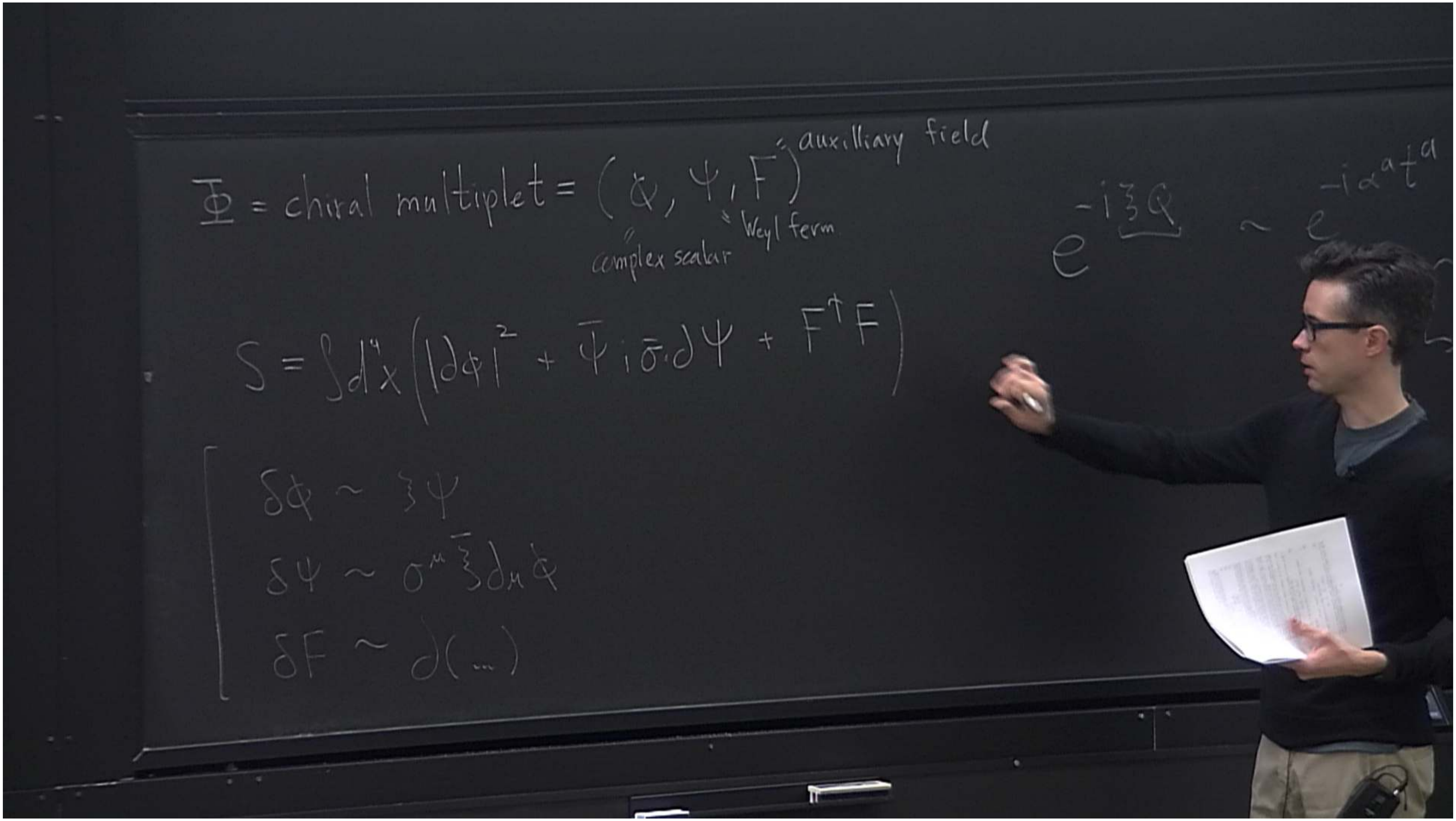
$$e^{-i\underbrace{\xi Q}} \sim e^{-i\alpha^a t^a}$$

$$S = \int d^4x \left(|\partial\phi|^2 + \bar{\psi}\, i\bar{\sigma}\cdot\partial\psi + F^\dagger F \right)$$

$$\delta\phi \sim \xi\psi$$

$$\delta\psi \sim \sigma^\mu \bar{\xi}\partial_\mu\phi$$

$$\delta F \sim \partial(\ldots)$$


Φ = chiral multiplet = (ϕ, ψ, F)
auxilliary field
Weyl ferm
complex scalar
$S = \int d^4x \left(|\partial\phi|^2 + \bar{\psi} i \bar{\sigma}\cdot\partial\psi + F^\dagger F \right)$
$\delta\phi \sim \xi\psi$
$\delta\psi \sim \sigma^\mu \bar{\xi} \partial_\mu \phi$
$\delta F \sim \partial(\dots)$
$e^{-i\xi Q} \sim e^{-i\alpha^a t^a}$

Φ = chiral multiplet = (ϕ, ψ, F)

ϕ: complex scalar

ψ: Weyl ferm

F: auxilliary field

$$e^{-i\underbrace{\xi Q}} \sim e^{-i\alpha^a t^a}$$

$$S = \int d^4x \left(|\partial\phi|^2 + \bar\psi i \bar\sigma \cdot \partial \psi + F^\dagger F \right)$$

$$\left[\begin{array}{l} \delta\phi \sim \xi\psi \\ \delta\psi \sim \sigma^\mu \bar\xi \partial_\mu \phi \\ \delta F \sim \partial(\dots) \end{array}\right.$$

$$\partial^2\phi = 0$$

$$i\bar\sigma\cdot\partial\psi = 0$$

$$F = 0$$

Φ = chiral multiplet = (ϕ, ψ, F)

complex scalar (ϕ), Weyl ferm (ψ), auxilliary field (F)

$$e^{-i\xi Q} \sim e^{-i\alpha^a t^a}$$

$$S = \int d^4x \left(|\partial\phi|^2 + \bar{\psi}\, i\bar{\sigma}\cdot\partial\psi + F^\dagger F \right)$$

$$\begin{aligned} \delta\phi &\sim \xi\psi \\ \delta\psi &\sim \sigma^\mu \bar{\xi}\, \partial_\mu \phi \\ \delta F &\sim \partial(\ldots) \end{aligned}$$

$$\begin{cases} \partial^2\phi = 0 \\ i\bar{\sigma}\cdot\partial\psi = 0 \\ F = 0 \end{cases}$$

$W(\Phi)$ = "superpotential"

$\hookrightarrow$ "holomorphic" $\rightarrow$ only depends on Φ, not $\Phi^\dagger$

$W(\Phi)$ = "superpotential"

↳ "holomorphic" → only depends on Φ, not $\Phi^\dagger$

$$\mathcal{L}_{int} = -\frac{1}{2}\frac{\partial^2 W}{\partial \Phi^2}\bigg|_a \psi\psi + F\frac{\partial W}{\partial \Phi}\bigg|_a + (h.c.)$$

$W(\Phi)$ = "superpotential"

↳ "holomorphic" → only depends on Φ, not $\Phi^\dagger$

$$\mathcal{L}_{int} = -\frac{1}{2}\frac{\partial^2 W}{\partial \Phi^2}\Big|_\phi \psi\psi + F\frac{\partial W}{\partial \Phi}\Big|_\phi + (h.c.)$$

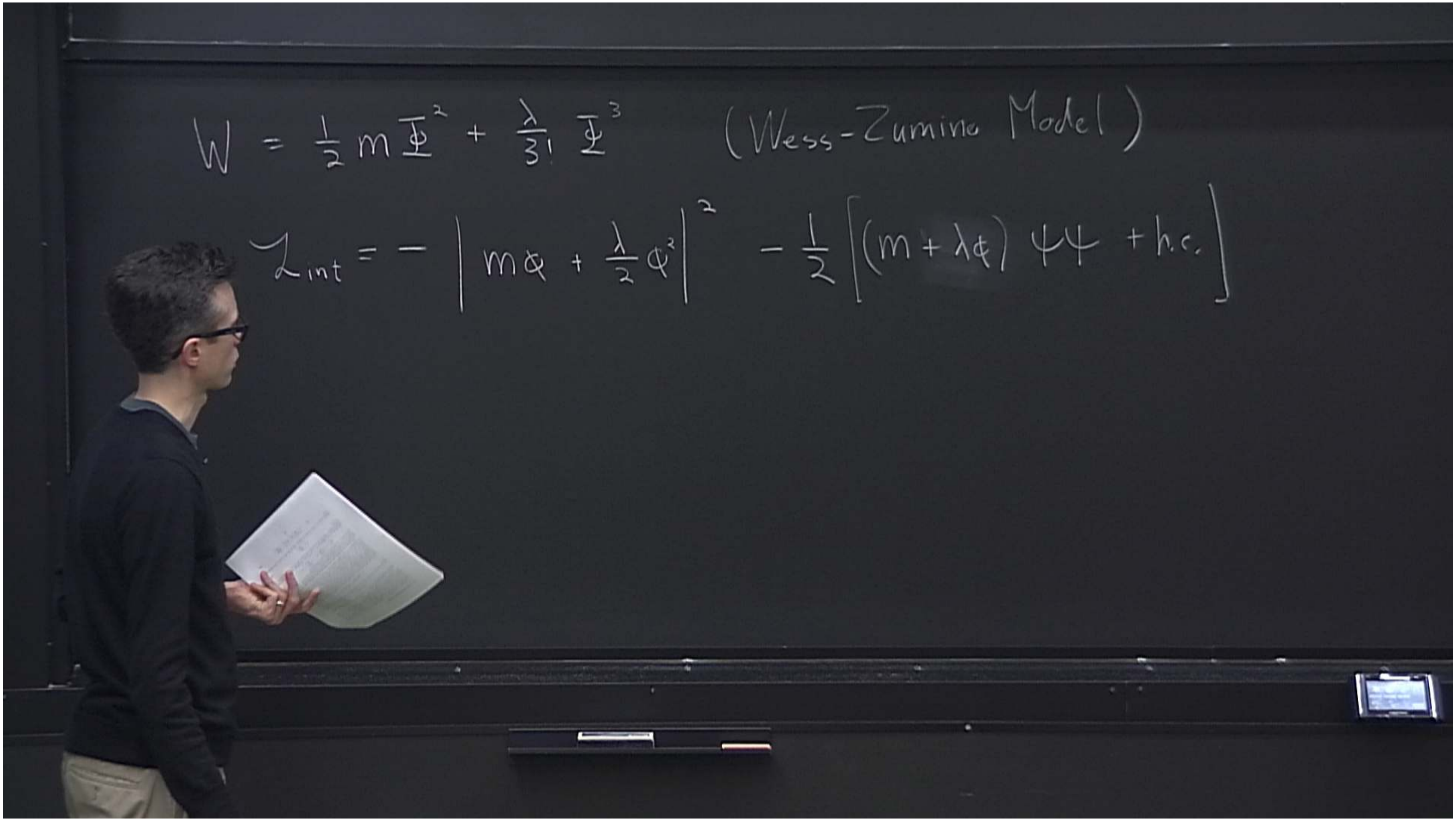
$$F^\dagger = -\frac{\partial W}{\partial \Phi}\Big|_\phi$$

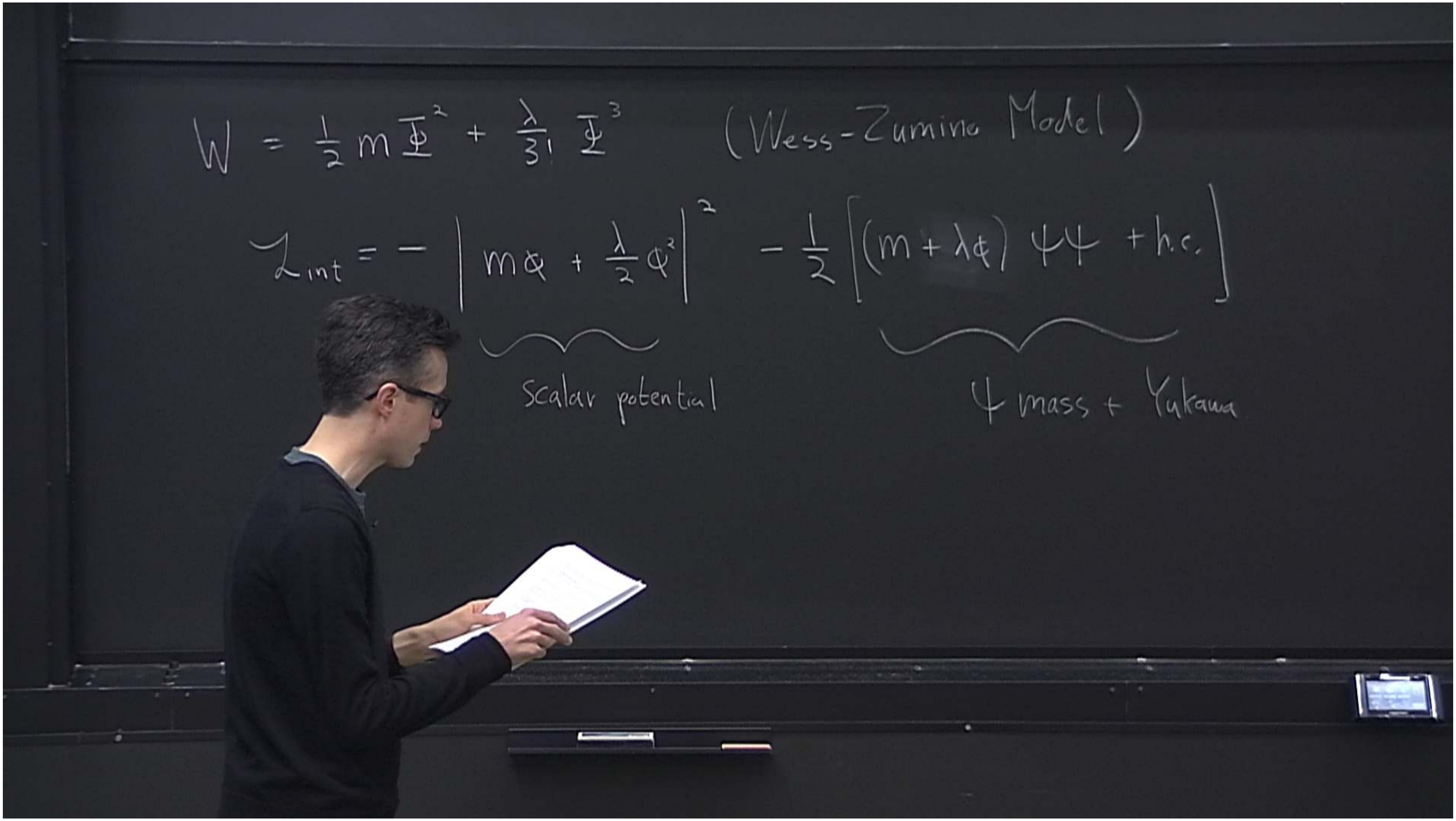
$W(\Phi)$ = "superpotential"

↳ "holomorphic" → only depends on Φ, not $\Phi^\dagger$

$$\mathcal{L}_{int} = -\frac{1}{2}\frac{\partial^2 W}{\partial \Phi^2}\bigg|_\phi \psi\psi + F\frac{\partial W}{\partial \Phi}\bigg|_\phi + (h.c.)$$

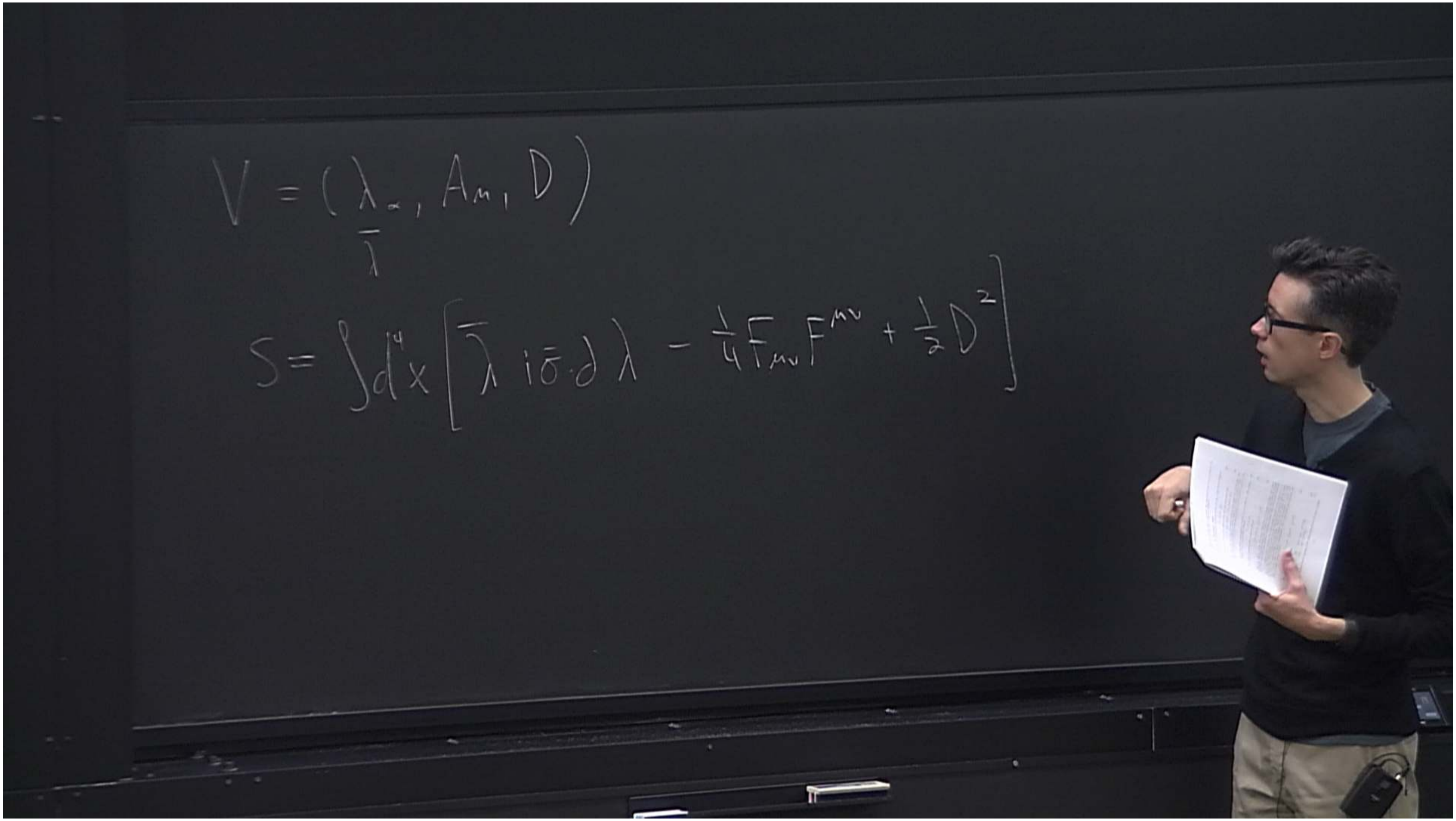
$$F^\dagger = -\frac{\partial W}{\partial \Phi}\bigg|_\phi \xrightarrow{\text{plug back}} \mathcal{L}_{int} = -\frac{1}{2}\left[\frac{\partial^2 W}{\partial \Phi^2}\bigg|_\phi \psi\psi + (h.c.)\right] - \left|\frac{\partial W}{\partial \Phi}\bigg|_\phi\right|^2$$

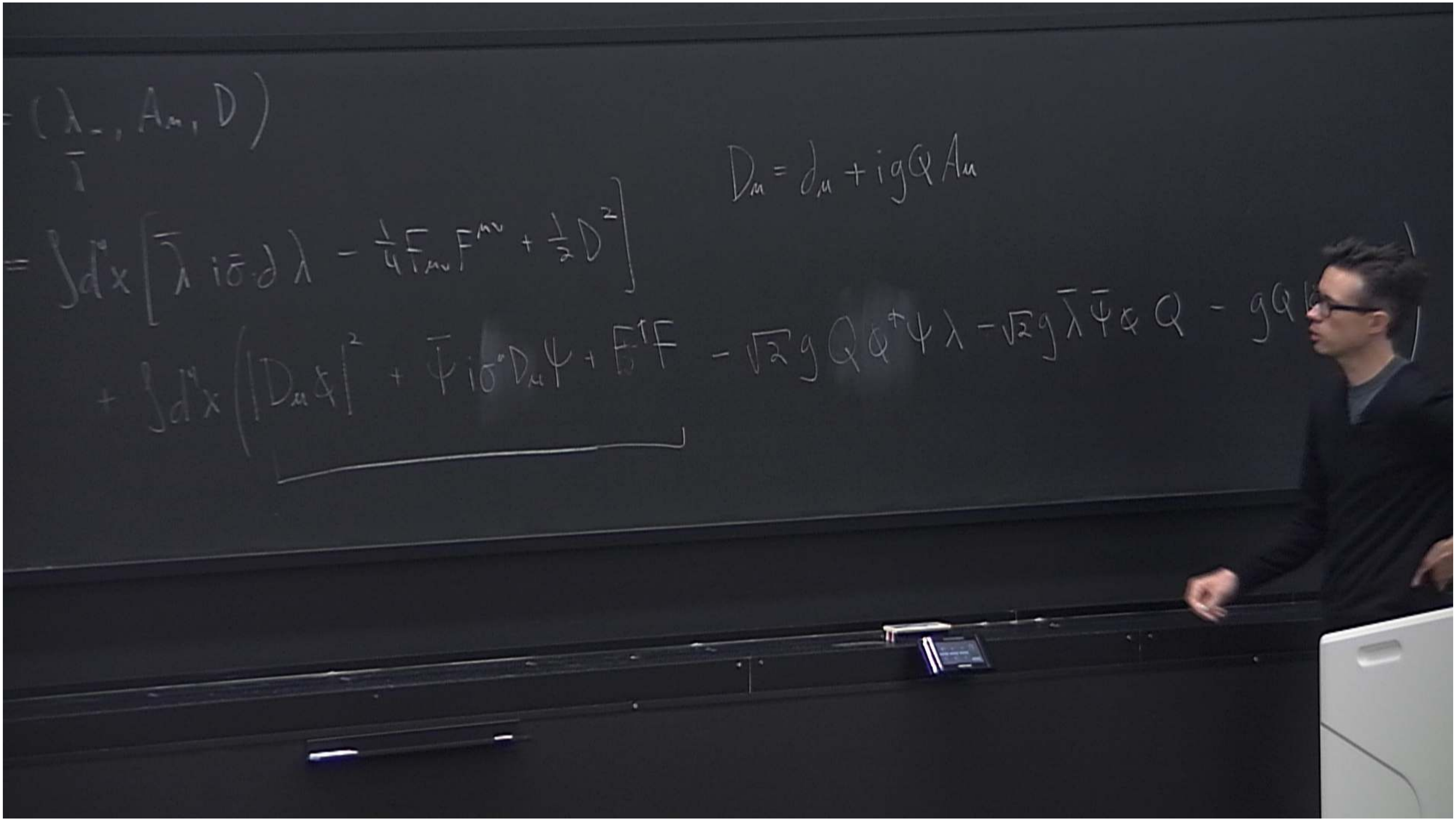

$W = \frac{1}{2} m \Phi^2 + \frac{\lambda}{3!} \Phi^3$ (Wess-Zumino Model)
$\mathcal{L}_{int} = - \left| m\phi + \frac{\lambda}{2}\phi^2 \right|^2 - \frac{1}{2}\left[(m + \lambda\phi)\psi\psi + h.c. \right]$


$W = \frac{1}{2} m \Phi^2 + \frac{\lambda}{3!} \Phi^3$
(Wess-Zumino Model)
$\mathcal{L}_{int} = - \underbrace{\left| m\phi + \frac{\lambda}{2}\phi^2 \right|^2}_{\text{scalar potential}} - \frac{1}{2} \underbrace{\left[(m + \lambda\phi)\psi\psi + h.c. \right]}_{\psi \text{ mass + Yukawa}}$
scalar potential
ψ mass + Yukawa

$$W = \frac{1}{2} m \Phi^2 + \frac{\lambda}{3!} \Phi^3 \qquad \text{(Wess-Zumino Model)}$$

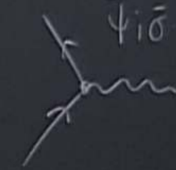
$$\mathcal{L}_{int} = -\underbrace{\left| m\phi + \frac{\lambda}{2}\phi^2 \right|^2}_{\text{scalar potential}} - \frac{1}{2}\underbrace{\left[(m + \lambda\phi)\psi\psi + h.c. \right]}_{\psi \text{ mass + Yukawa}}$$


$V = (\lambda_\alpha, A_\mu, D)$
$\bar{\lambda}$
$S = \int d^4x \left[\bar{\lambda}\, i \bar{\sigma}\cdot\partial\, \lambda - \frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \frac{1}{2} D^2 \right]$


= (λ₋ , Aμ , D)
λ̄
Dμ = ∂μ + igQ Aμ
= ∫d⁴x [λ̄ iσ̄·∂ λ − ¼ Fμν F^μν + ½ D²]
+ ∫d⁴x (|Dμ φ|² + ψ̄ iσ̄^μ Dμ ψ + F†F − √2 g Q φ† ψ λ − √2 g λ̄ ψ̄ φ Q − gQ

$$= (\lambda_-, A_\mu, D)$$
$$\bar{\lambda}$$

$$D_\mu = \partial_\mu + igQA_\mu$$



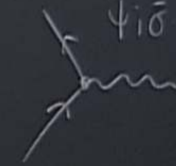
$\bar{\psi} i\bar{\sigma} D_\mu \psi$

$$= \int d^4x \left[\bar{\lambda}\, i\bar{\sigma}\cdot\partial \lambda - \frac{1}{4} F_{\mu\nu}F^{\mu\nu} + \frac{1}{2} D^2 \right]$$

$$+ \int d^4x \Big(\underbrace{|D_\mu \phi|^2 + \bar{\psi}\, i\bar{\sigma}^\mu D_\mu \psi + F^\dagger F} - \sqrt{2} g Q \phi^\dagger \psi \lambda - \sqrt{2} g \bar{\lambda} \bar{\psi} \phi Q - g Q |\phi|^2 D \Big)$$

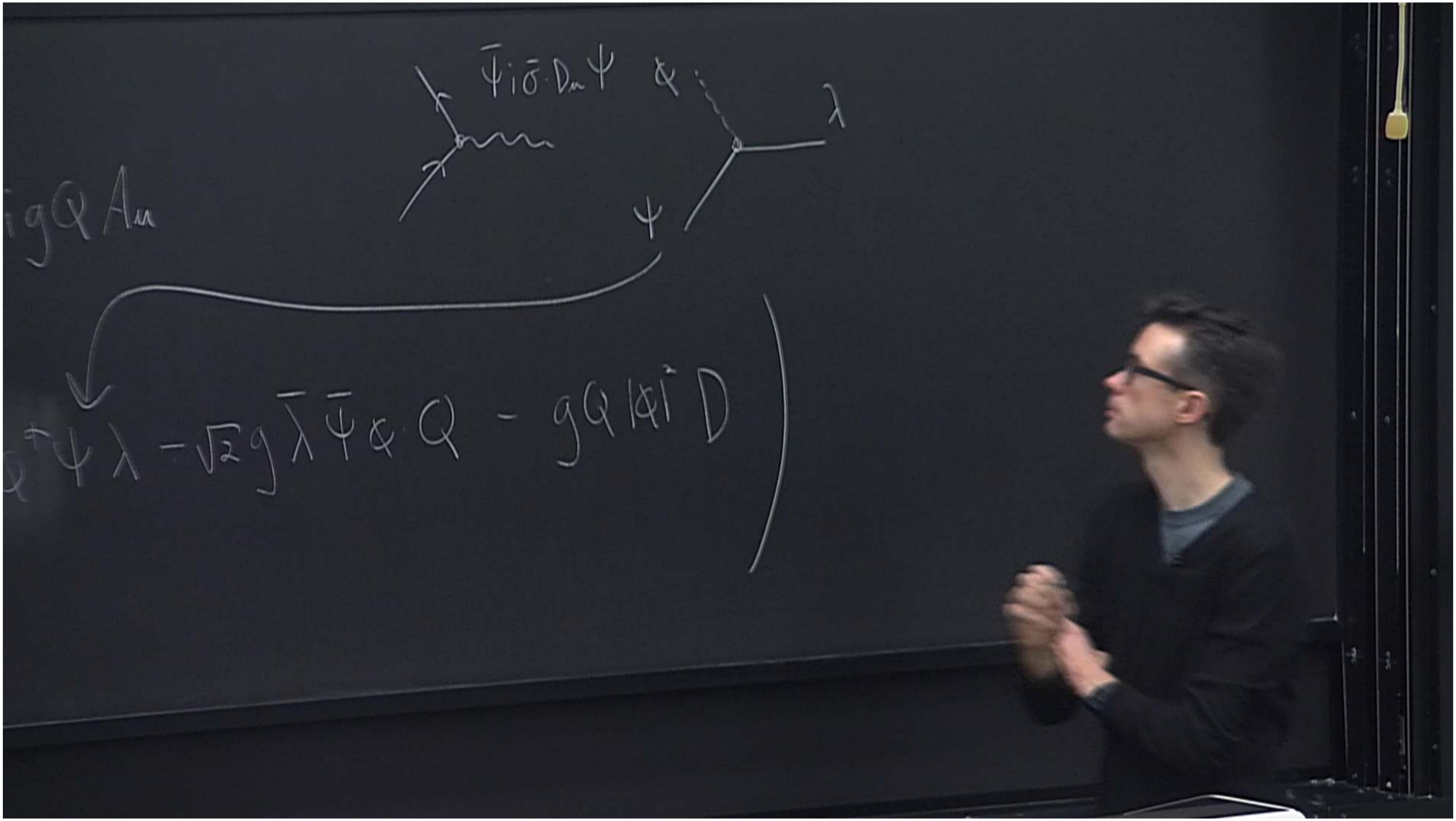
$= (\lambda_-, A_\mu, D)$
$\quad \bar{\lambda}$

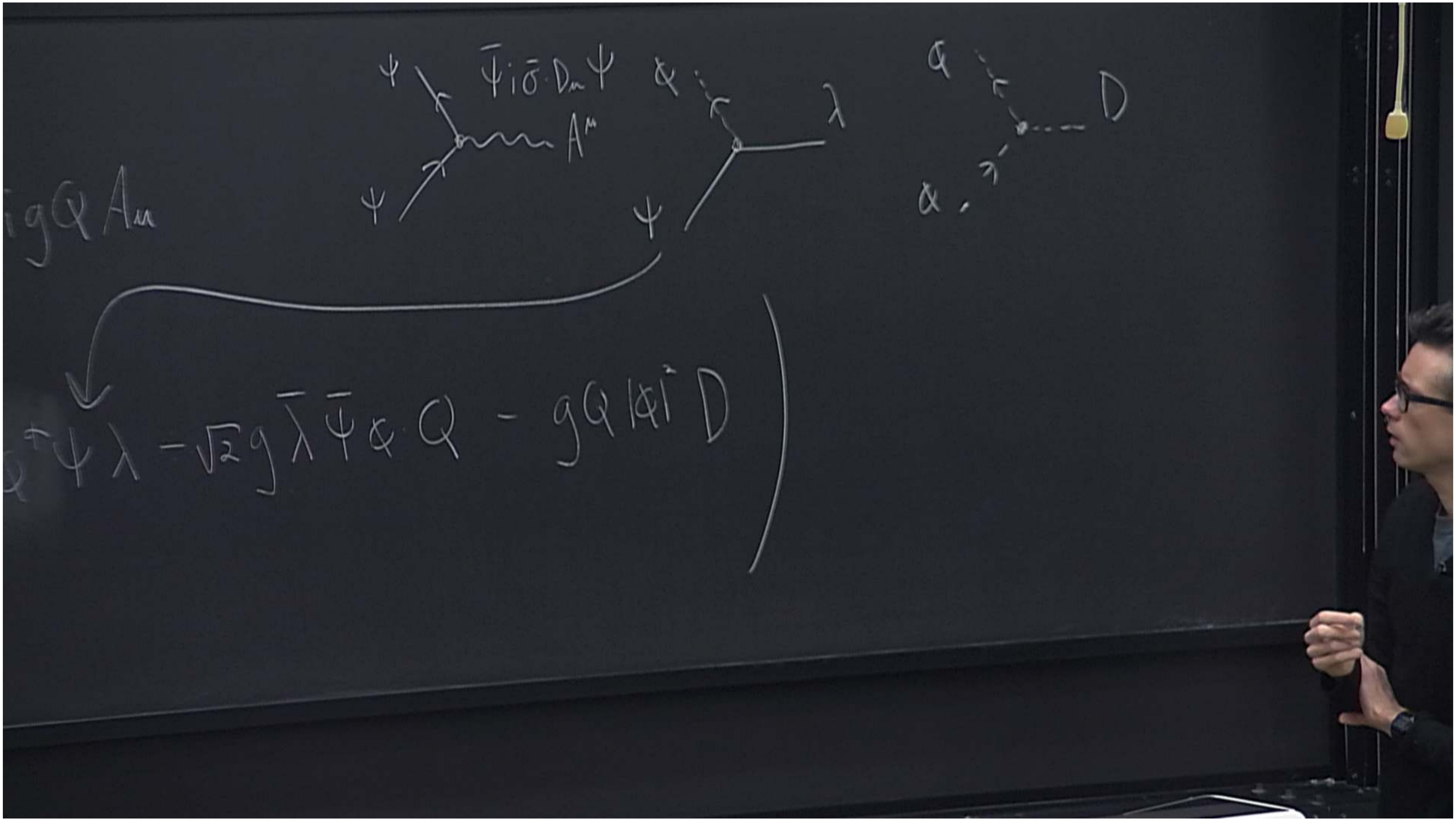
$D_\mu = \partial_\mu + igQA_\mu$

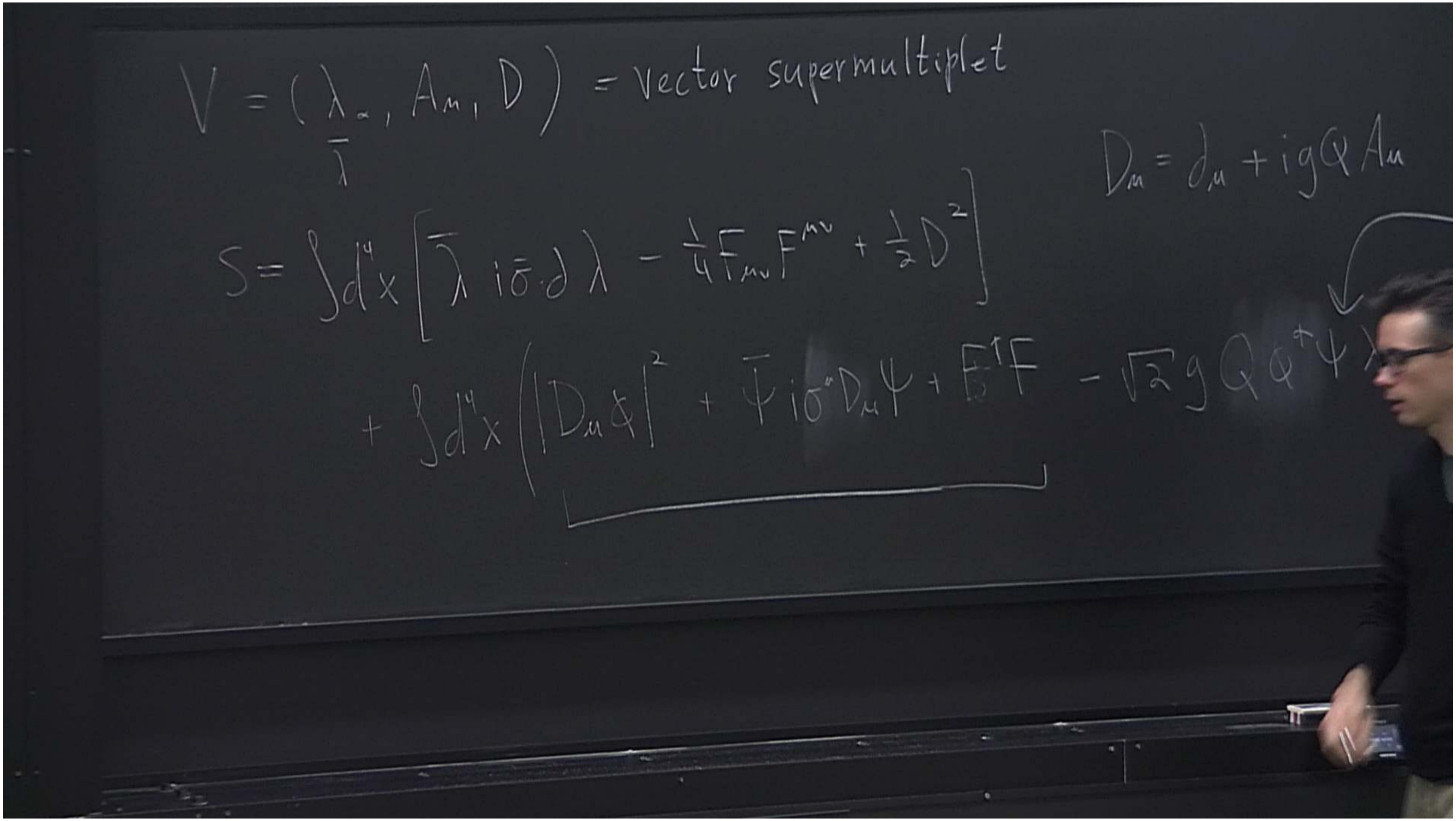


$$= \int d^4x \left[\bar{\lambda} i\bar{\sigma}\cdot\partial\lambda - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \frac{1}{2}D^2 \right]$$

$$+ \int d^4x \Big(\underbrace{|D_\mu \phi|^2 + \bar{\Psi} i\bar{\sigma}^\mu D_\mu \Psi + F^\dagger F}_{} - \sqrt{2}\, g\, Q \phi^\dagger \Psi \lambda - \sqrt{2}\, g\, \bar{\lambda} \bar{\Psi} \phi\, Q - gQ|\phi|^2 D \Big)$$


$\bar{\psi} i \bar{\sigma} \cdot D_\mu \psi$
ϕ
λ
ψ
$igQA_\mu$
$\phi^* \psi \lambda - \sqrt{2} g \bar{\lambda} \bar{\psi} \phi \cdot Q - gQ|\phi|^2 D$


$\bar{\psi} i \bar{\sigma} \cdot D_\mu \psi$
A^μ
λ
D
$igQ A_\mu$
$\psi\lambda - \sqrt{2} g \bar{\lambda} \bar{\psi} \phi \cdot Q - gQ|\phi|^2 D$


$V = (\lambda_\alpha, A_\mu, D)$ = vector supermultiplet
$\bar{\lambda}$
$D_\mu = \partial_\mu + igQA_\mu$
$S = \int d^4x \left[\bar{\lambda} i \bar{\sigma}\cdot\partial \lambda - \frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \frac{1}{2} D^2 \right]$
$+ \int d^4x \left(|D_\mu \phi|^2 + \bar{\psi} i \bar{\sigma}^\mu D_\mu \psi + F^\dagger F \right. - \sqrt{2} g Q \phi^\dagger \psi \lambda$