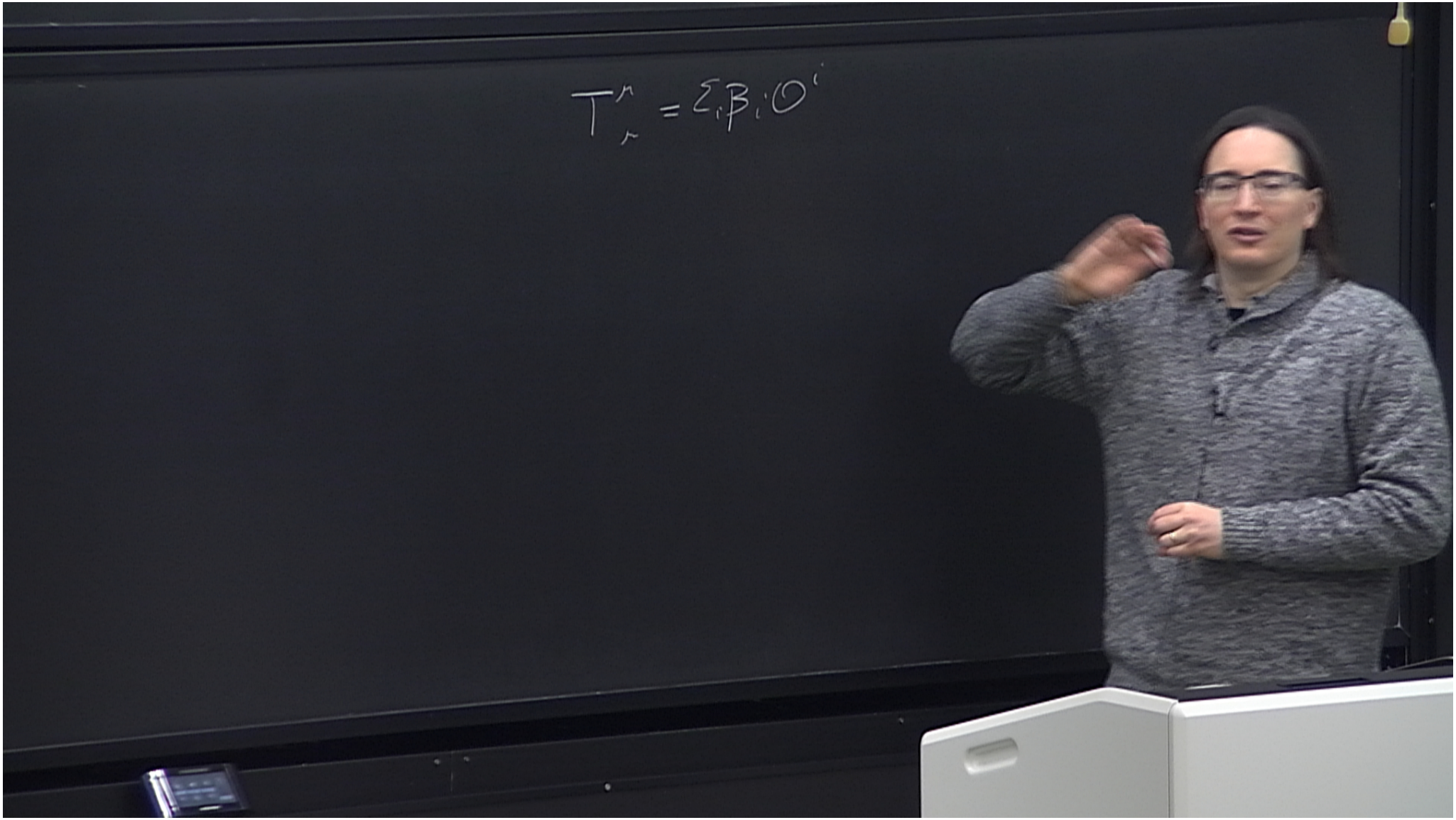
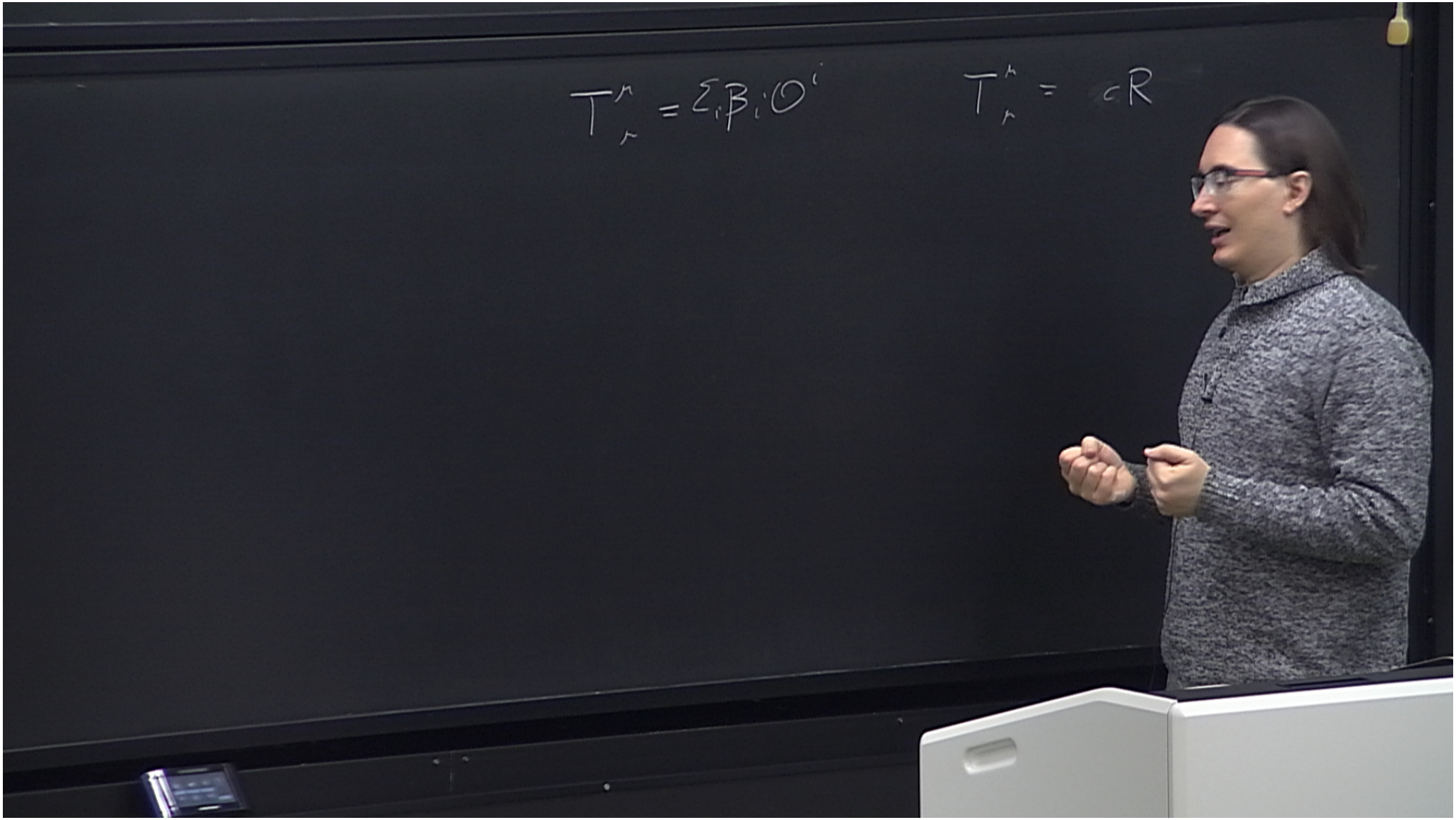
Title: PSI 2015/2016 String Theory - Lecture 5

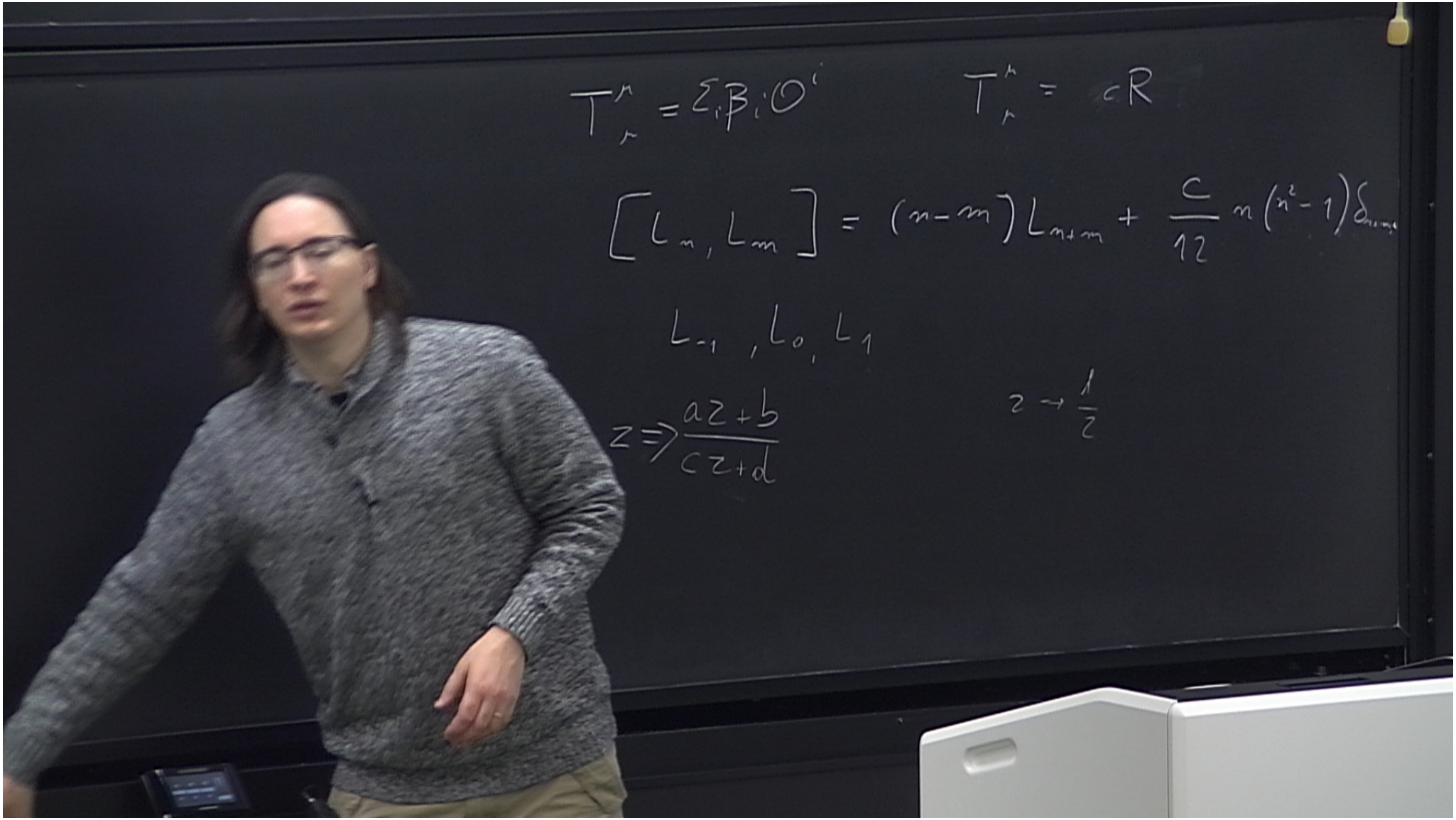
Date: Feb 05, 2016 10:15 AM

URL: http://pirsa.org/16020039

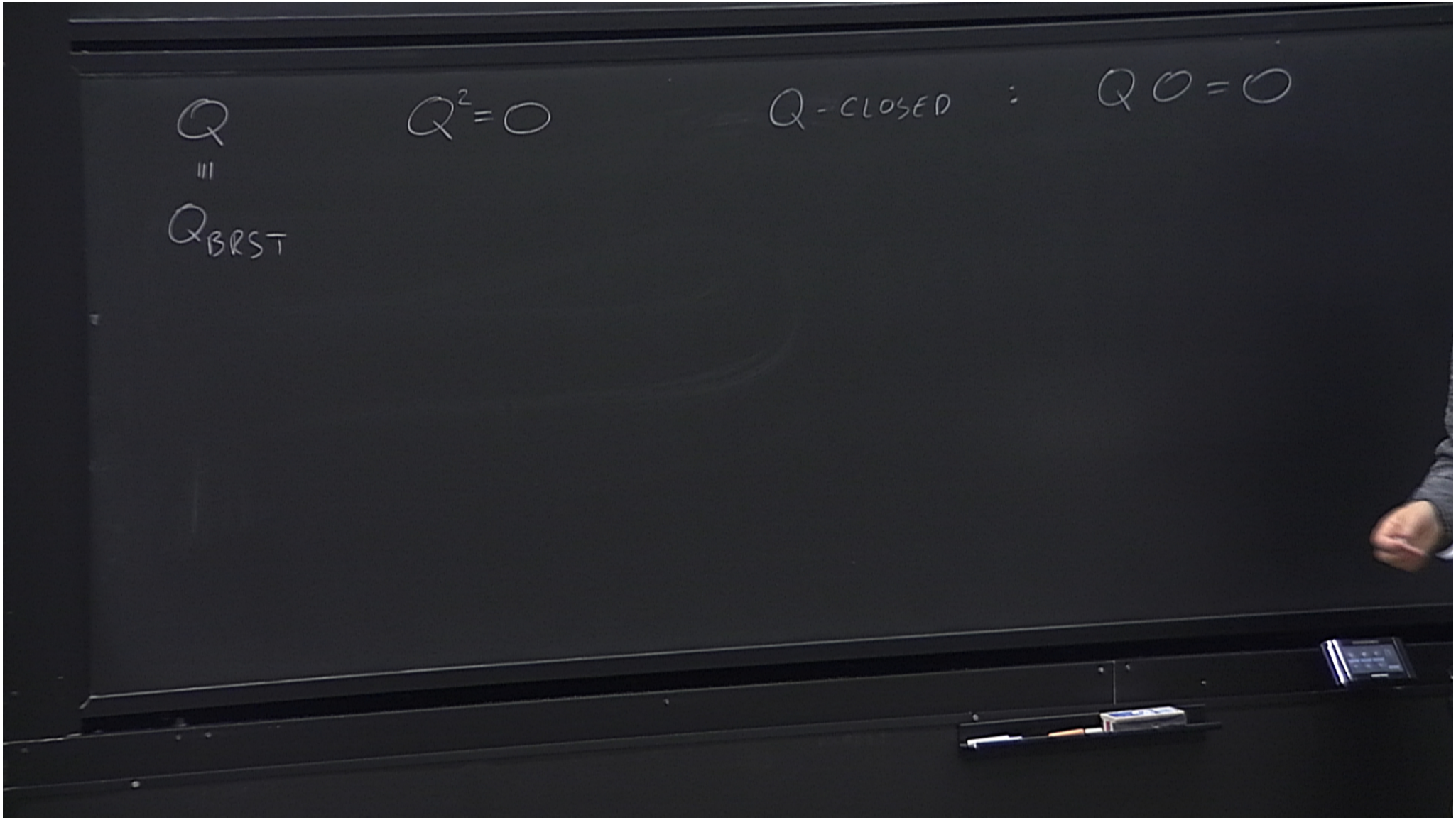
Abstract:

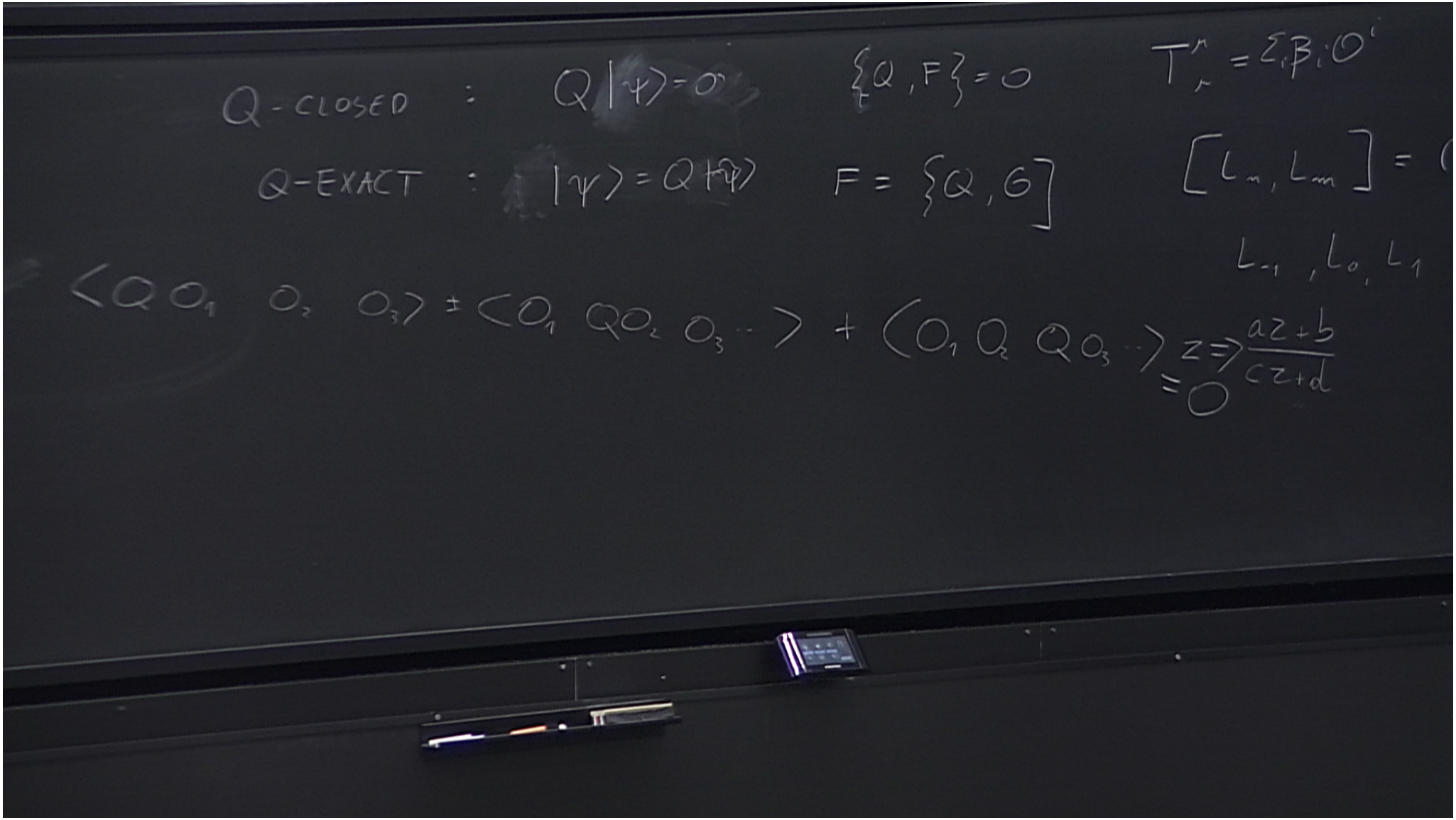

$T^{\wedge}_{\wedge} = \Sigma_i \beta_i O^i$

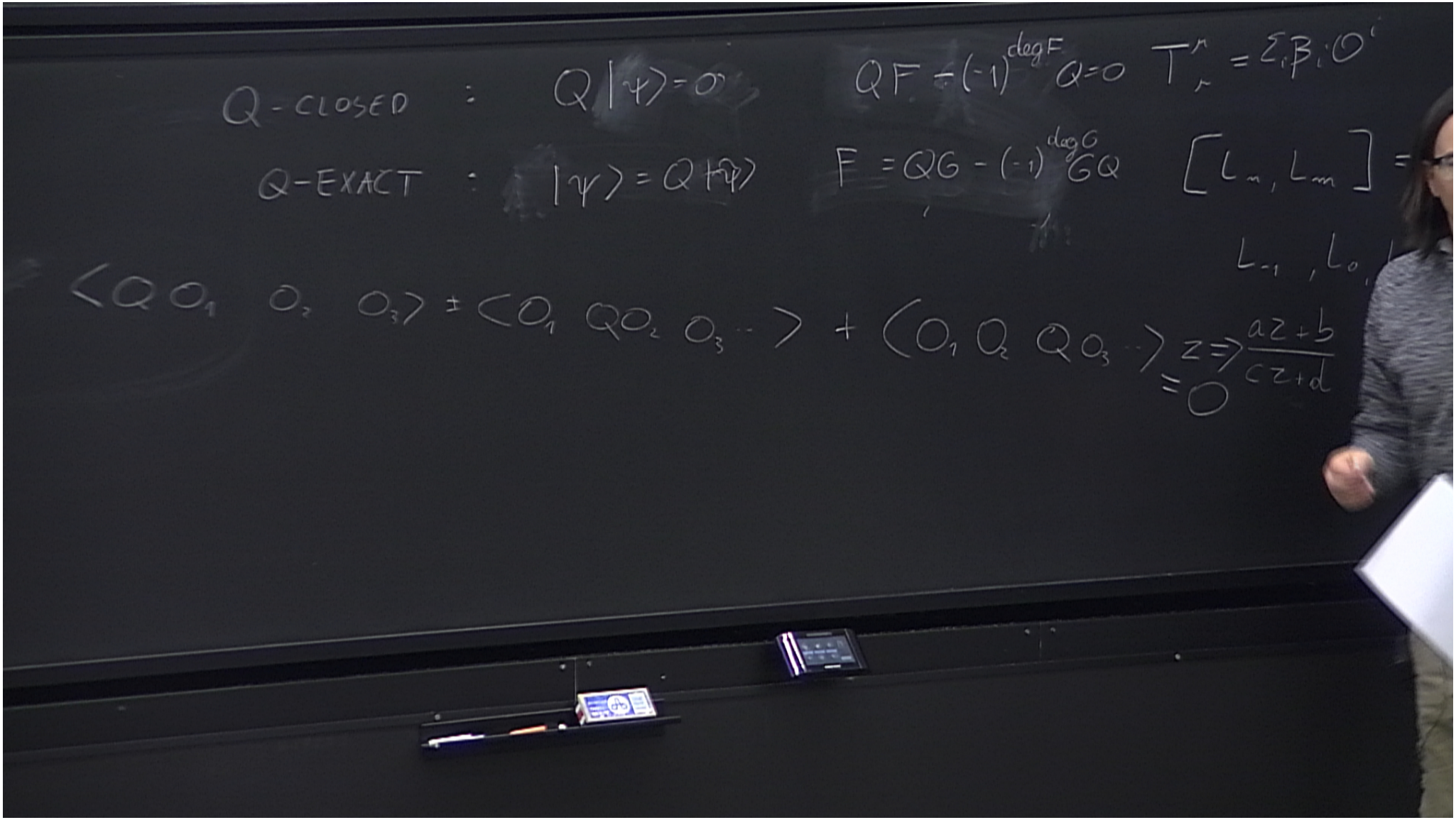

$T^{\wedge}_{\wedge} = \Sigma_i \beta_i O^i$
$T^{\wedge}_{\wedge} = cR$

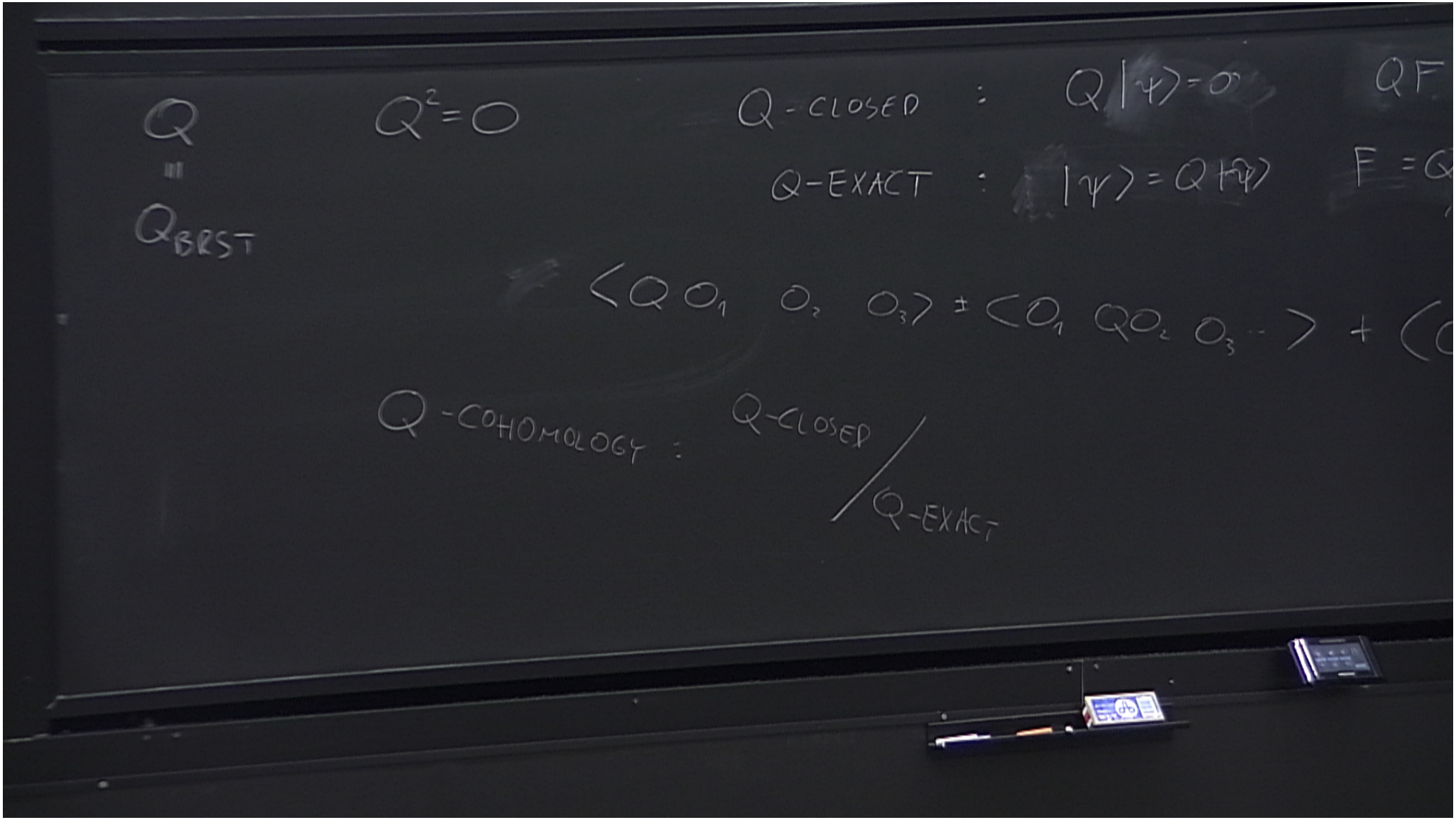

$T^{\Lambda}_{\Lambda} = \Sigma_i \beta_i \mathcal{O}^i$
$T^{\Lambda}_{\Lambda} = cR$
$[L_n, L_m] = (n-m)L_{n+m} + \frac{c}{12} n(n^2-1)\delta_{n+m}$
L_{-1}, L_0, L_1
$z \Rightarrow \frac{az+b}{cz+d}$
$z \to \frac{1}{z}$


Q
$Q^2 = 0$
Q_{BRST}

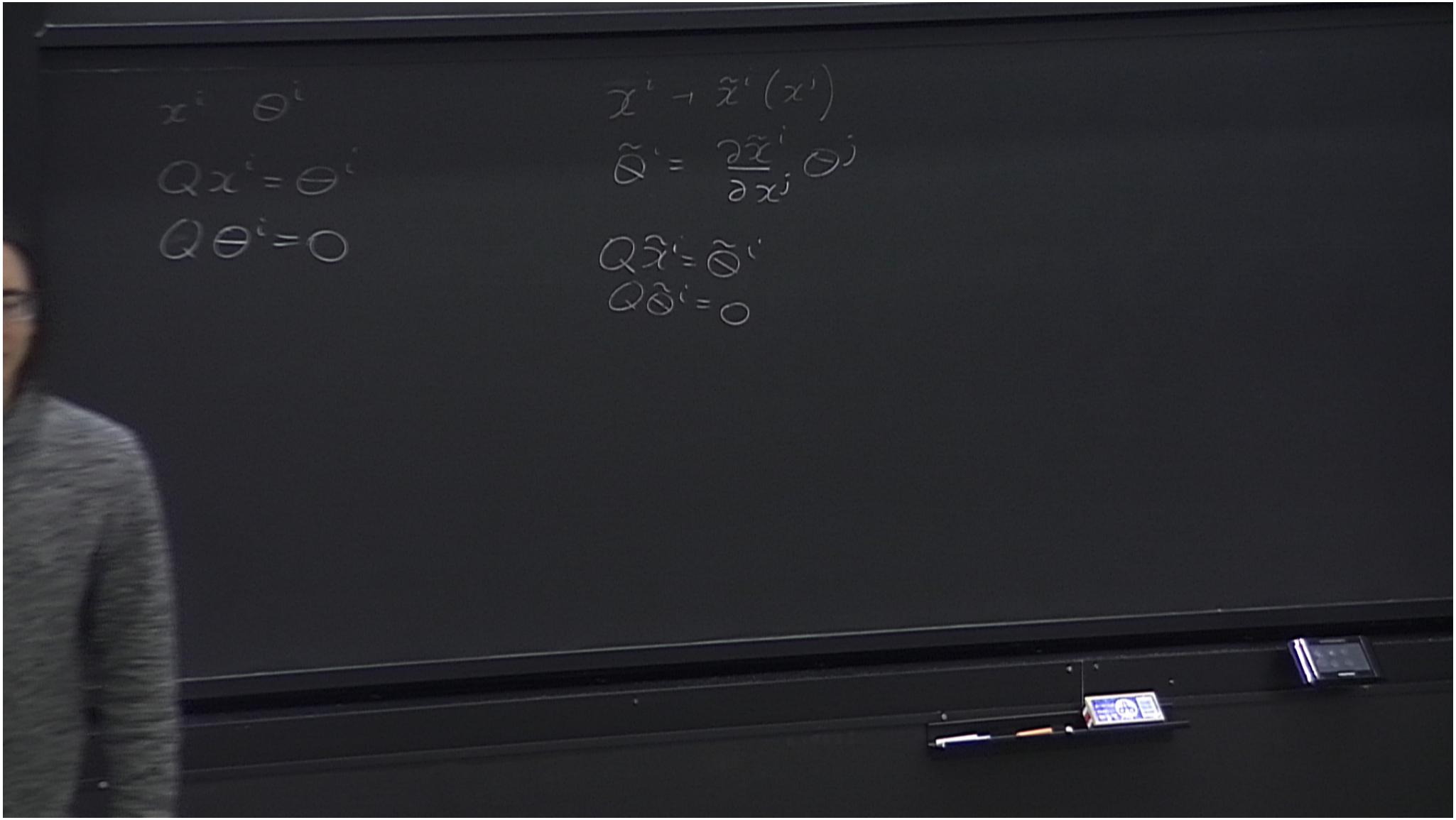

Q
$Q^2 = 0$
Q - CLOSED :
$Q\mathcal{O} = 0$
=
Q_{BRST}

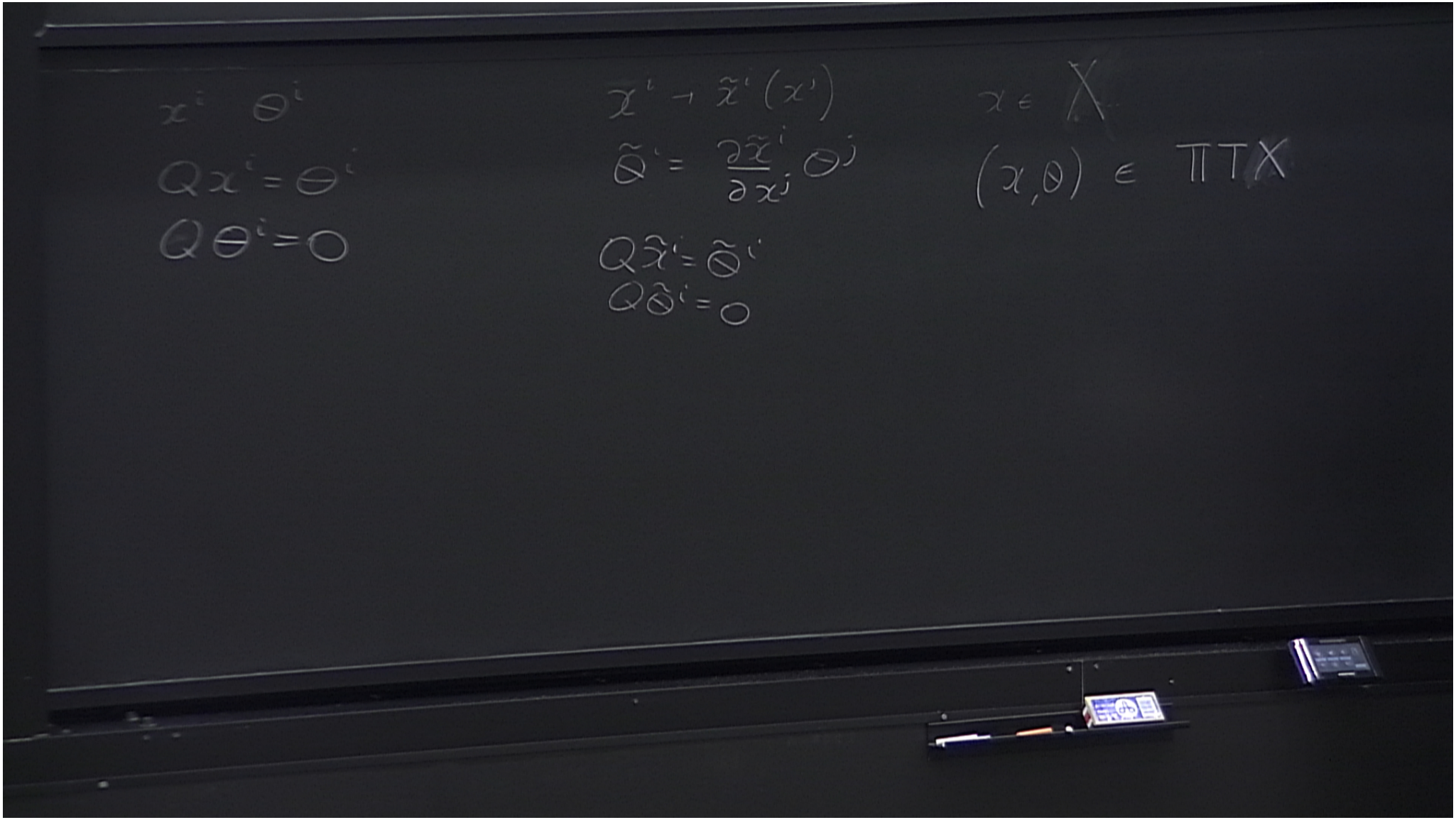

Q-CLOSED : $Q|\psi\rangle = 0$
$\{Q, F\} = 0$
$T_r = \sum_i \beta_i O^i$
Q-EXACT : $|\psi\rangle = Q|\phi\rangle$
$F = \{Q, G\}$
$[L_m, L_{-m}] =$
L_{-1}, L_0, L_1
$\langle Q O_1 O_2 O_3 \rangle \pm \langle O_1 Q O_2 O_3 \cdots \rangle + \langle O_1 O_2 Q O_3 \cdots \rangle$
$z \Rightarrow \frac{az+b}{cz+d}$
$= 0$

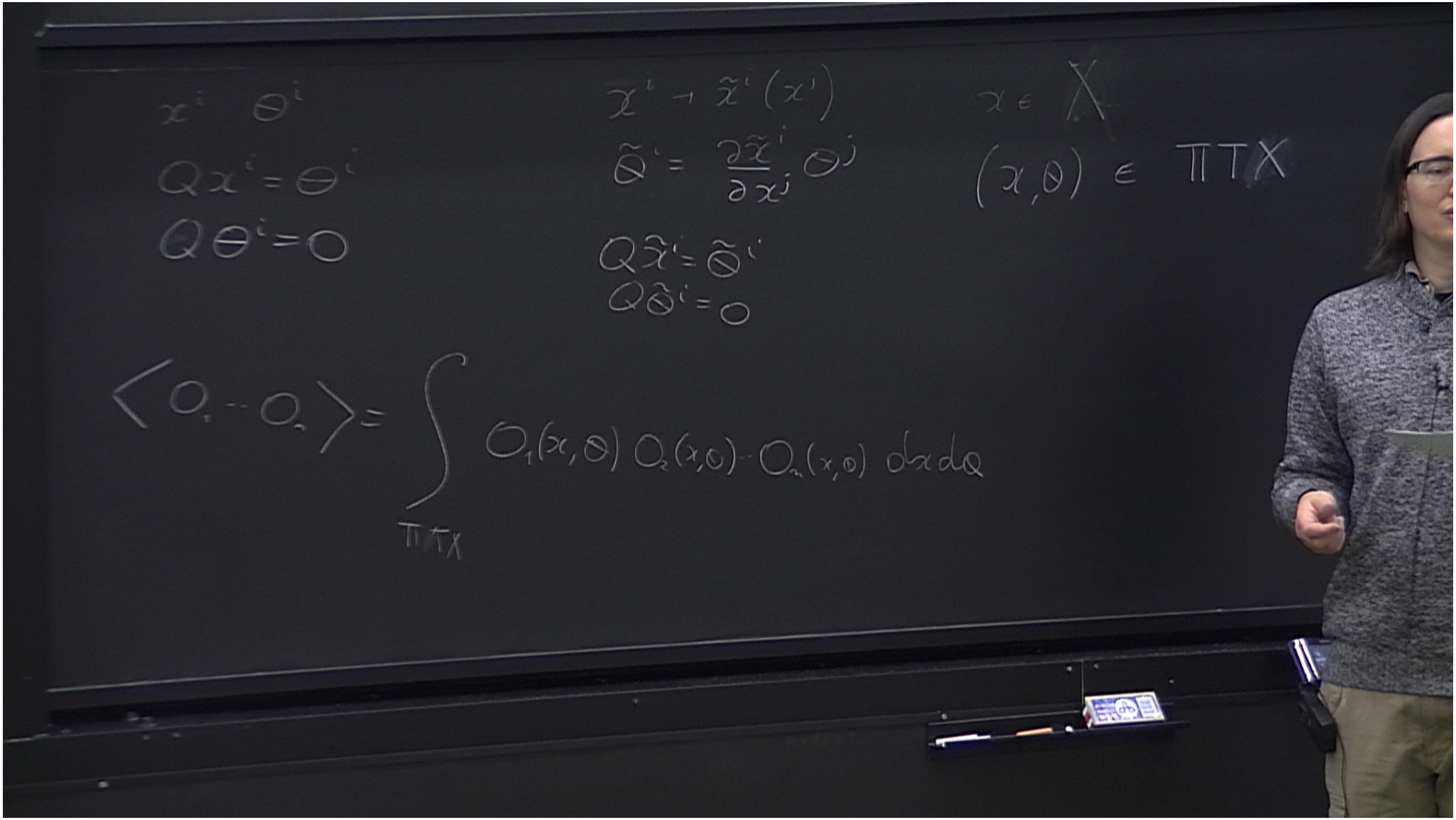

Q-CLOSED : $Q|\psi\rangle = 0$
$QF = (-1)^{\deg F} FQ = 0$
$T'_r = \Sigma_i \beta_i O^i$
Q-EXACT : $|\psi\rangle = Q|\Phi\rangle$
$F = QG - (-1)^{\deg G} GQ$
$[L_m, L_{-m}] =$
$L_{-1}, L_0,$
$\langle Q O_1 O_2 O_3 \rangle \pm \langle O_1 Q O_2 O_3 \cdots \rangle + \langle O_1 O_2 Q O_3 \cdots \rangle = 0$
$z \Rightarrow \frac{az+b}{cz+d}$

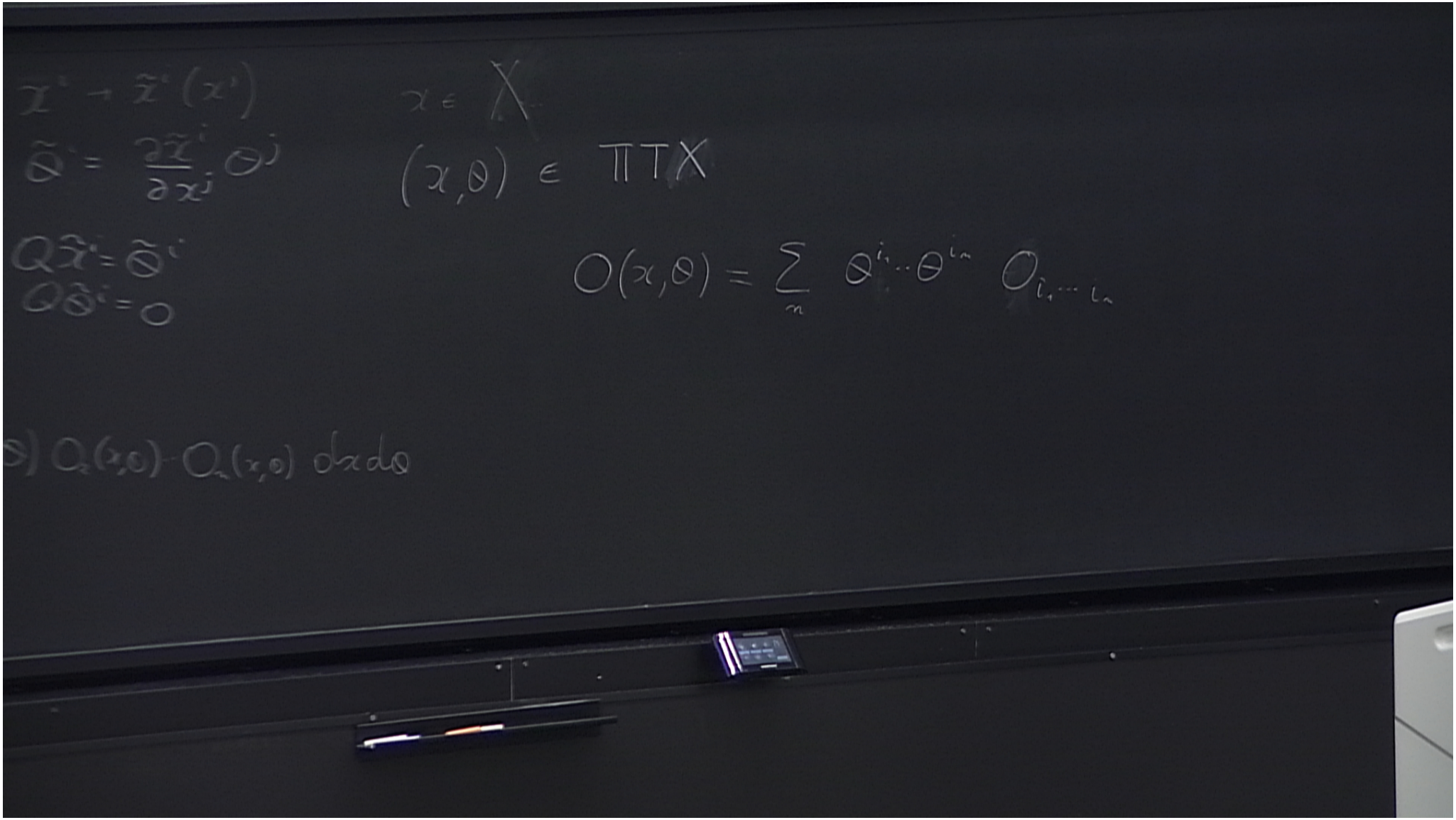

Q
=
Q_{BRST}
$Q^2 = 0$
Q - CLOSED : $Q|\psi\rangle = 0$
Q-EXACT : $|\psi\rangle = Q|\Phi\rangle$
$\langle Q O_1 O_2 O_3 \rangle \pm \langle O_1 Q O_2 O_3 \cdots \rangle +$
Q - COHOMOLOGY : Q-CLOSED / Q-EXACT

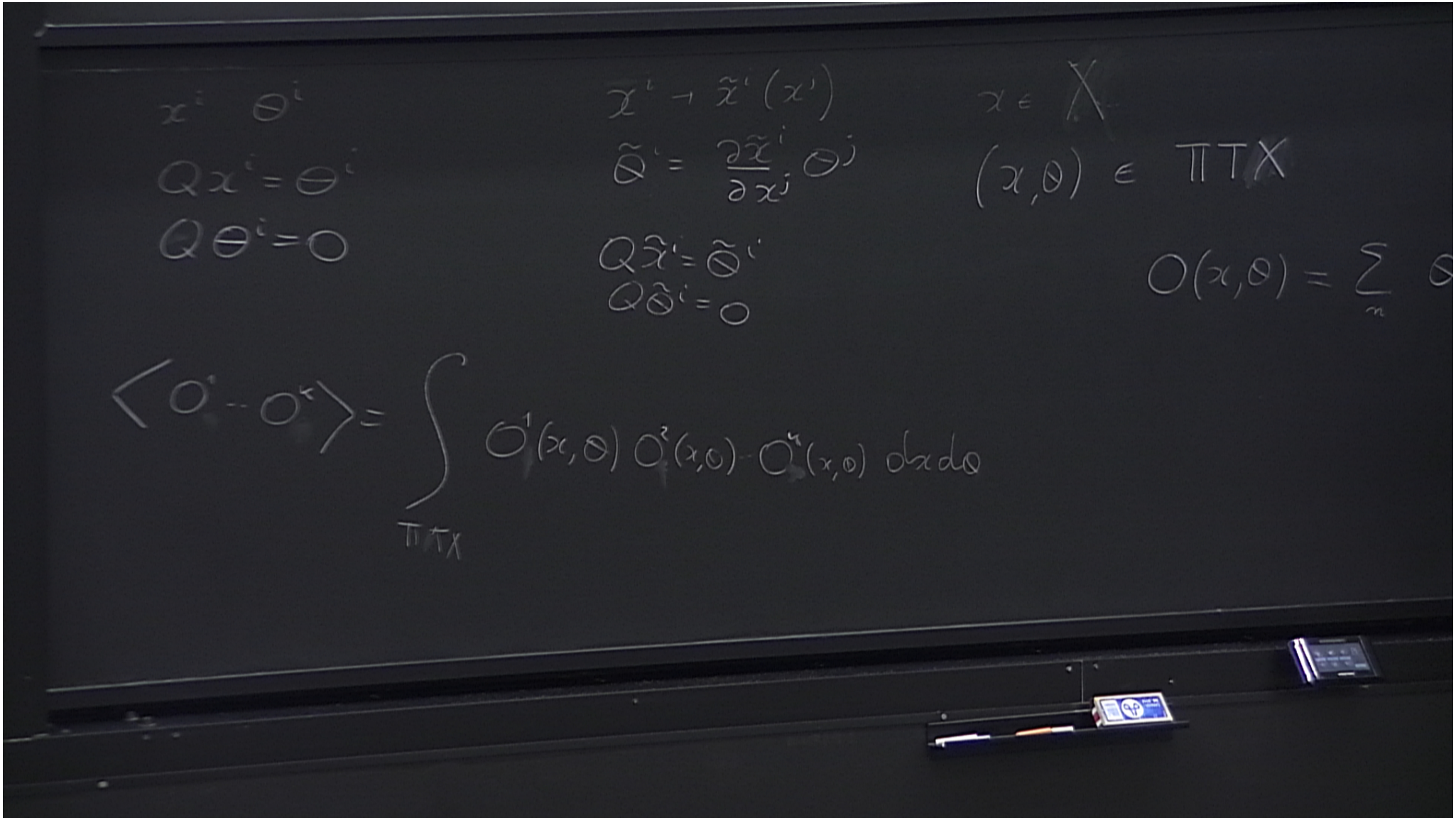

$x^i \quad \theta^i$
$Q x^i = \theta^i$
$Q \theta^i = 0$

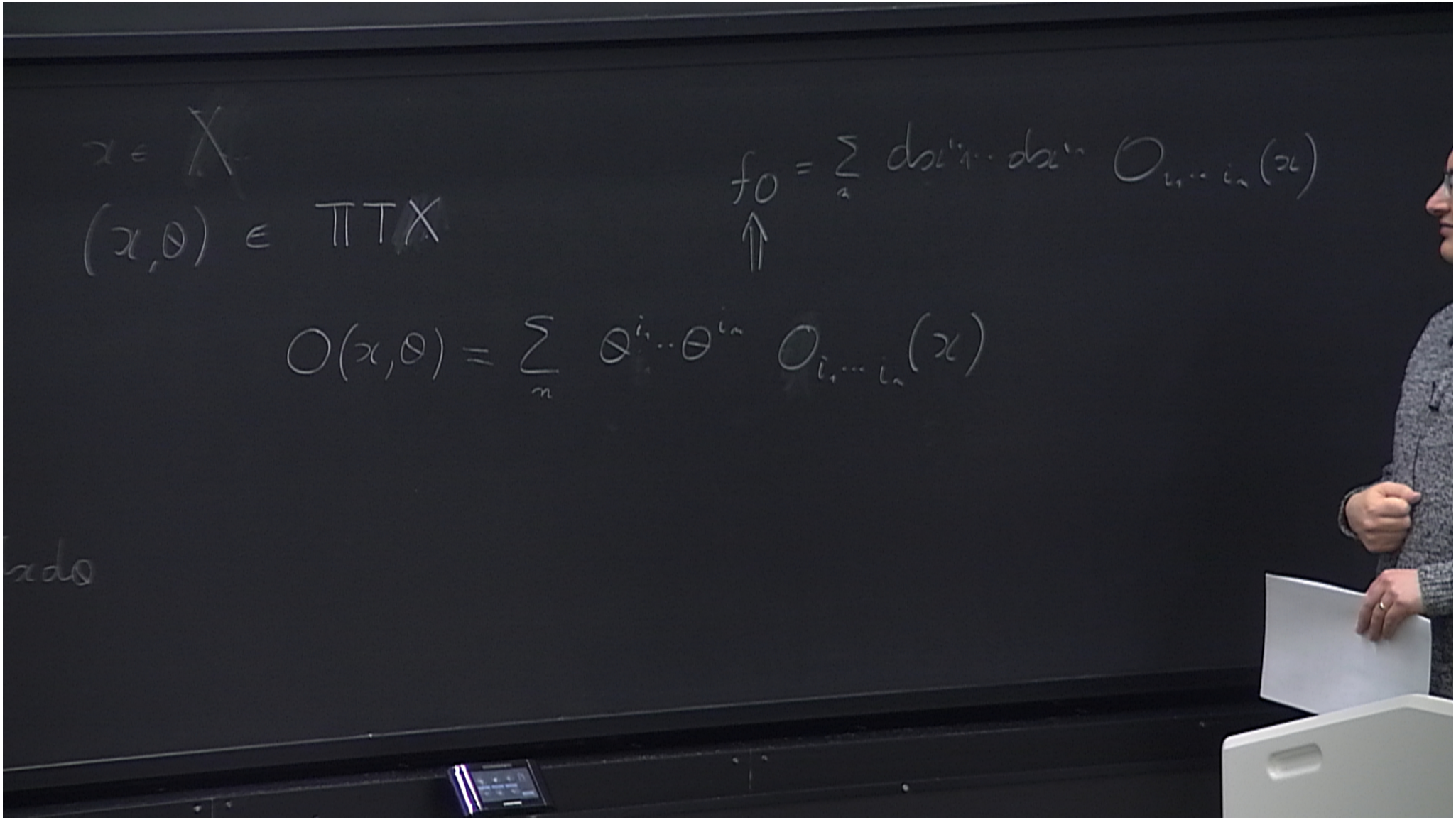

$x^i \quad \theta^i$
$Qx^i = \theta^i$
$Q\theta^i = 0$
$x^i \to \tilde{x}^i(x^i)$
$\tilde{\theta}^i = \frac{\partial \tilde{x}^i}{\partial x^j}\theta^j$
$Q\tilde{x}^i = \tilde{\theta}^i$
$Q\tilde{\theta}^i = 0$

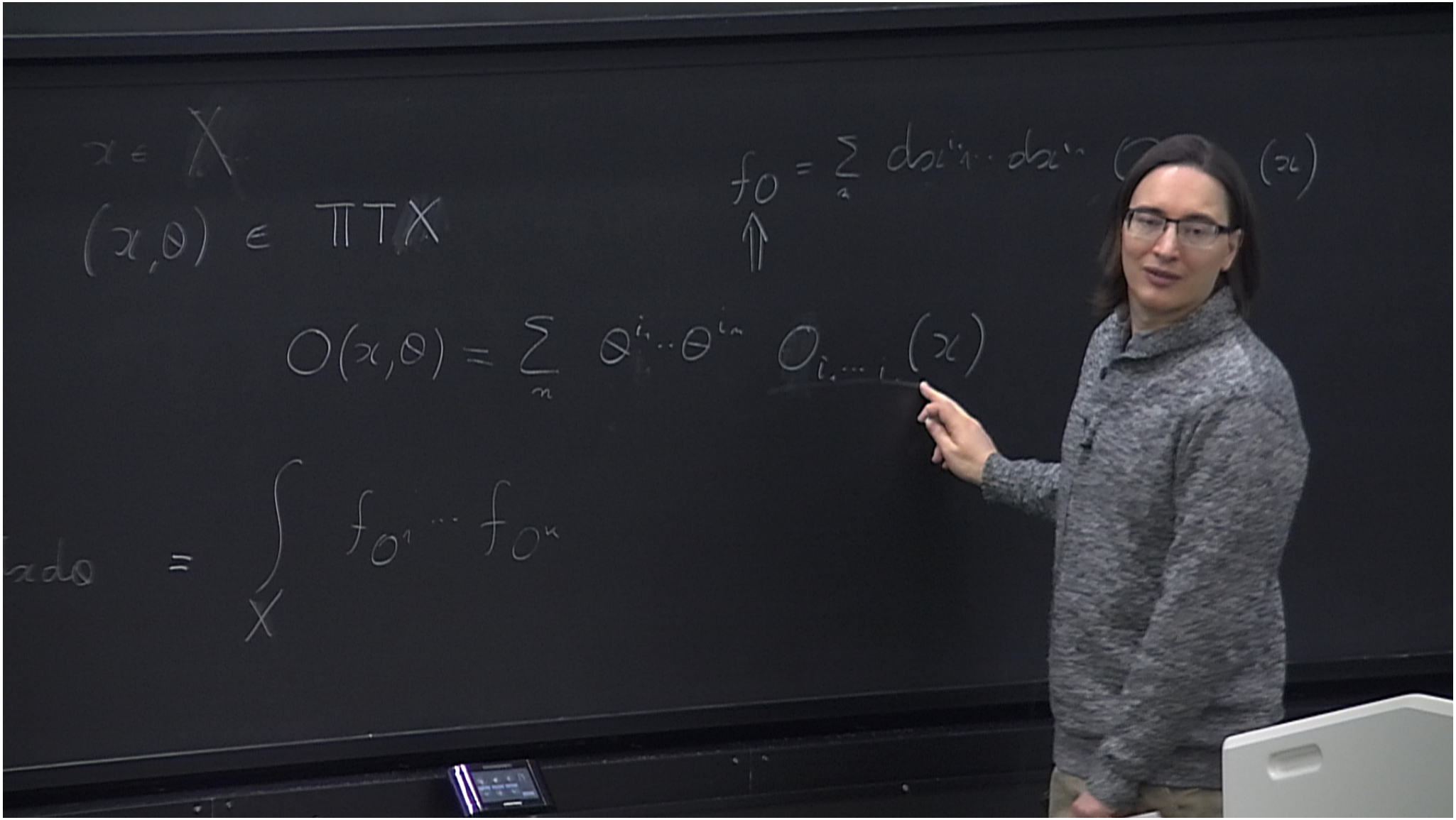

$x^i \quad \theta^i$
$Qx^i = \theta^i$
$Q\theta^i = 0$
$x^i \to \tilde{x}^i(x^i)$
$\tilde{\theta}^i = \frac{\partial \tilde{x}^i}{\partial x^j}\theta^j$
$Q\tilde{x}^i = \tilde{\theta}^i$
$Q\tilde{\theta}^i = 0$
$x \in X$
$(x, \theta) \in TTX$

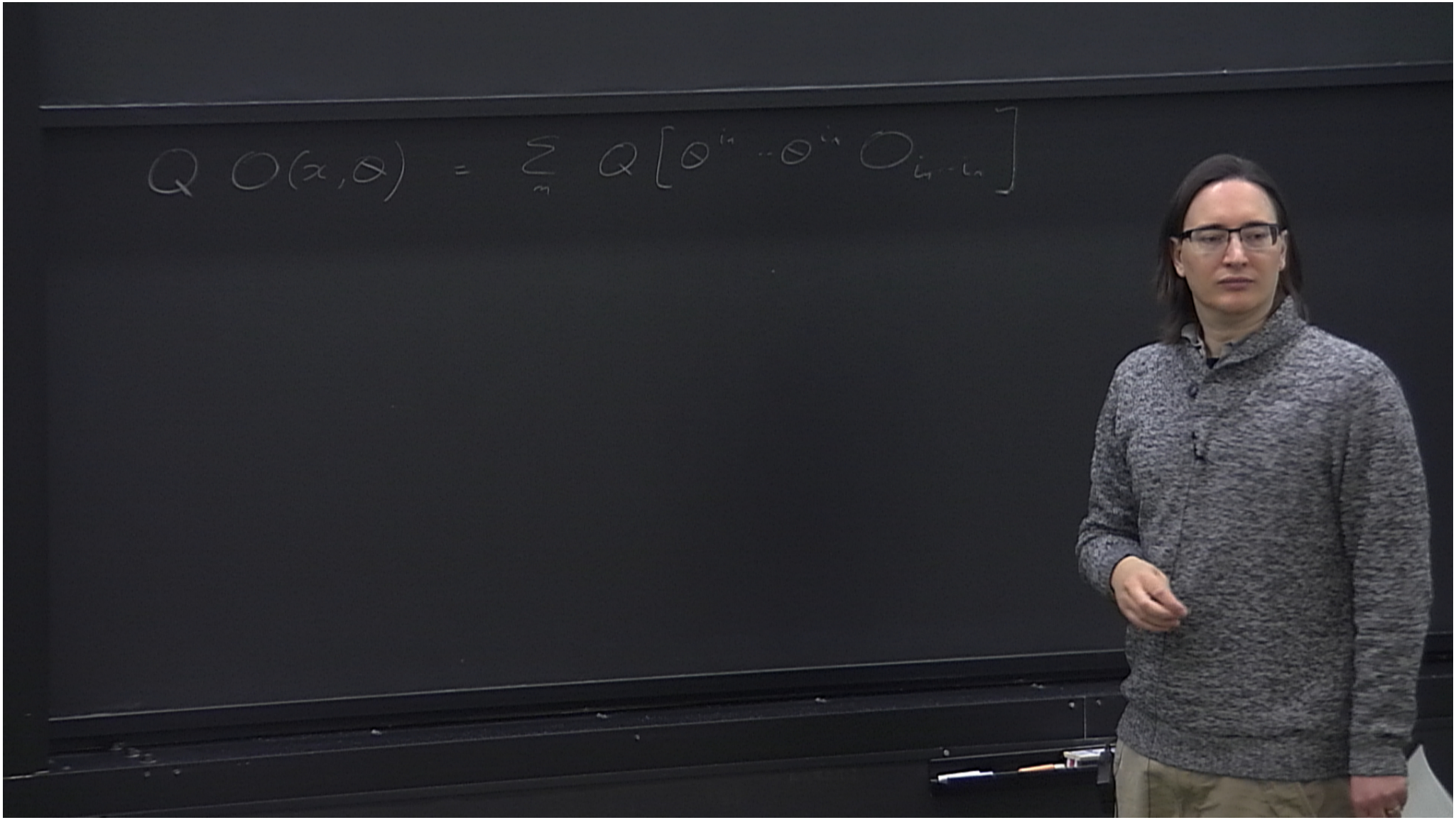

$x^i \quad \theta^i$
$Qx^i = \theta^i$
$Q\theta^i = 0$
$x^i \to \tilde{x}^i(x^i)$
$\tilde{\theta}^i = \frac{\partial \tilde{x}^i}{\partial x^j}\theta^j$
$Q\tilde{x}^i = \tilde{\theta}^i$
$Q\tilde{\theta}^i = 0$
$x \in X$
$(x,\theta) \in \Pi TX$
$\langle O_1 \cdots O_n \rangle = \int_{\Pi TX} O_1(x,\theta)\, O_2(x,\theta) \cdots O_n(x,\theta)\, dx\, d\theta$

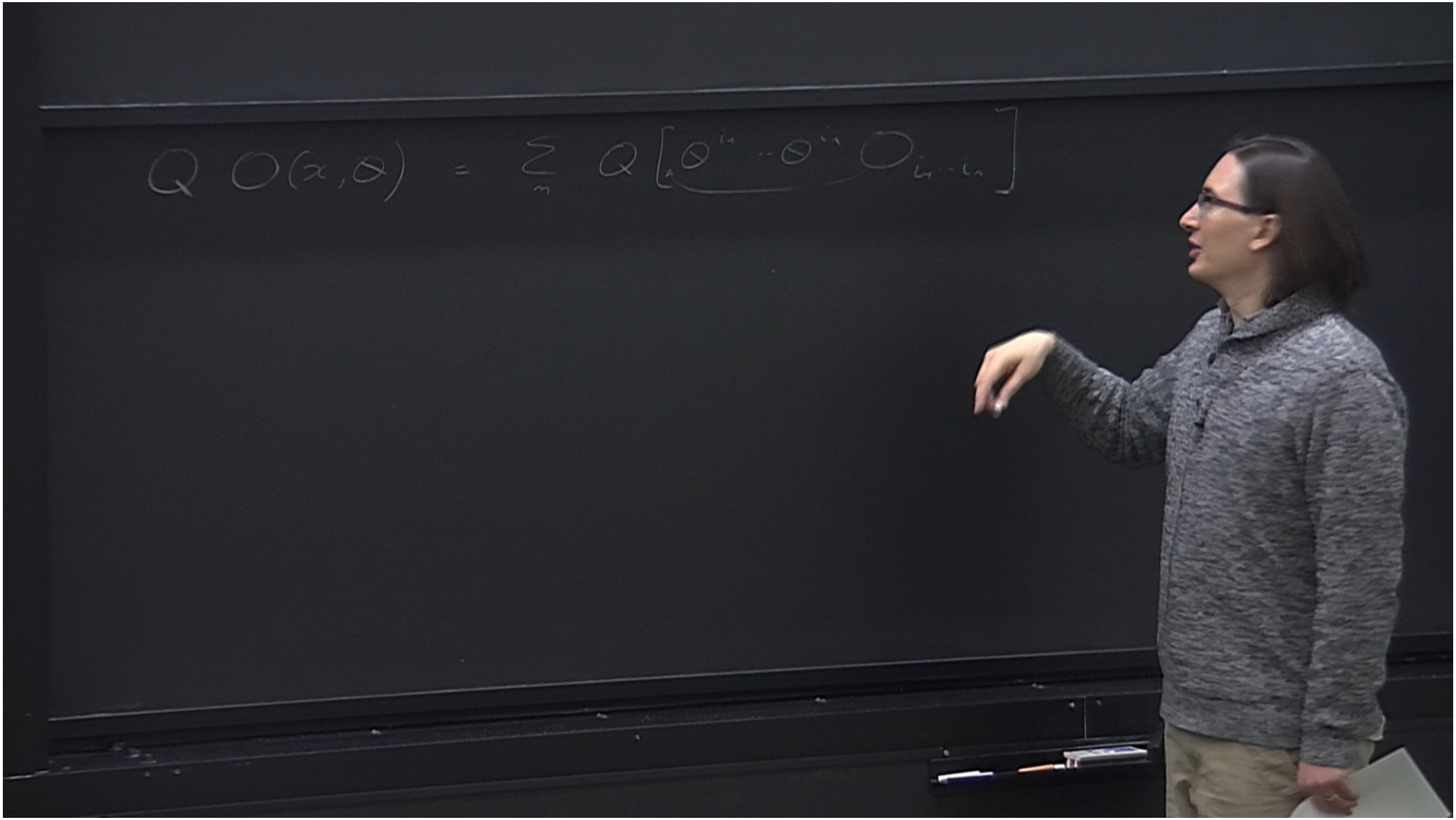

$x^i \to \tilde{x}^i(x')$
$\tilde{\theta}^i = \frac{\partial \tilde{x}^i}{\partial x^j}\theta^j$
$Q\tilde{x}^i = \tilde{\theta}^i$
$Q\tilde{\theta}^i = 0$
$x \in X$
$(x,\theta) \in \Pi TX$
$O(x,\theta) = \sum_n \theta^{i_1}\cdots\theta^{i_n} O_{i_1\cdots i_n}$
$O_1(x,\theta) \cdot O_2(x,\theta)\, dx\, d\theta$

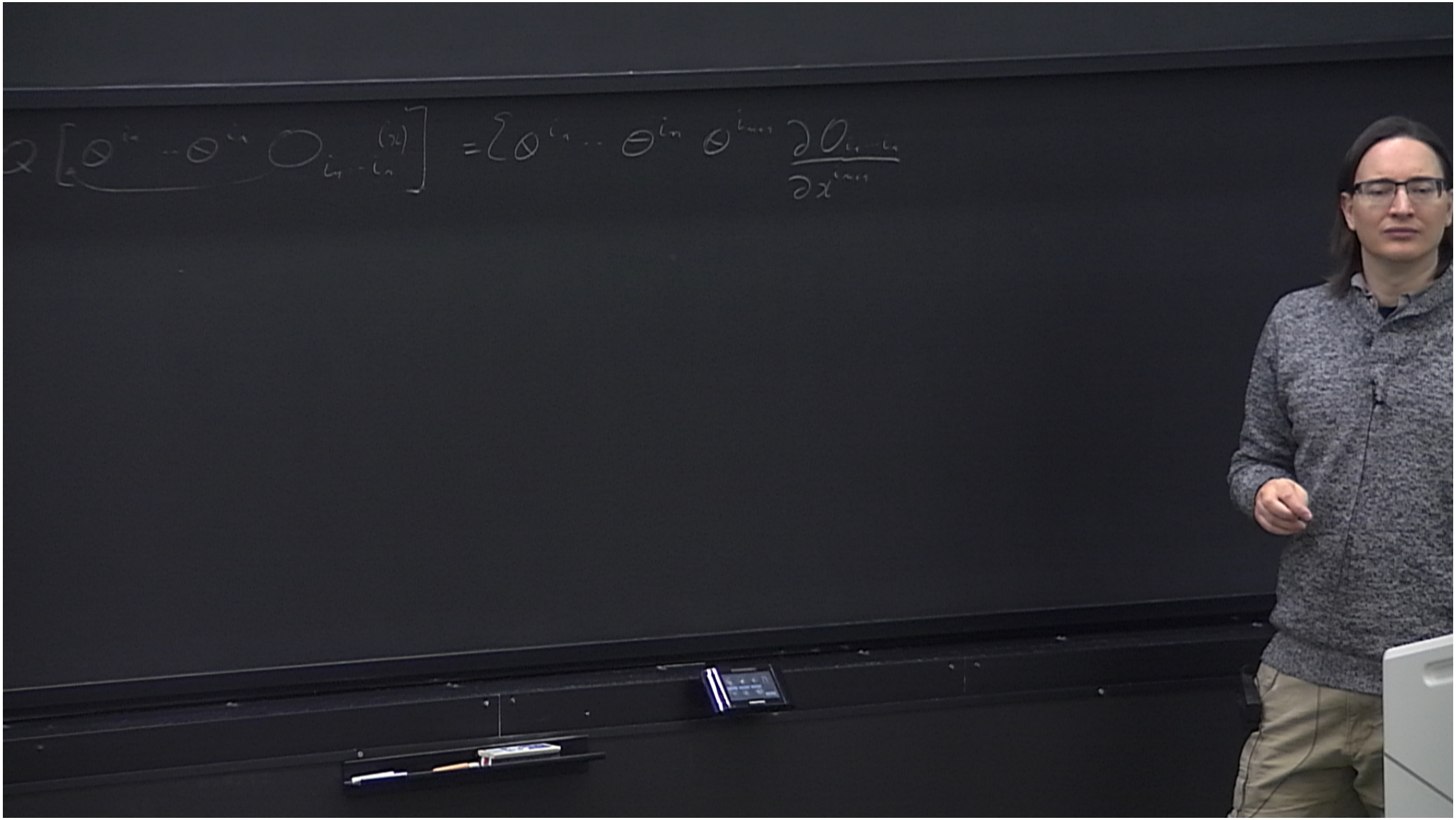

$x^i \quad \theta^i$
$Qx^i = \theta^i$
$Q\theta^i = 0$
$x^i \to \tilde{x}^i(x')$
$\tilde{\theta}^i = \frac{\partial \tilde{x}^i}{\partial x^j}\theta^j$
$Q\tilde{x}^i = \tilde{\theta}^i$
$Q\tilde{\theta}^i = 0$
$x \in X$
$(x,\theta) \in \Pi TX$
$O(x,\theta) = \sum_n$
$\langle O^1 \cdots O^k \rangle = \int_{\Pi TX} O^1(x,\theta)\, O^2(x,0) \cdots O^k(x,0)\, dx\, d\theta$

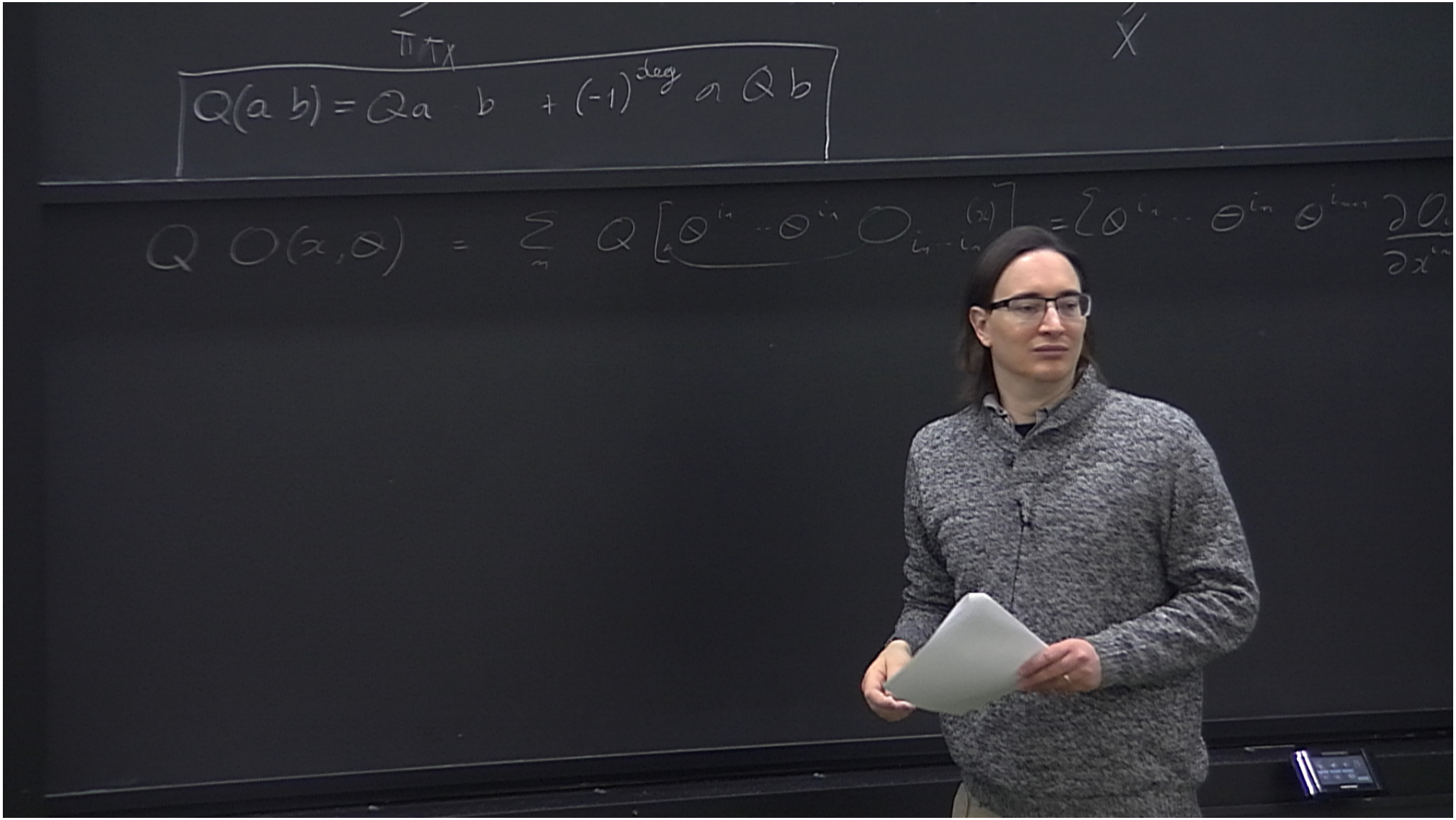

$x \in X$
$(x,\theta) \in \Pi TX$
$f_O = \sum_n dx^{i_1} \cdots dx^{i_n} O_{i_1 \cdots i_n}(x)$
$O(x,\theta) = \sum_n \theta^{i_1} \cdots \theta^{i_n} O_{i_1 \cdots i_n}(x)$

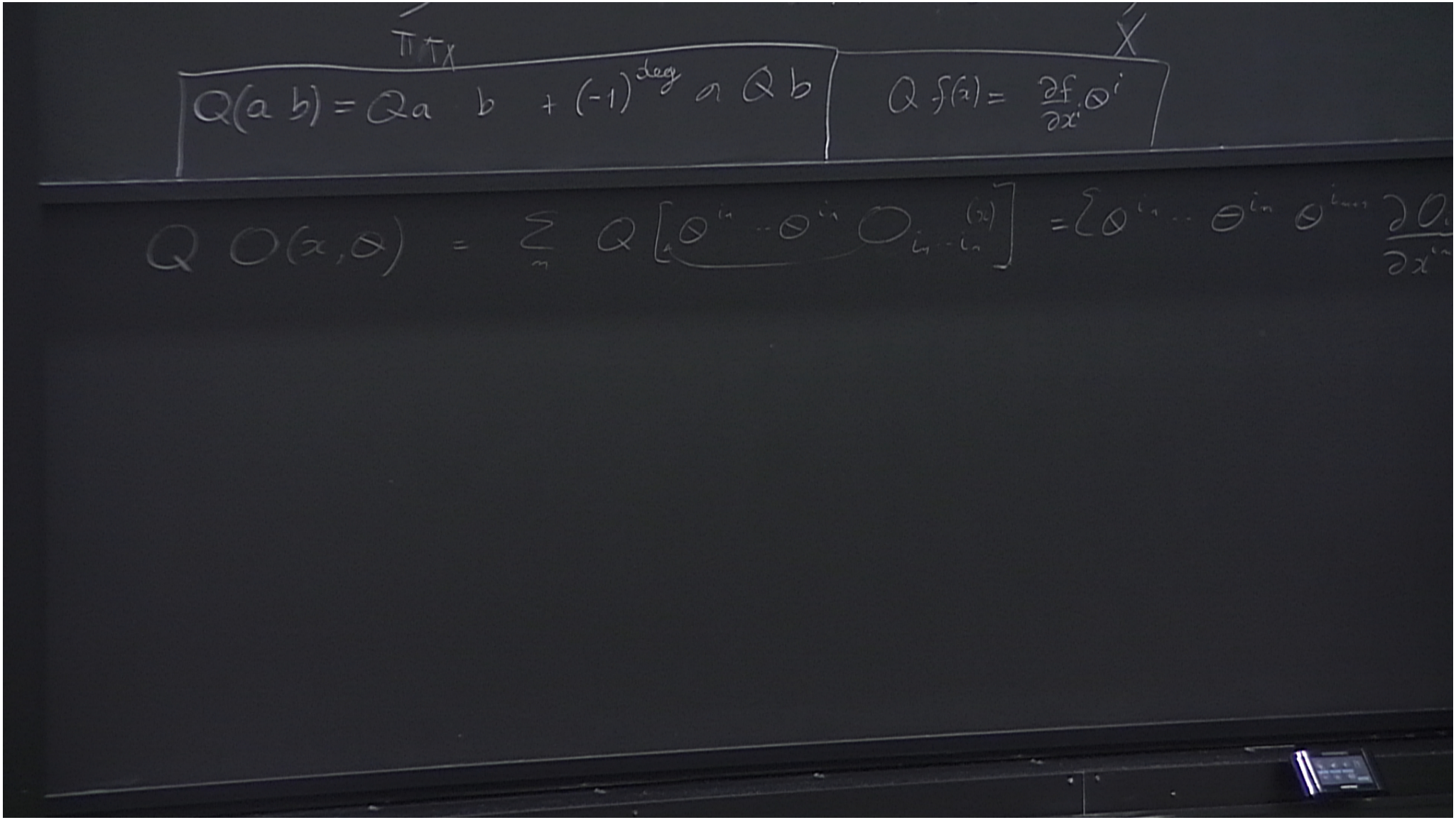

$x \in X$
$(x,\theta) \in \Pi T X$
$f_O = \sum_a$
$O(x,\theta) = \sum_n \theta^{i_1} \cdots \theta^{i_n} O_{i_1 \cdots i_n}(x)$
$= \int_X f_{O^1} \cdots f_{O^k}$

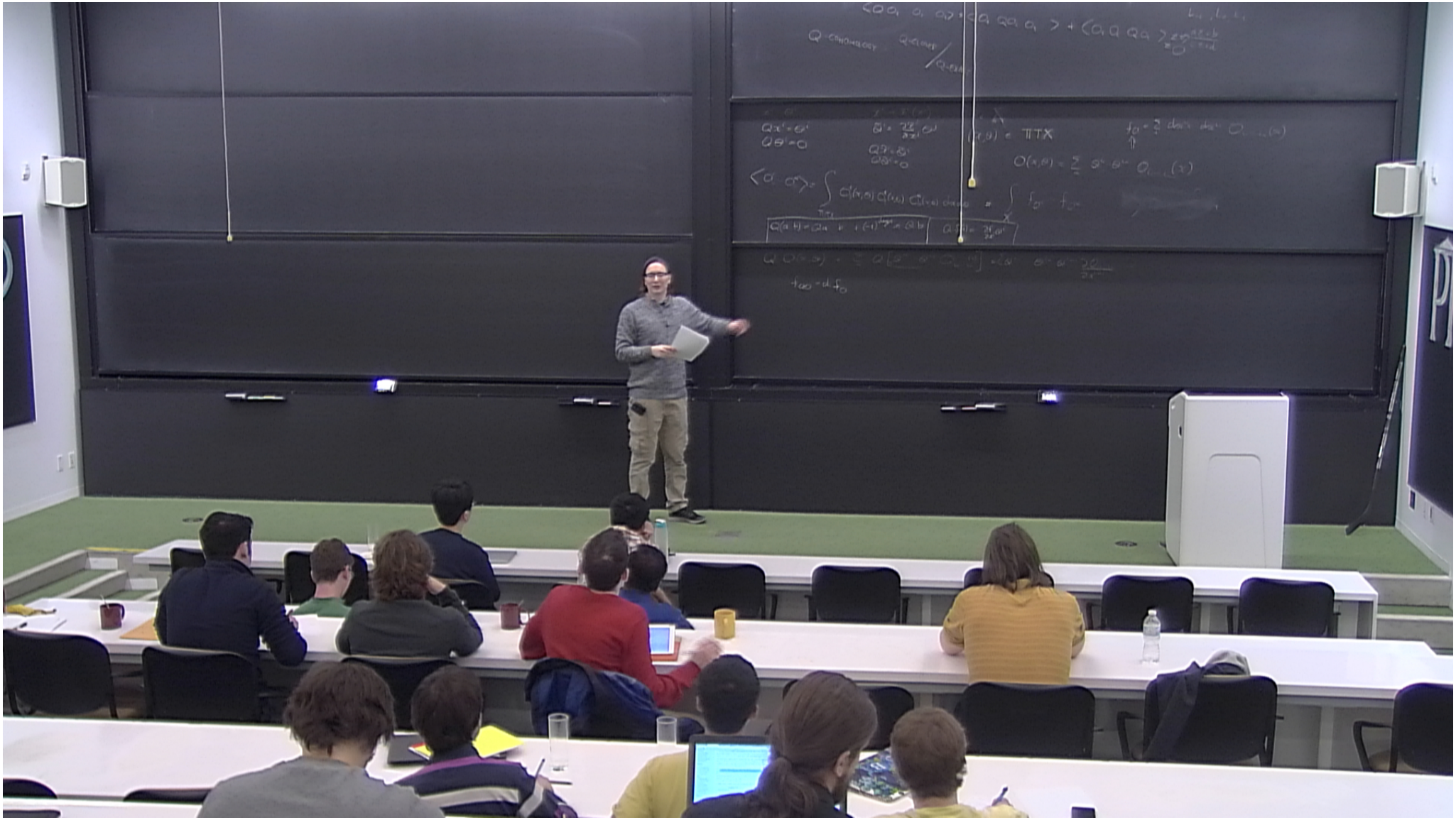

$Q\,O(x,\theta) = \sum_m Q\left[\theta^{i_1}\cdots\theta^{i_m} O_{i_1\cdots i_m}\right]$

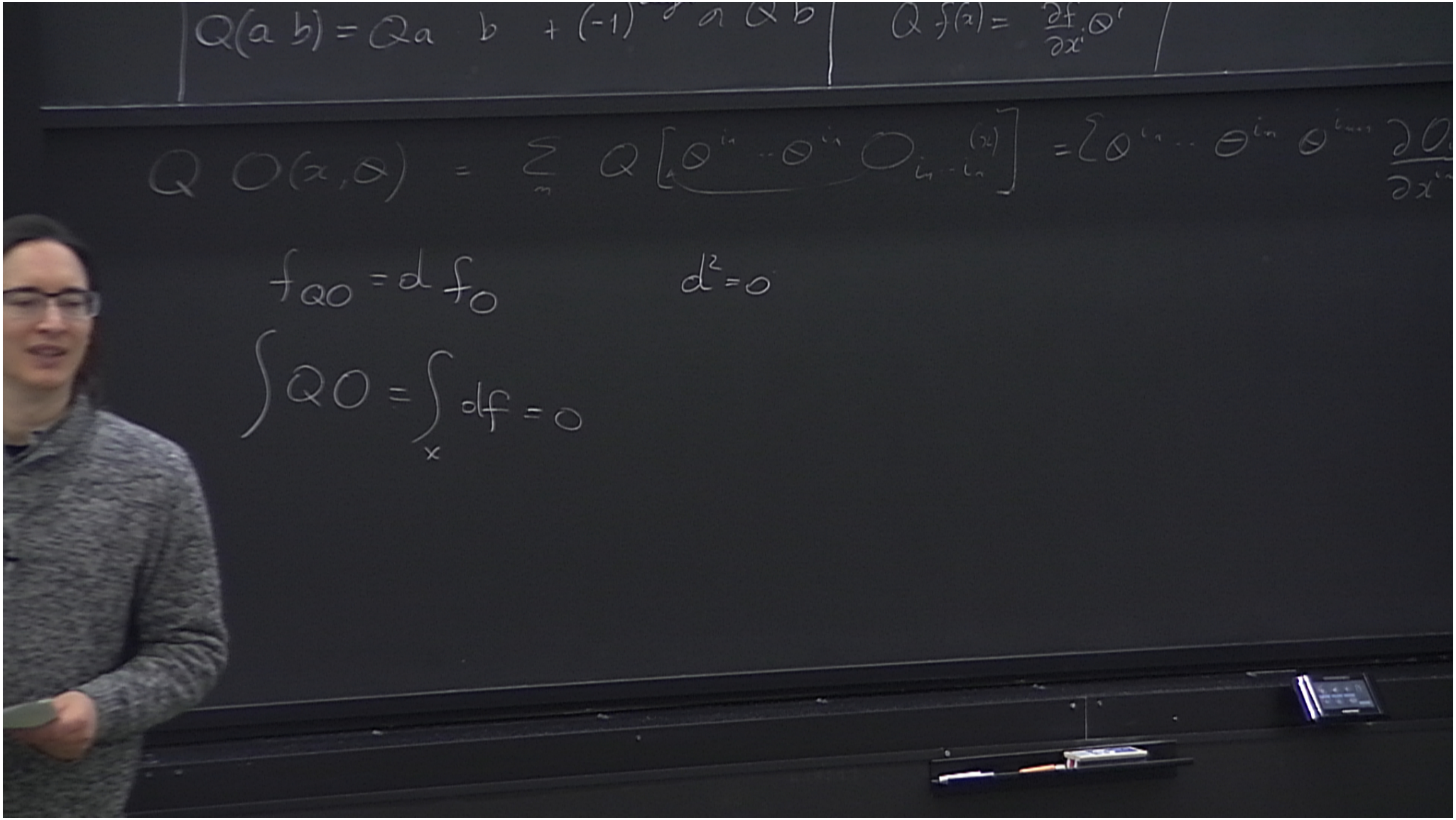

$Q\,O(x,\theta) = \sum_m Q\left[\theta^{i_1}\cdots\theta^{i_m} O_{i_1\cdots i_m}\right]$

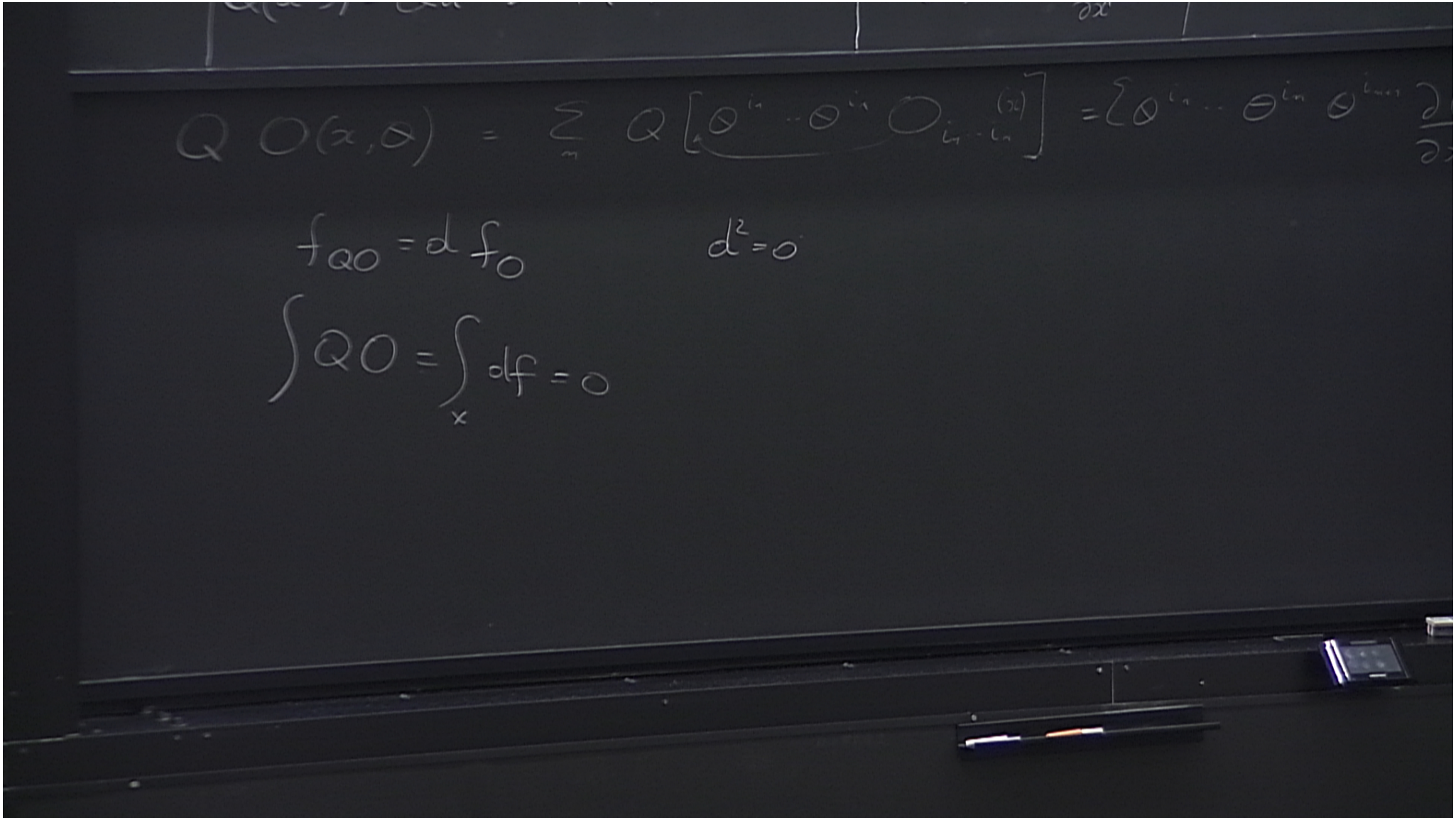

$Q\left[\theta^{i_1}\cdots\theta^{i_n}\,O_{i_1\cdots i_n}^{(n)}\right] = \left\{\theta^{i_1}\cdots\theta^{i_n}\,\theta^{i_{n+1}}\,\frac{\partial O_{i_1\cdots i_n}}{\partial x^{i_{n+1}}}\right.$

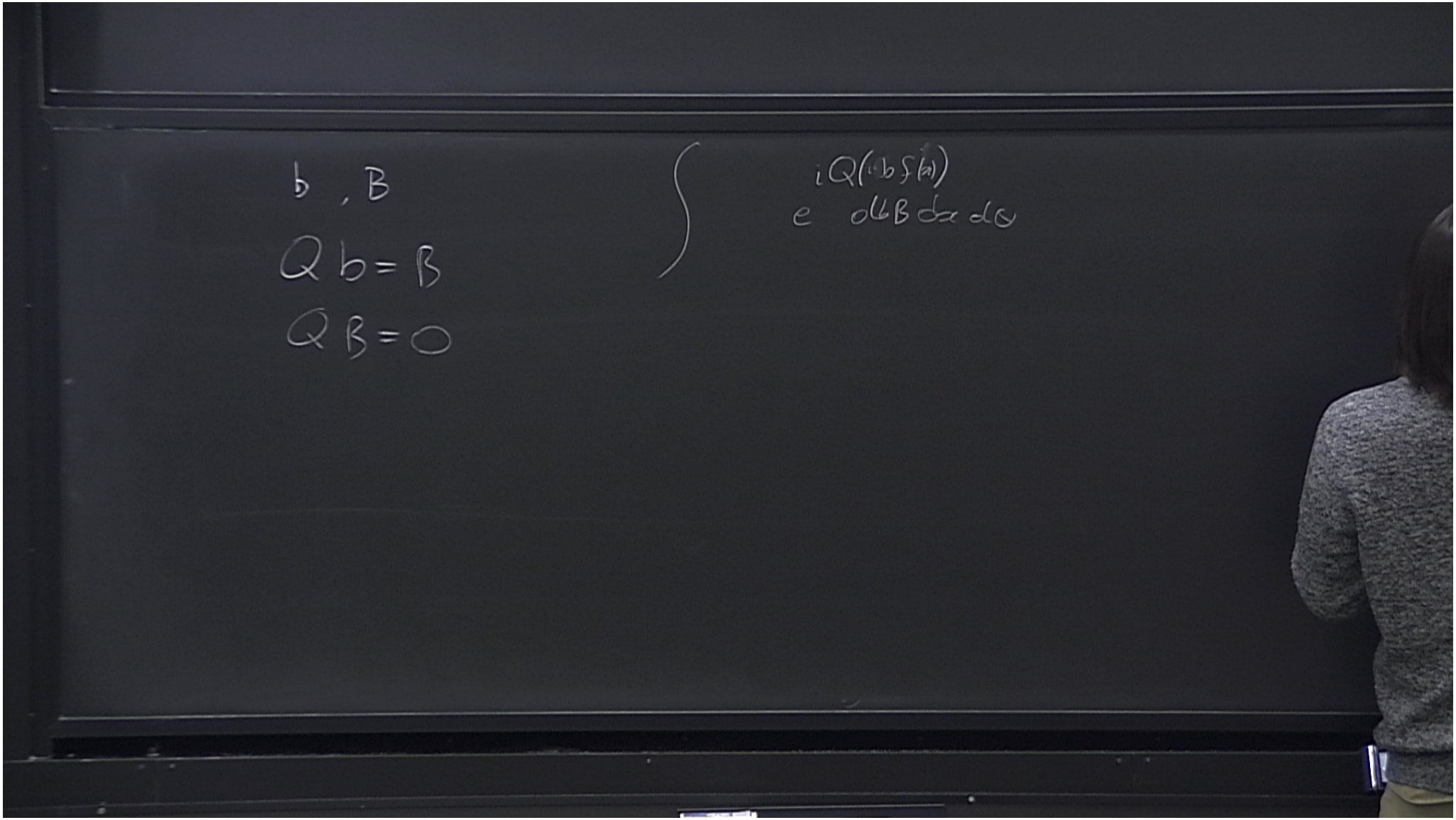

ΠTX
Q(a b) = Qa b + (-1)^deg a Qb
X

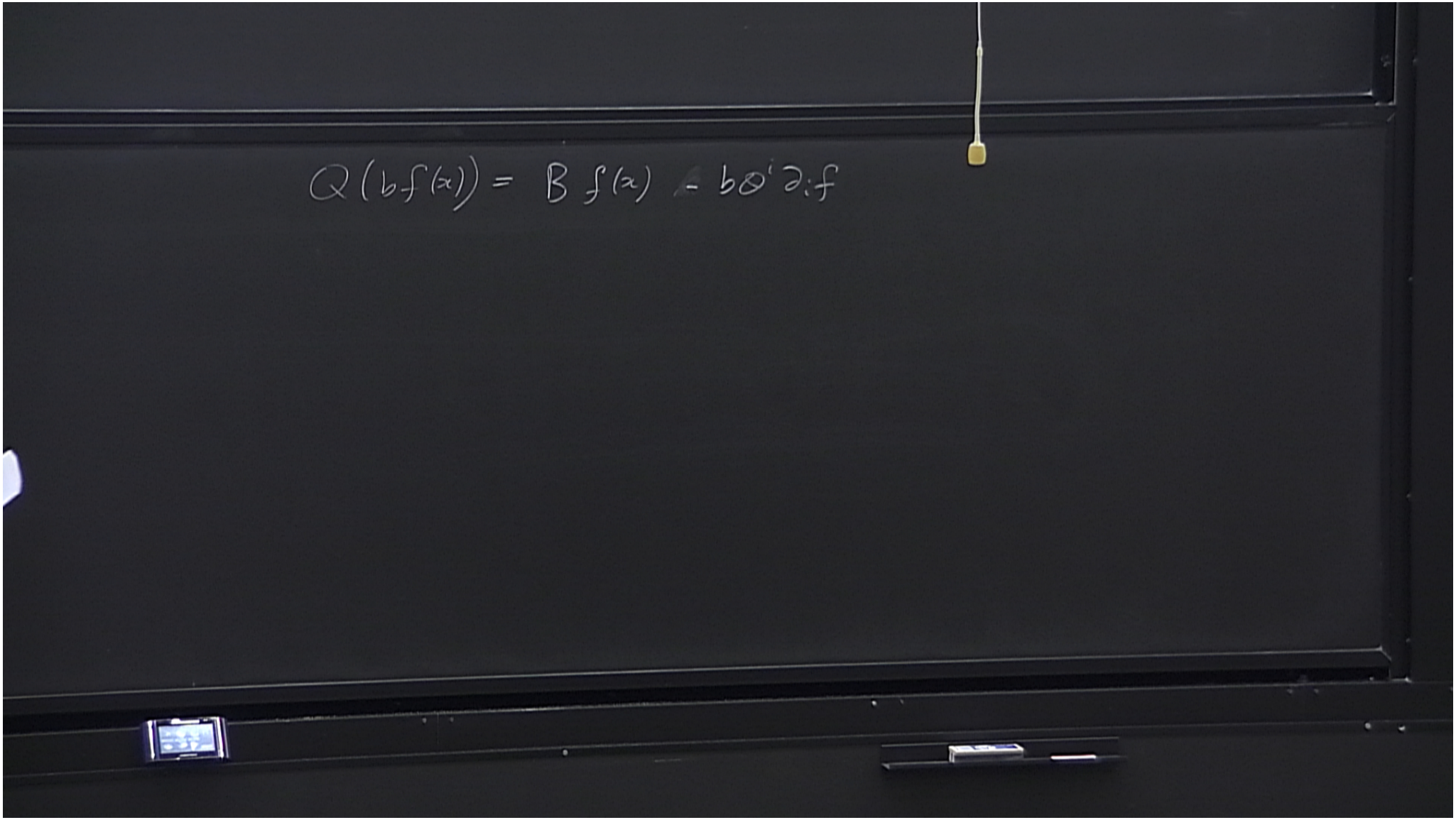

ΠTX
$Q(a\,b) = Qa\;\; b \;+ (-1)^{\deg a} a\, Qb$
X
$Q f(x) = \frac{\partial f}{\partial x^i} \theta^i$
$Q\, O(x,\theta) = \sum_m Q\left[\theta^{i_1} \cdots \theta^{i_m} O^{(x)}_{i_1 \cdots i_m}\right] = \{\theta^{i_1} \cdots \theta^{i_m} \theta^{i_{m+1}} \frac{\partial O}{\partial x^{i_m}}$

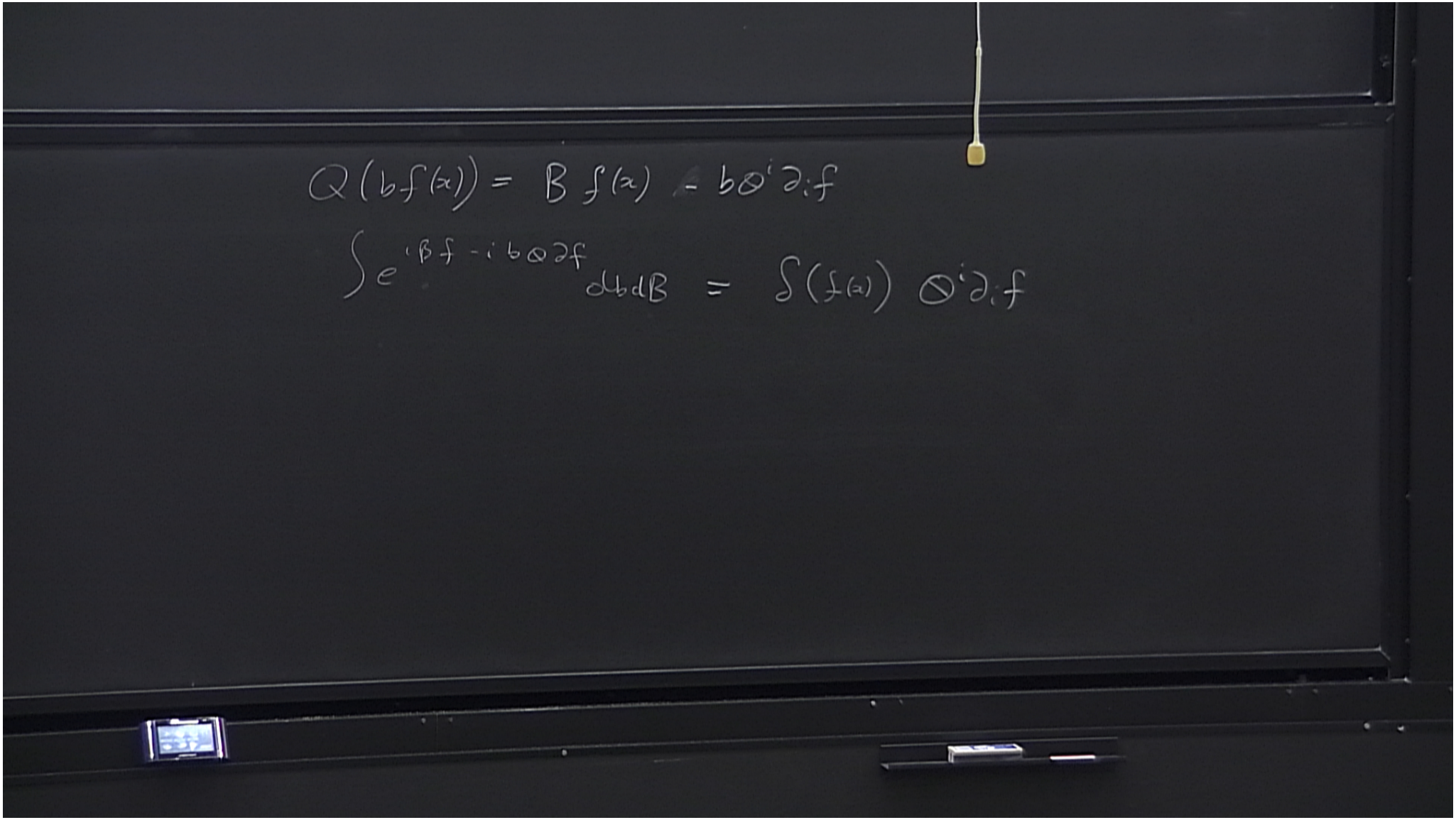


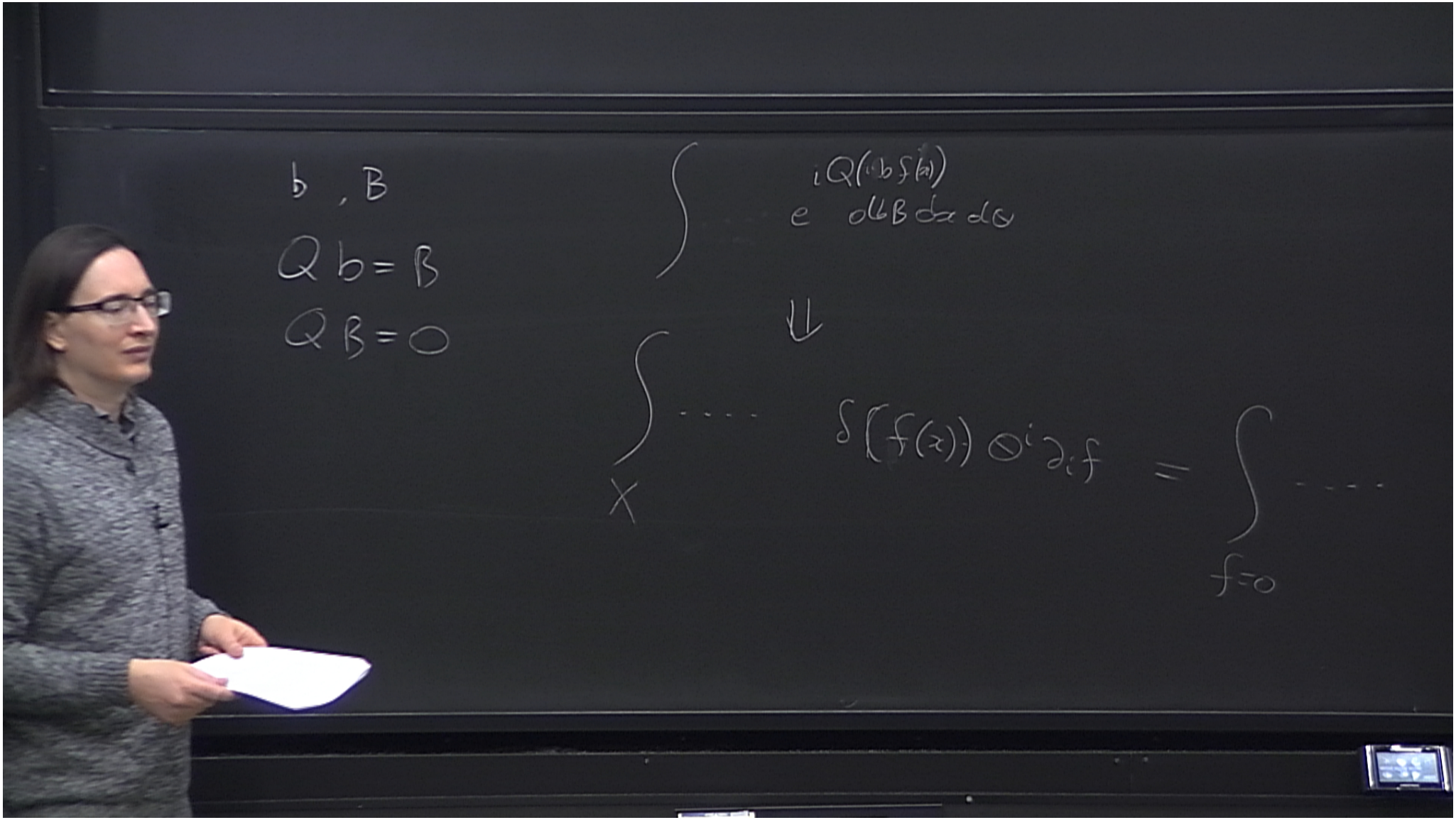

Q(a b) = Qa b + (-1)
Q f(x) = ∂f/∂x^i θ^i
Q O(x,θ) = Σ_n Q [θ^{i_1} ... θ^{i_n} O_{i_1 ... i_n}(x)] = [θ^{i_1} ... θ^{i_n} θ^{i_{n+1}} ∂O
f_{QO} = d f_O
d^2 = 0
∫ QO = ∫_x df = 0


$Q\,O(\alpha,\theta) = \sum_m Q\left[\theta^{i_1}\cdots\theta^{i_m} O^{(\alpha)}_{i_1\cdots i_m}\right] = \left[\theta^{i_1}\cdots\theta^{i_m}\theta^{i_{m+1}}\frac{\partial}{\partial}\right.$
$f_{QO} = d f_O$
$d^2 = 0$
$\int QO = \int_X df = 0$


b , B
Q b = B
Q B = 0
∫
i Q(·, b) f(a)
e dα dB da dQ


$Q(bf(x)) = B f(x) - b\partial' \partial f$


$Q(bf(x)) = Bf(x) - b\partial_i f$
$\int e^{i\beta f - ib\partial f} d\beta db = \delta(f(x))\,\partial_i f$


b , B
Qb = B
QB = 0
$\int$ $e^{iQ(\dots b \dots f(a))}$ dbB da dQ
$\int \dots$ X
$\delta(f(x)) \Theta^i \partial_i f = \int \dots$
f=0

b_m , B_m

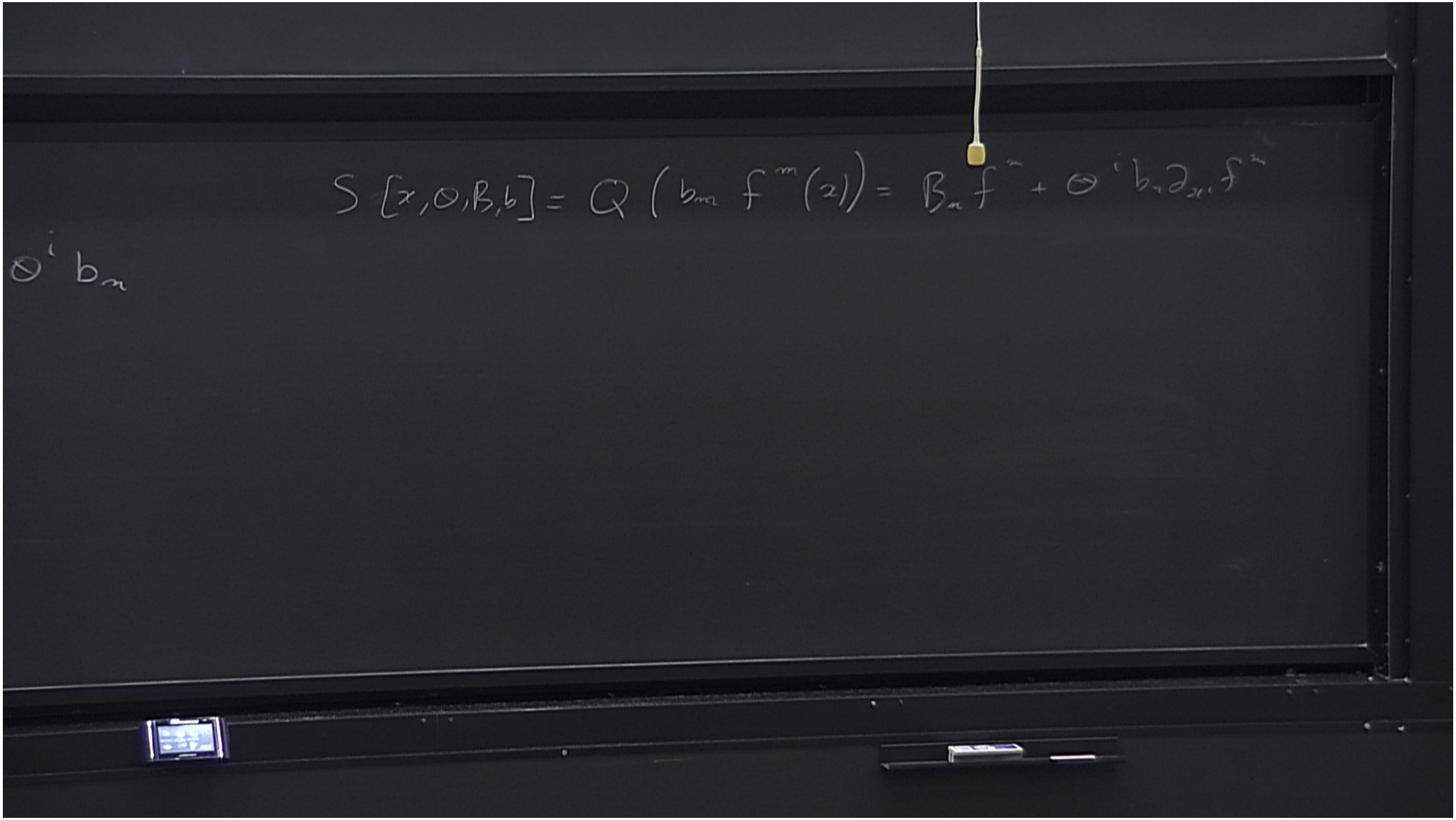
$Q\, b_m = B_m$

$Q\, B_m = 0$

$\tilde{b}_m = e^{n}_{m}(x)\, b_n$

$\tilde{B}_m = e^{n}_{m}(x) B_n + \partial_{x^i} e^{n}_{m}\, \theta^i\, b_n$



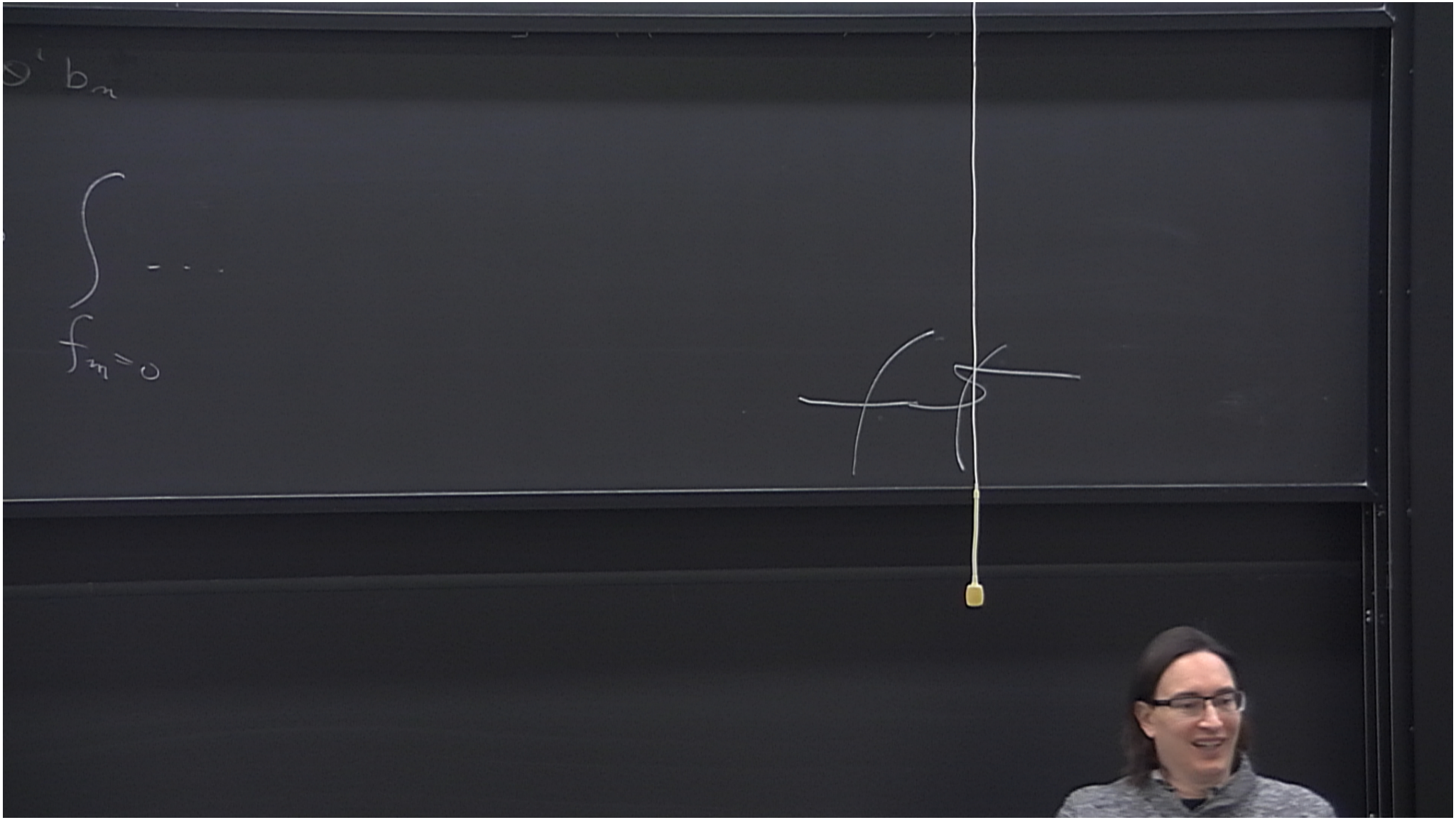

$S[x,\theta,B,b] = Q\left(b_m f^m(x)\right) = B_m f^m + \theta^i b_m \partial_{x^i} f^m$
$\theta^i b_m$

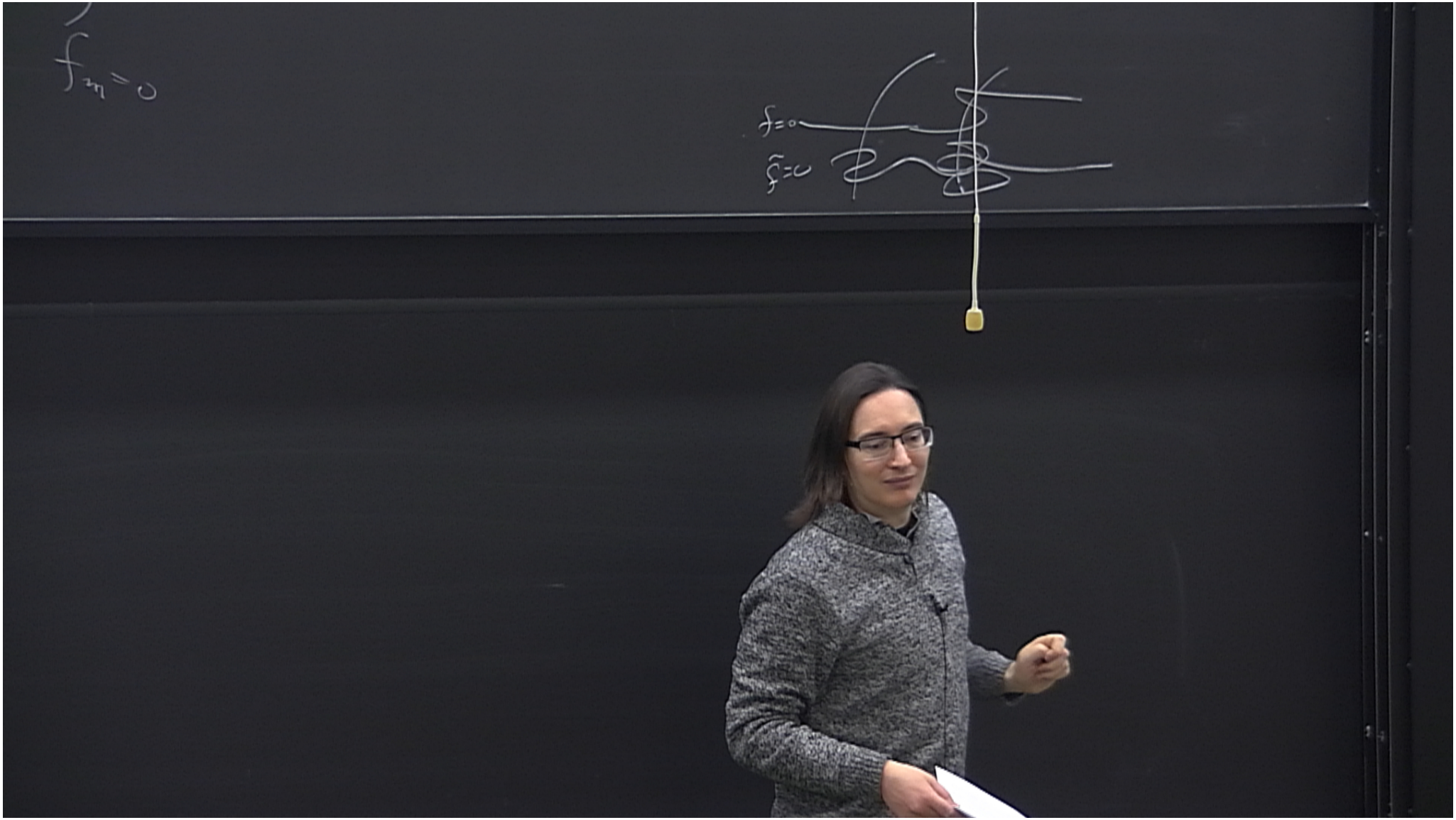
$$\tilde{b}_m = e^n_m(x)\, b_n$$

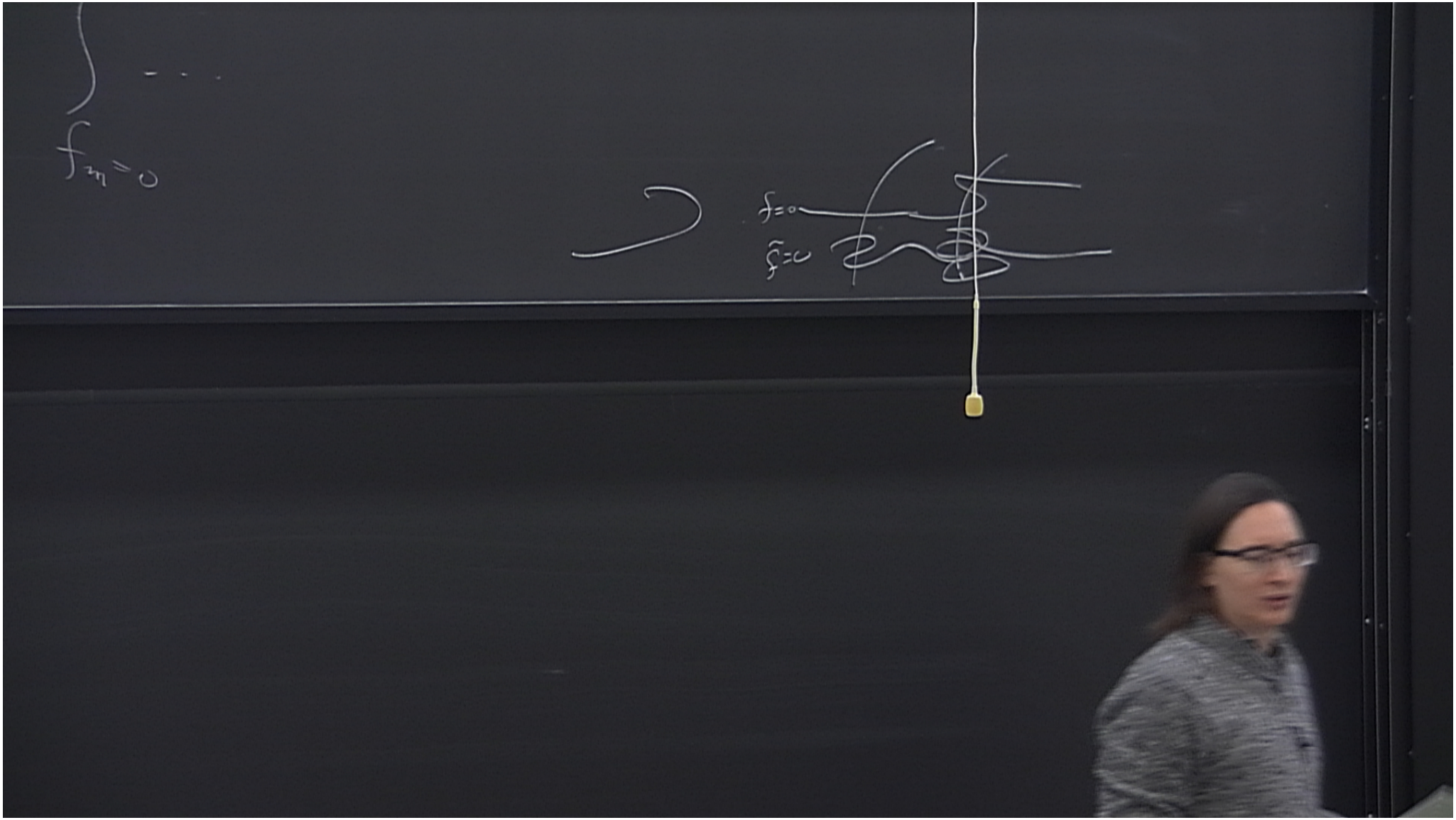
$$\tilde{B}_m = e^n_m(x) B_n + \partial_{x^i} e^n_m\, \theta^i b_n$$

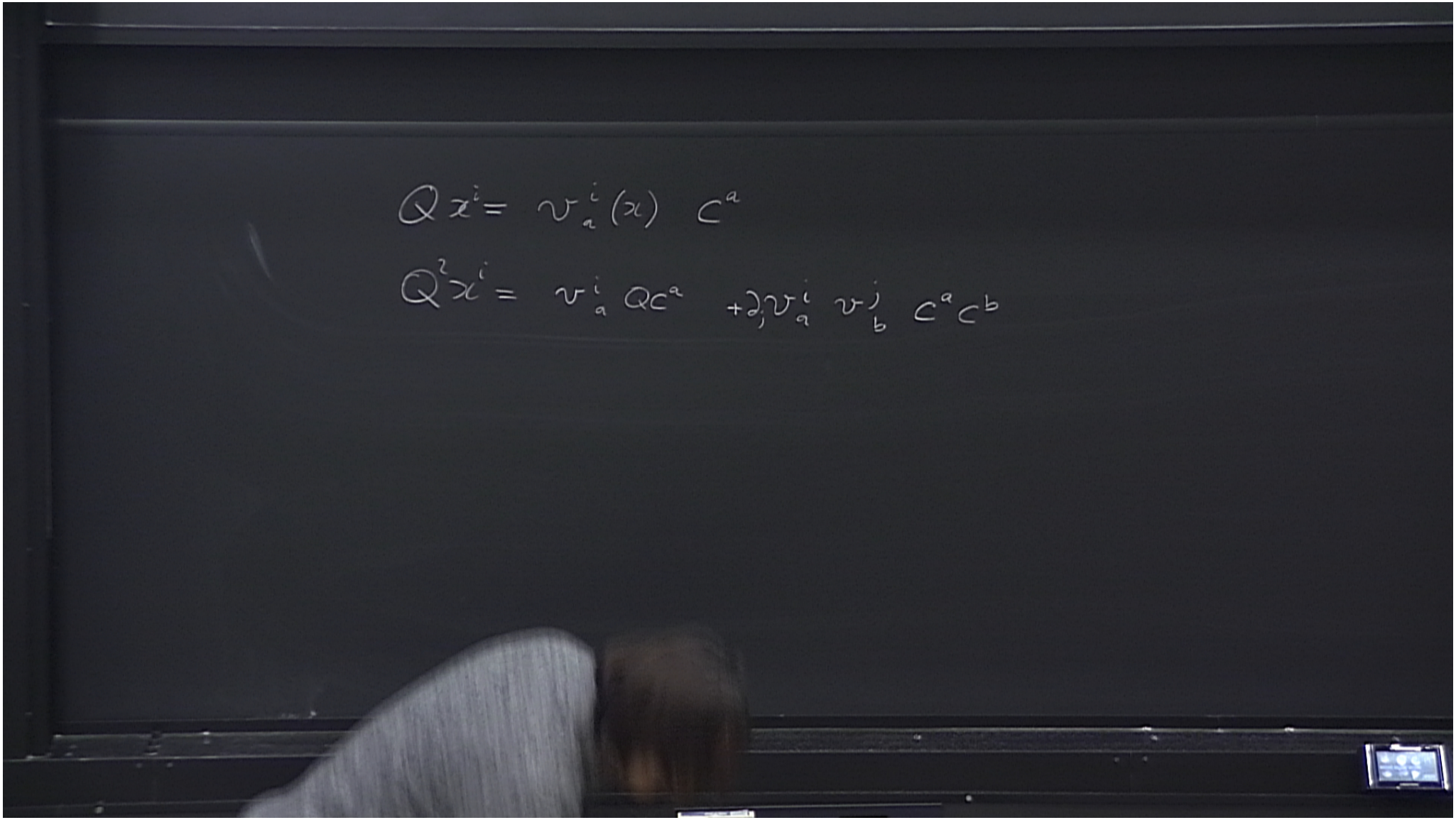
$$\int_X \cdots db\, dB\, dx\, d\theta \Longrightarrow \int_{f_m = 0} \cdots$$

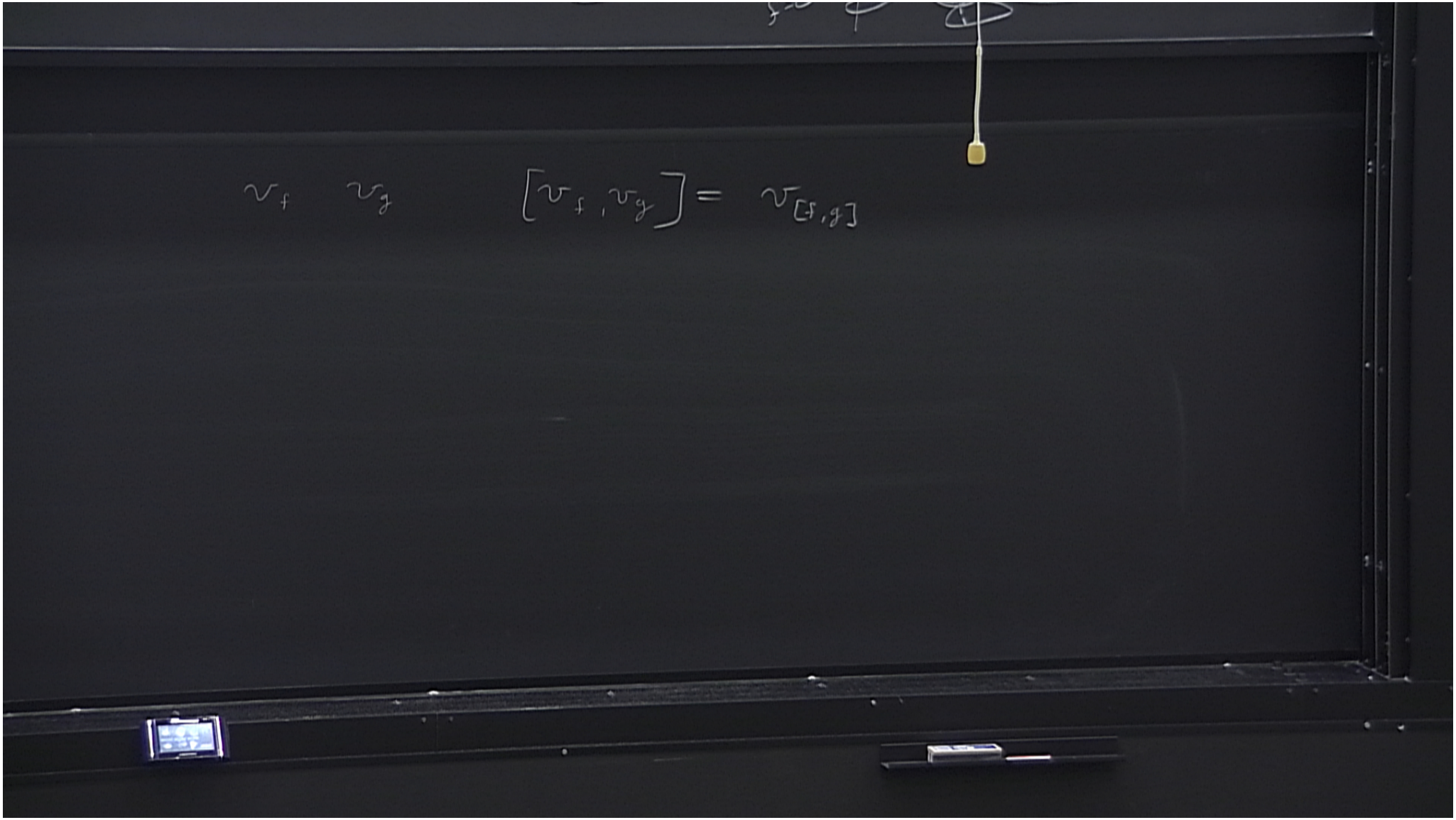
$$S[x, \theta, B, b] = Q\,(b_m f^m(x$$

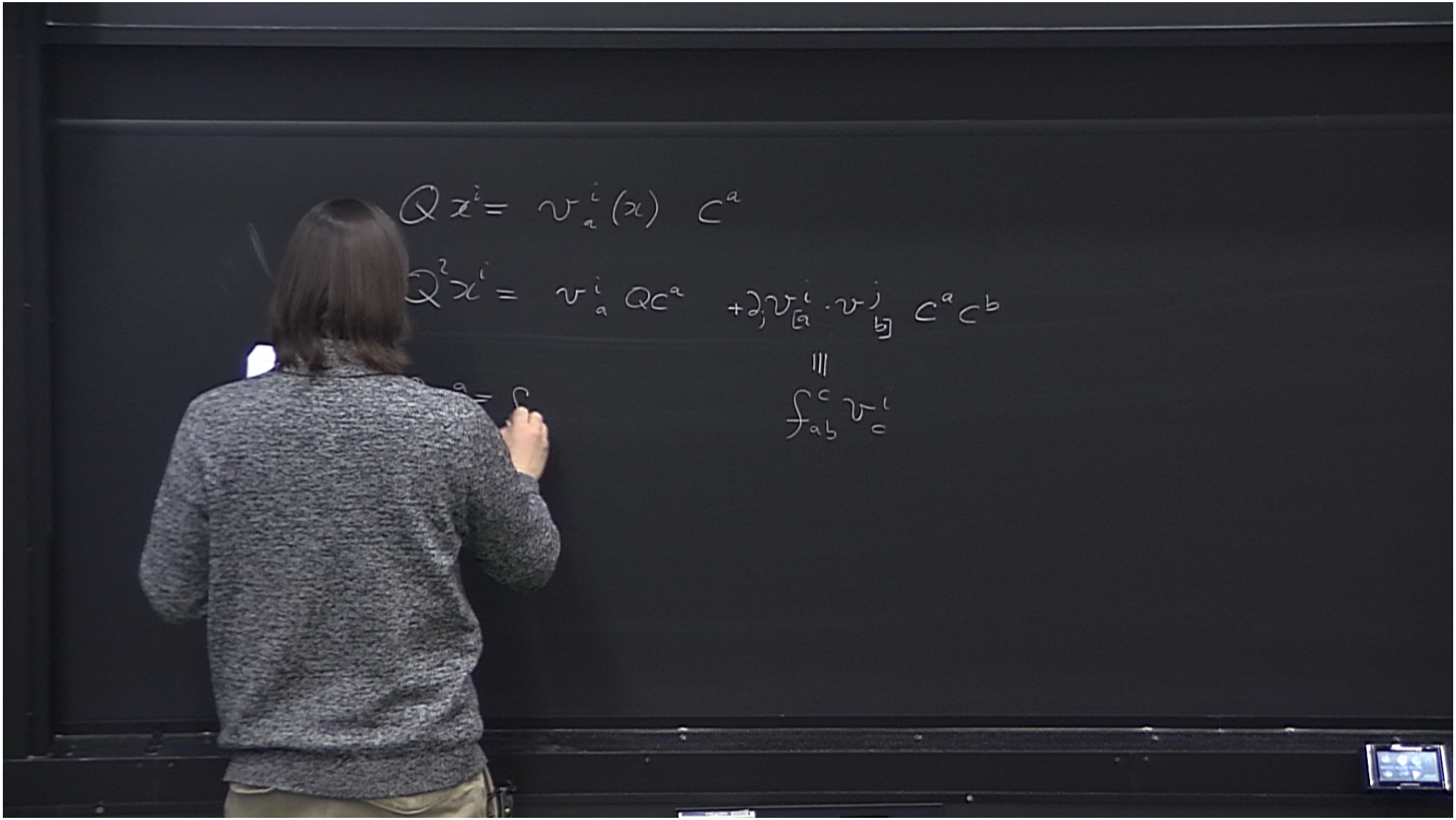

b_m
$f_m = 0$

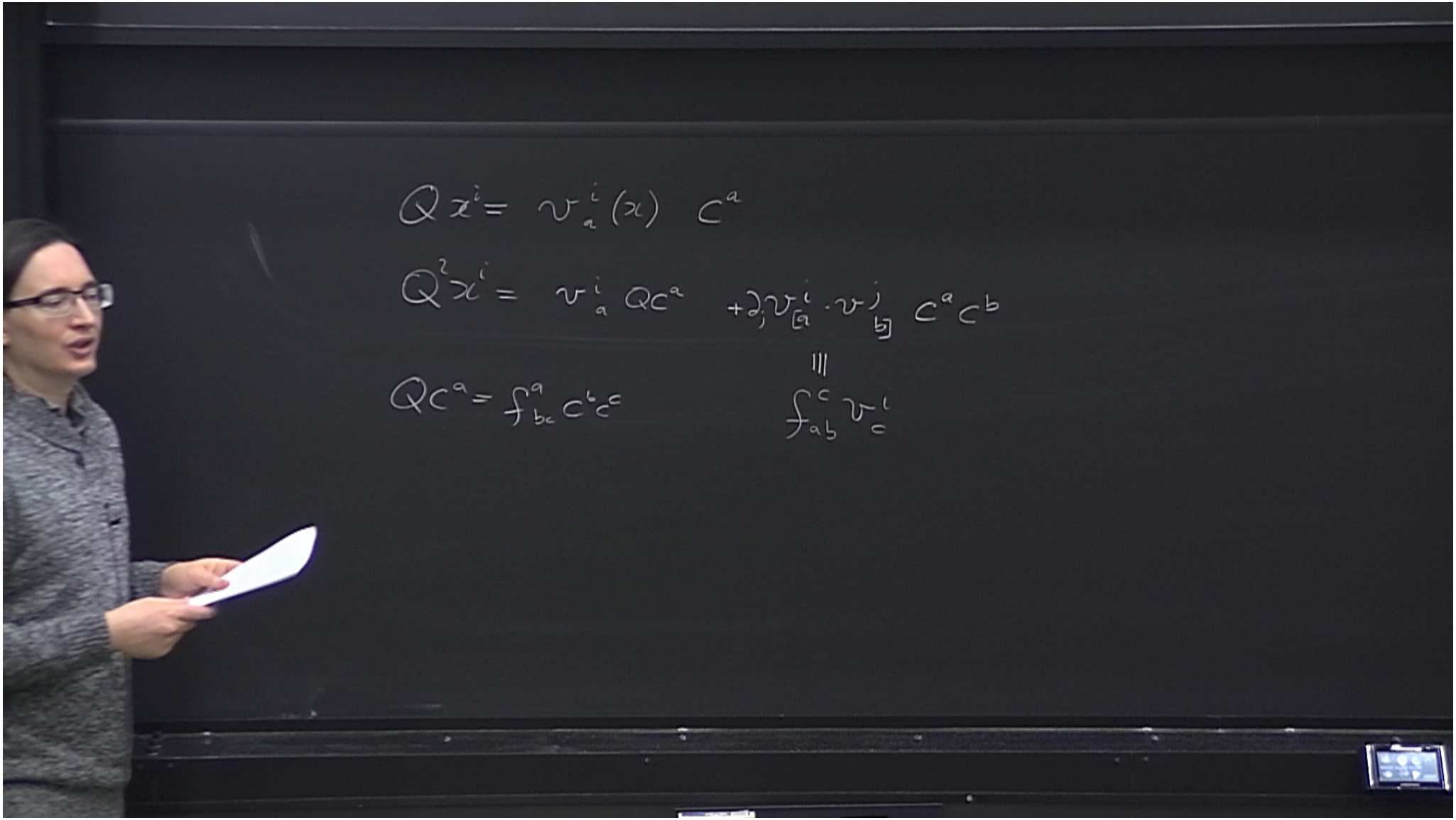

$f_m = 0$
$f = 0$
$\tilde{f} = 0$

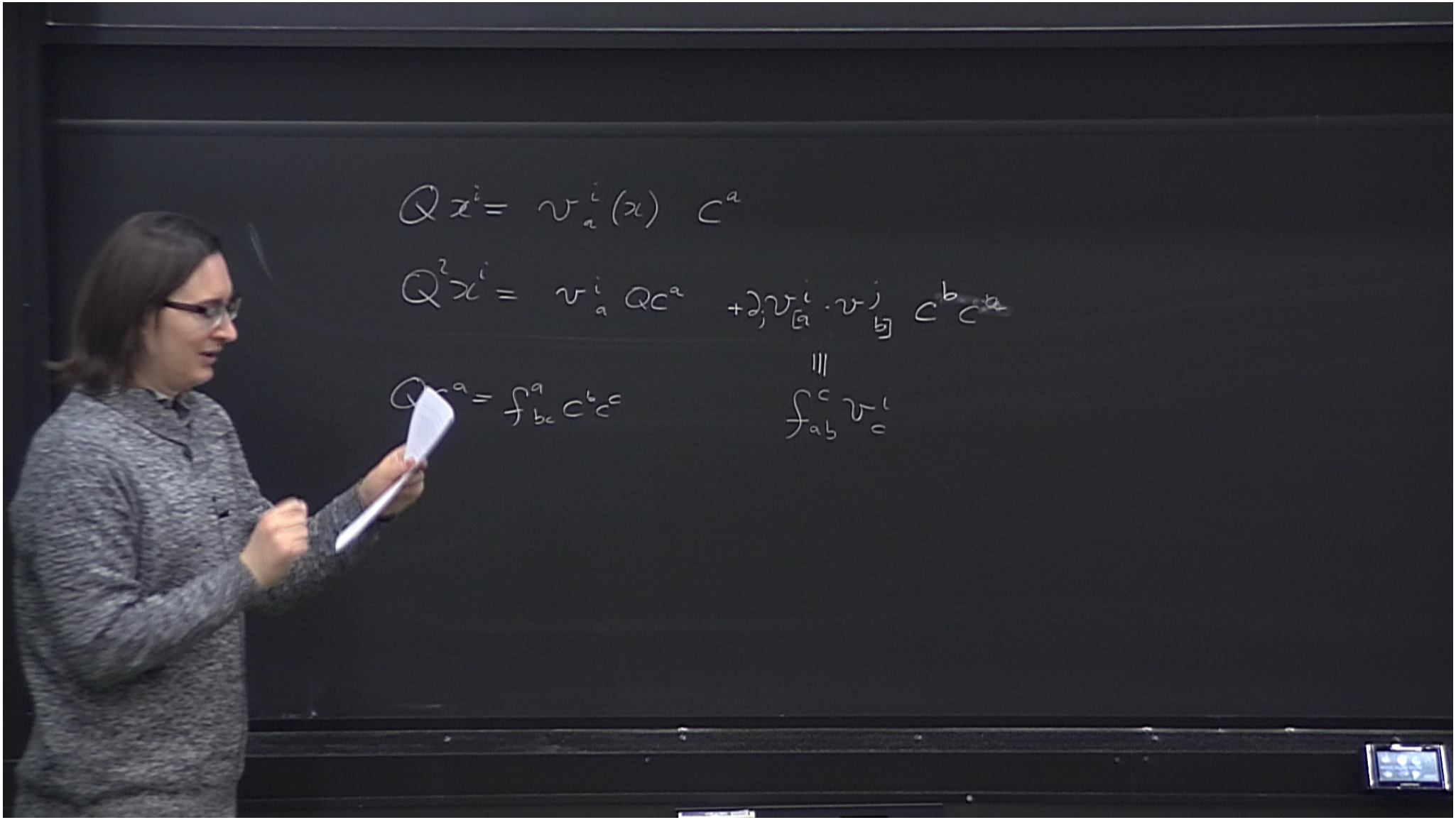

$f_m = 0$
$f = 0$
$\tilde{f} = 0$

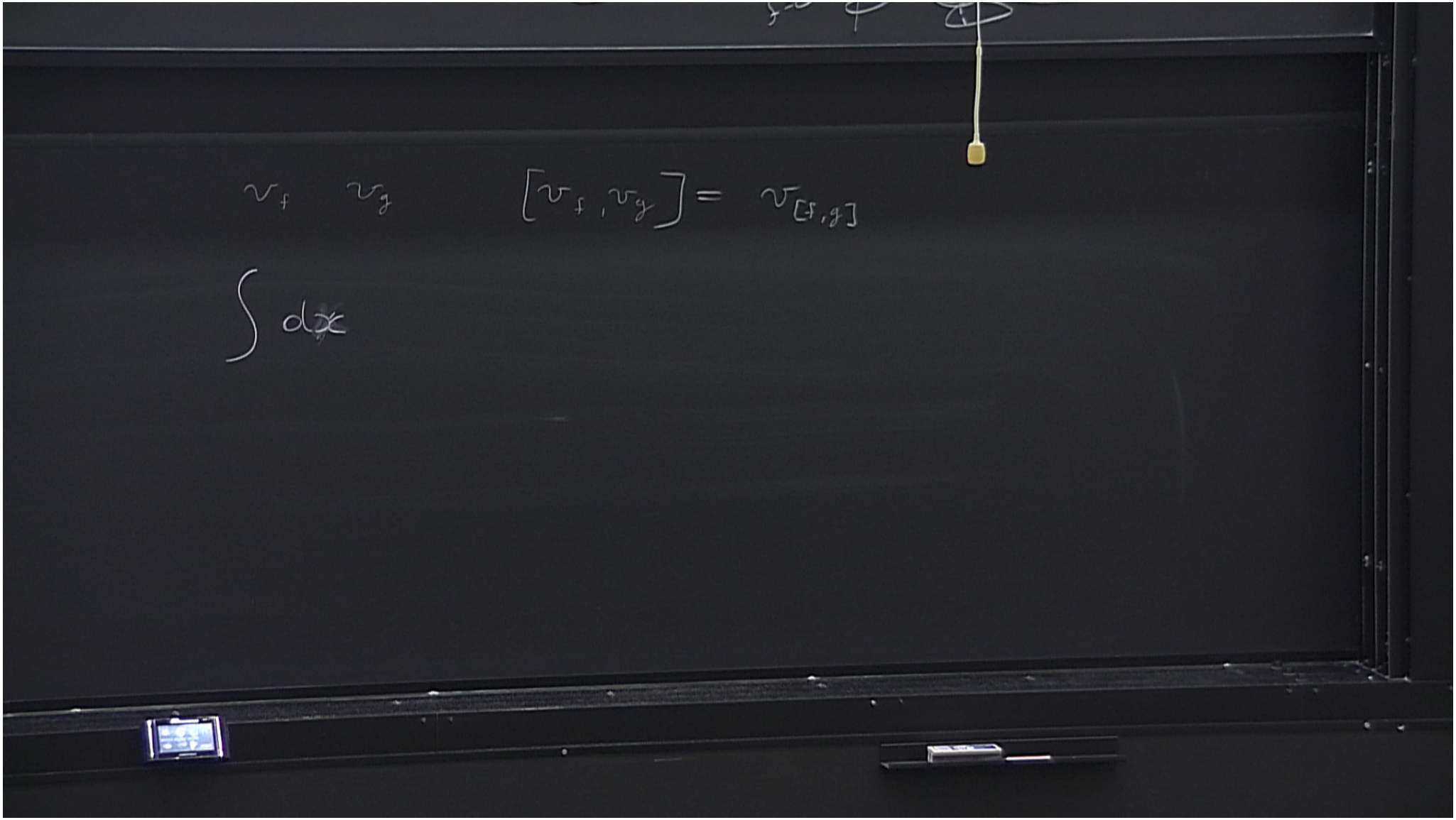

$Q x^i = v_a^i(x)\ c^a$
$Q^2 x^i = v_a^i\, Qc^a + \partial_j v_a^i\, v_b^j\, c^a c^b$

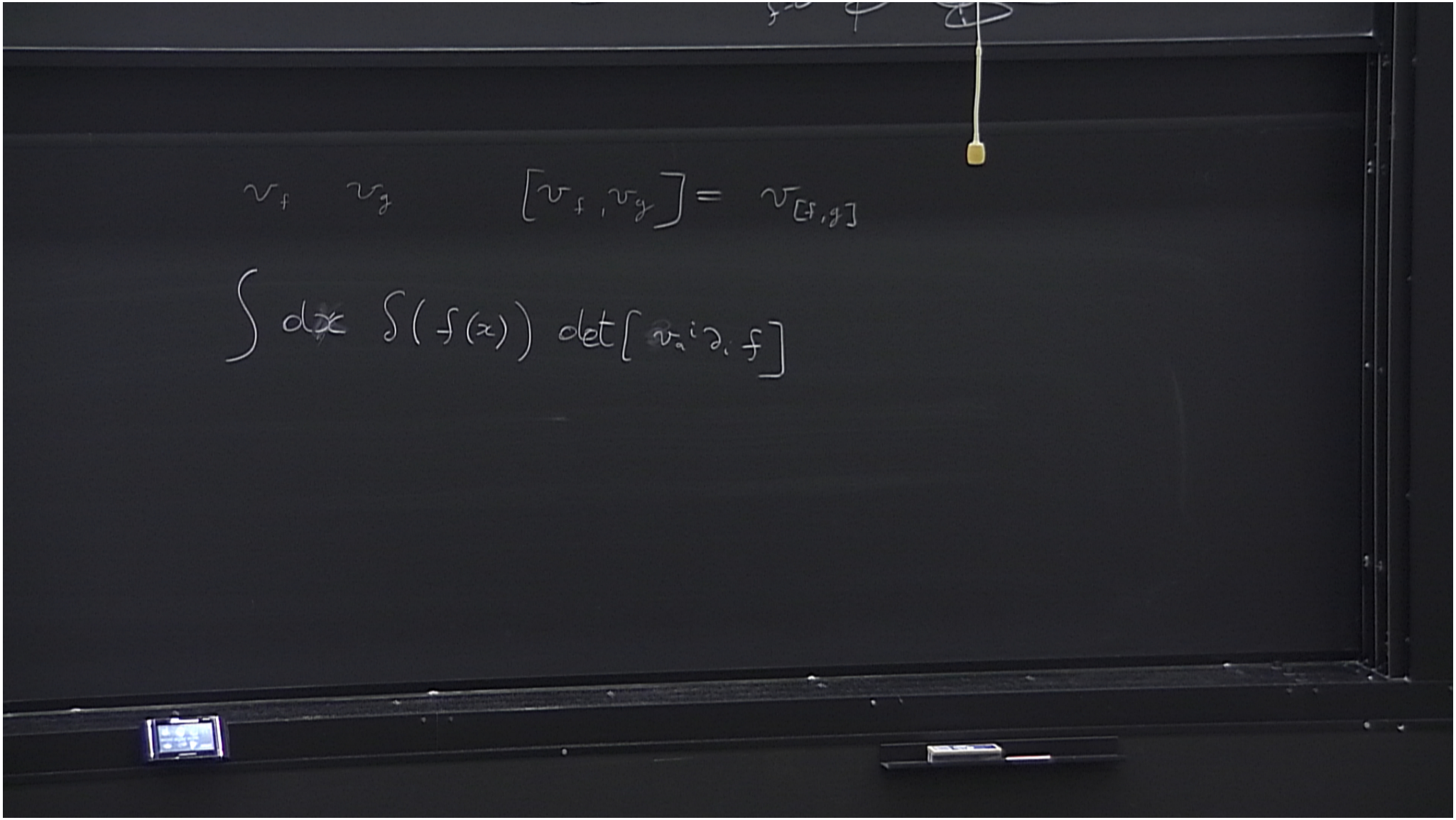

$v_f \quad v_g \qquad [v_f, v_g] = v_{[f,g]}$

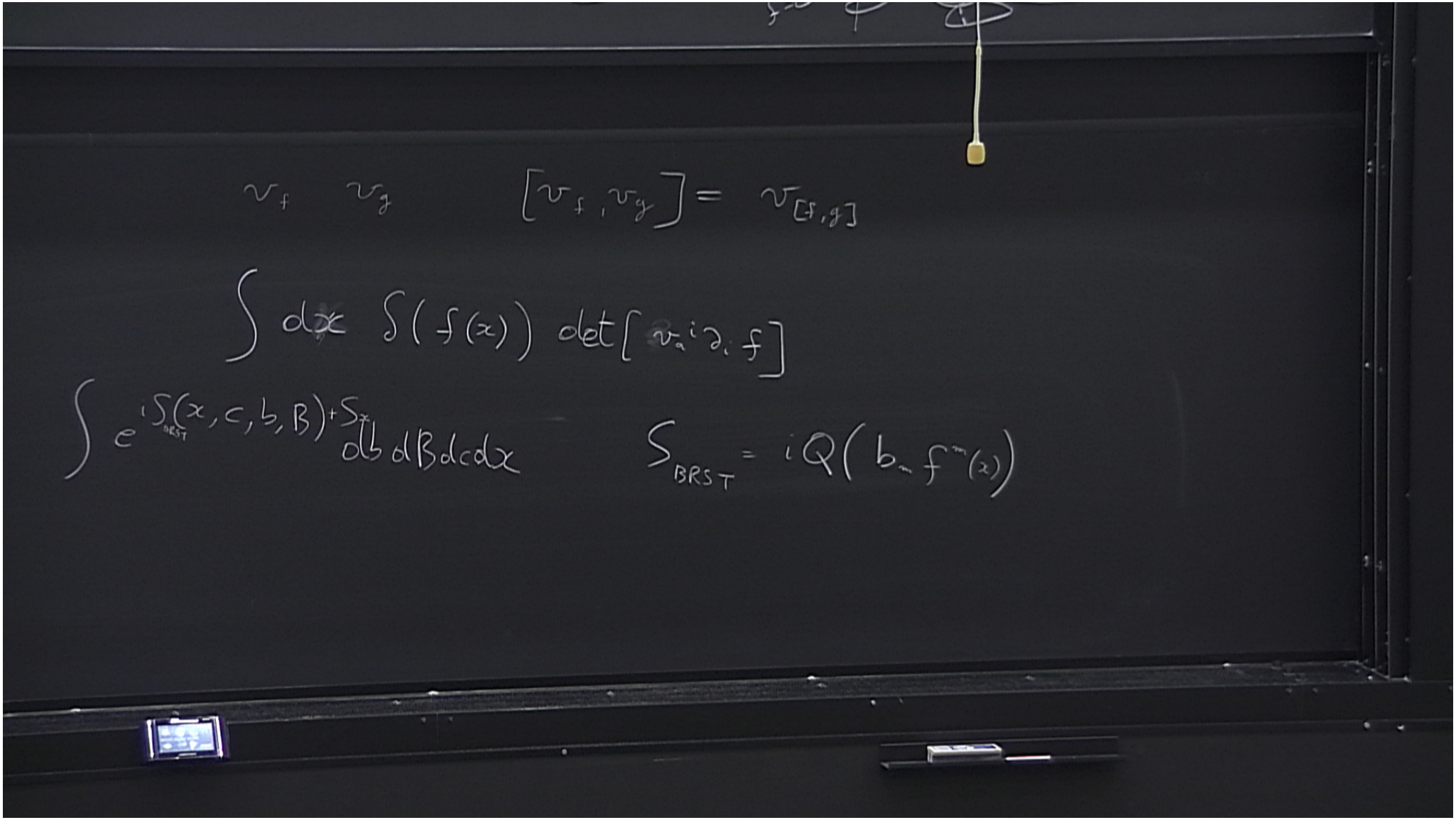

$Qx^i = v_a^i(x)\ c^a$
$Q^2x^i = v_a^i\, Qc^a + \partial_j v_a^i \cdot v_b^j\ c^a c^b$
$\| \quad f_{ab}^c v_c^i$

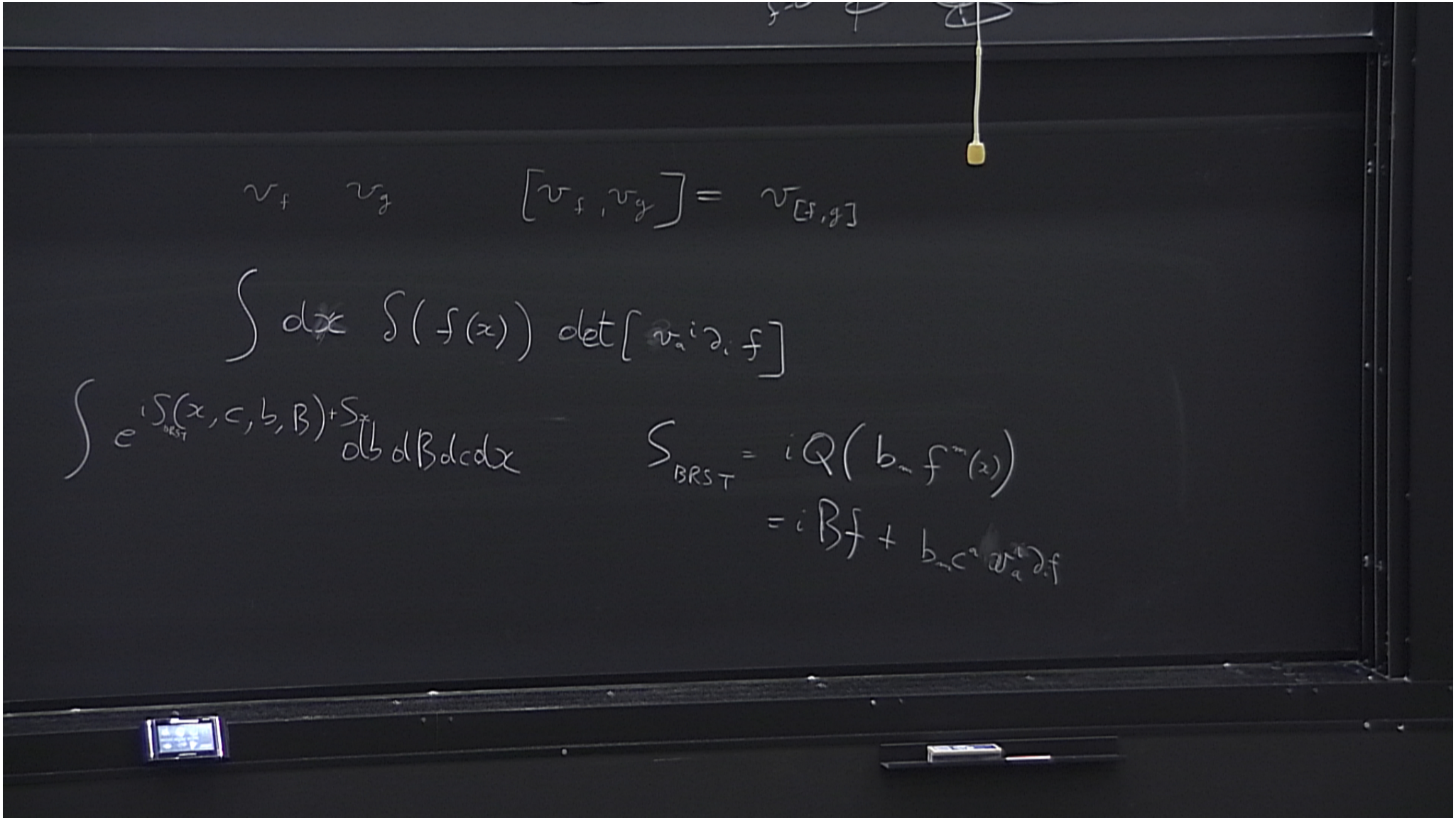

$Q x^i = v^i_a(x)\ c^a$
$Q^2 x^i = v^i_a\, Qc^a + \partial_j v^i_a \cdot v^j_b\ c^a c^b$
$Qc^a = f^a_{bc} c^b c^c$
$\equiv$
$f^c_{ab} v^i_c$

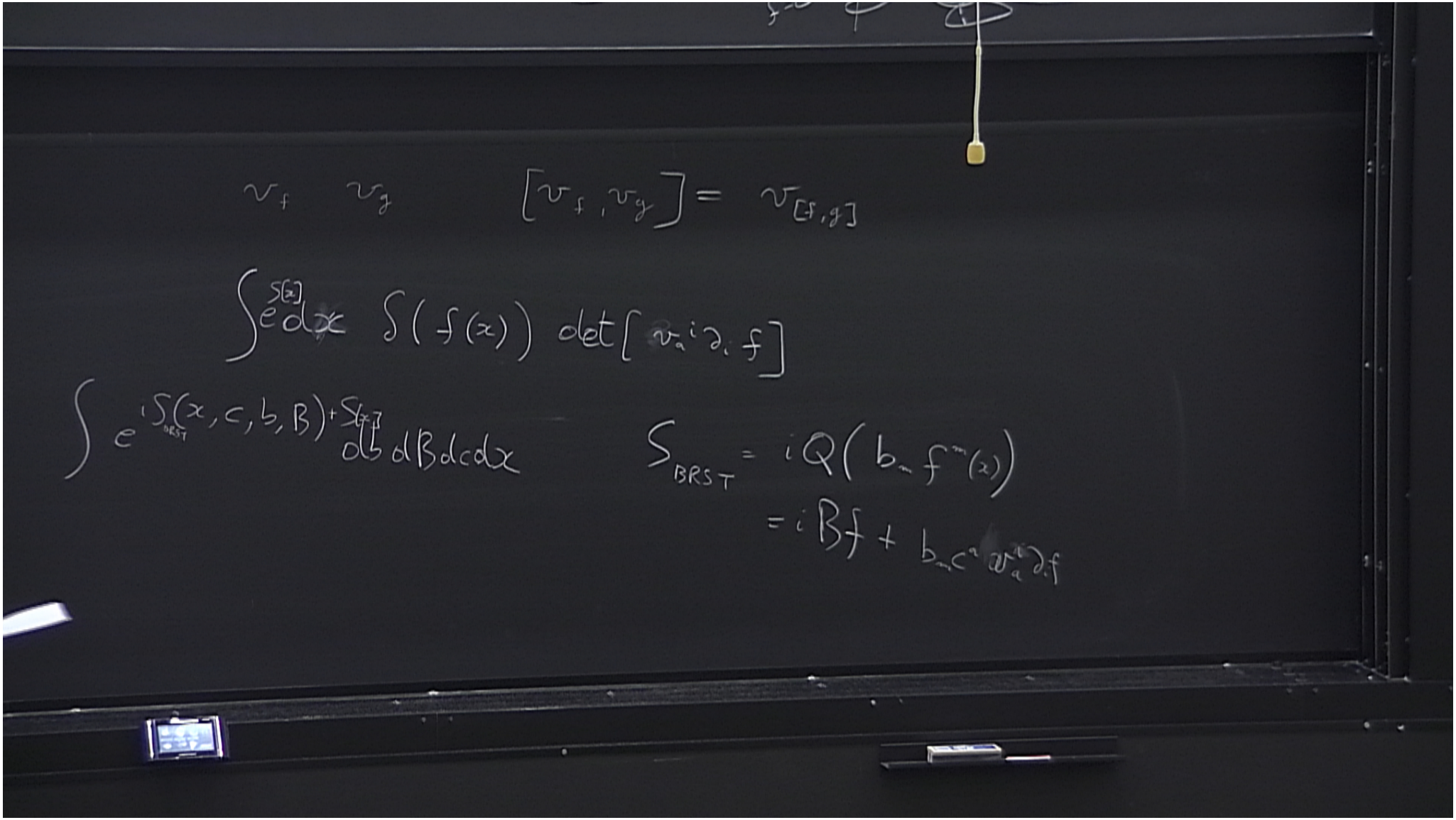

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$Q c^a = f_{bc}^a c^b c^c$
$f_{ab}^c v_c^i$

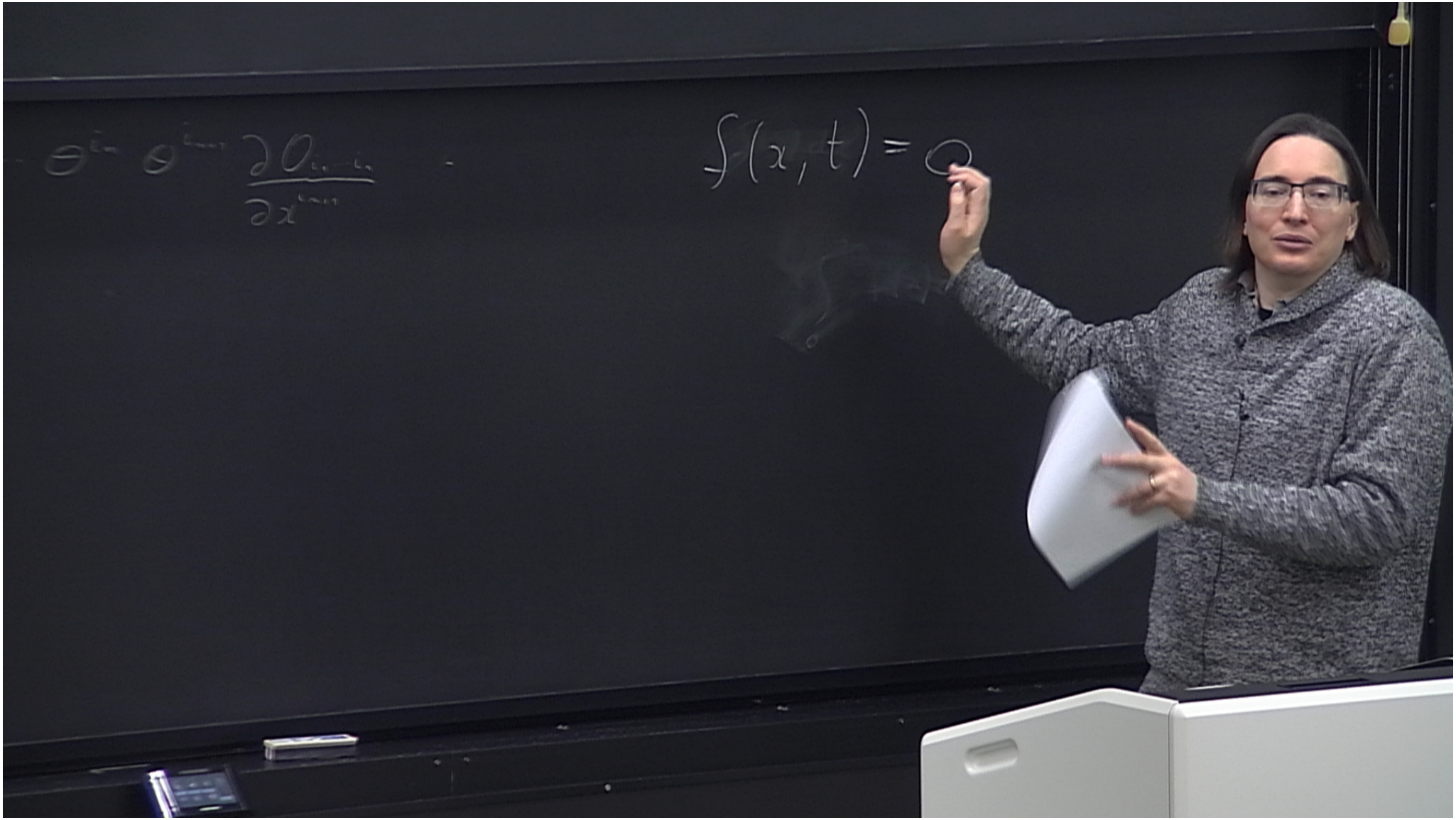

$v_f \quad v_g \qquad [v_f, v_g] = v_{[f,g]}$
$\int dx$

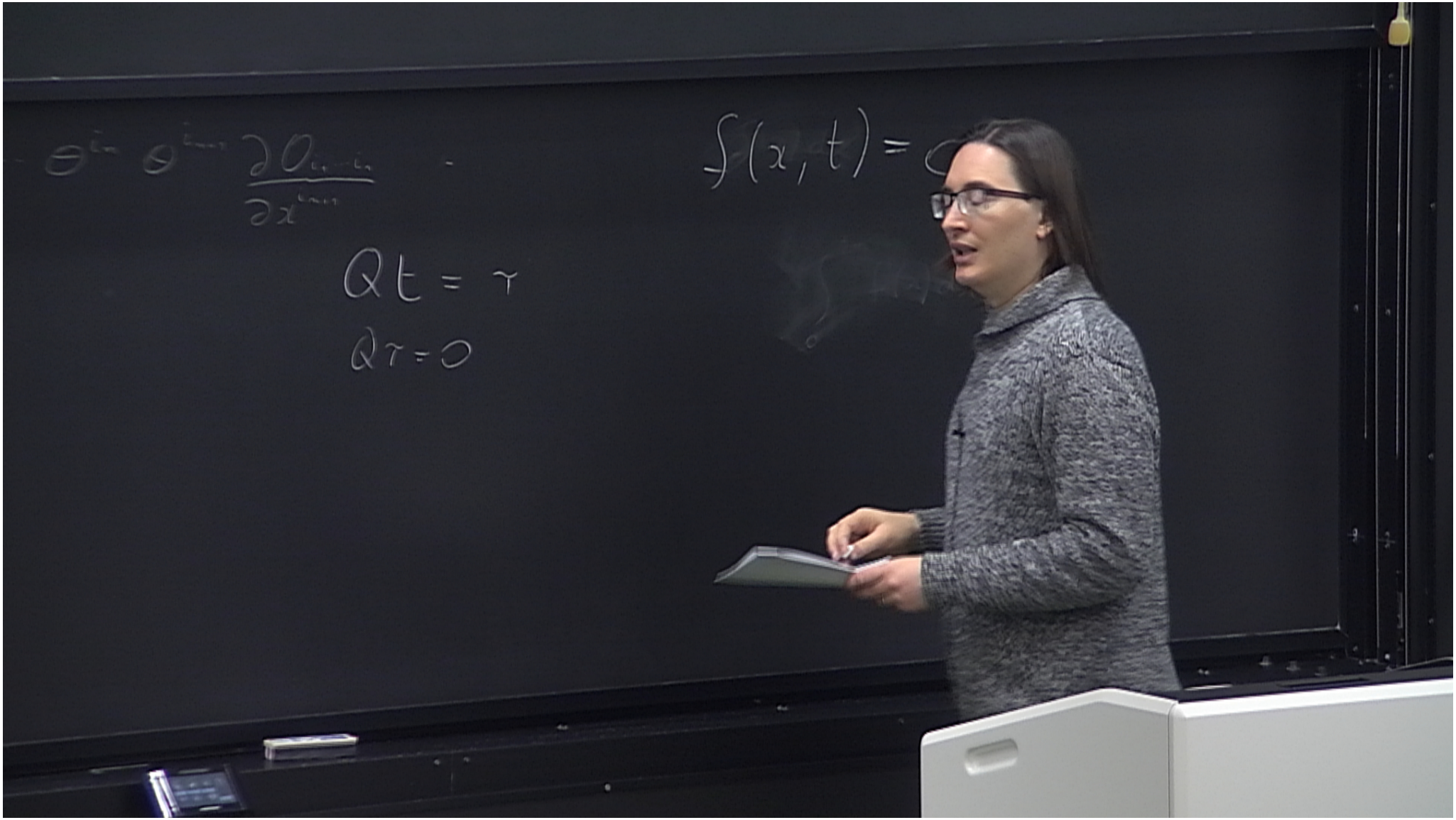

$v_f \quad v_g \qquad [v_f, v_g] = v_{[f,g]}$
$\int dx\ \delta(f(x))\ \det[v, \partial, f]$

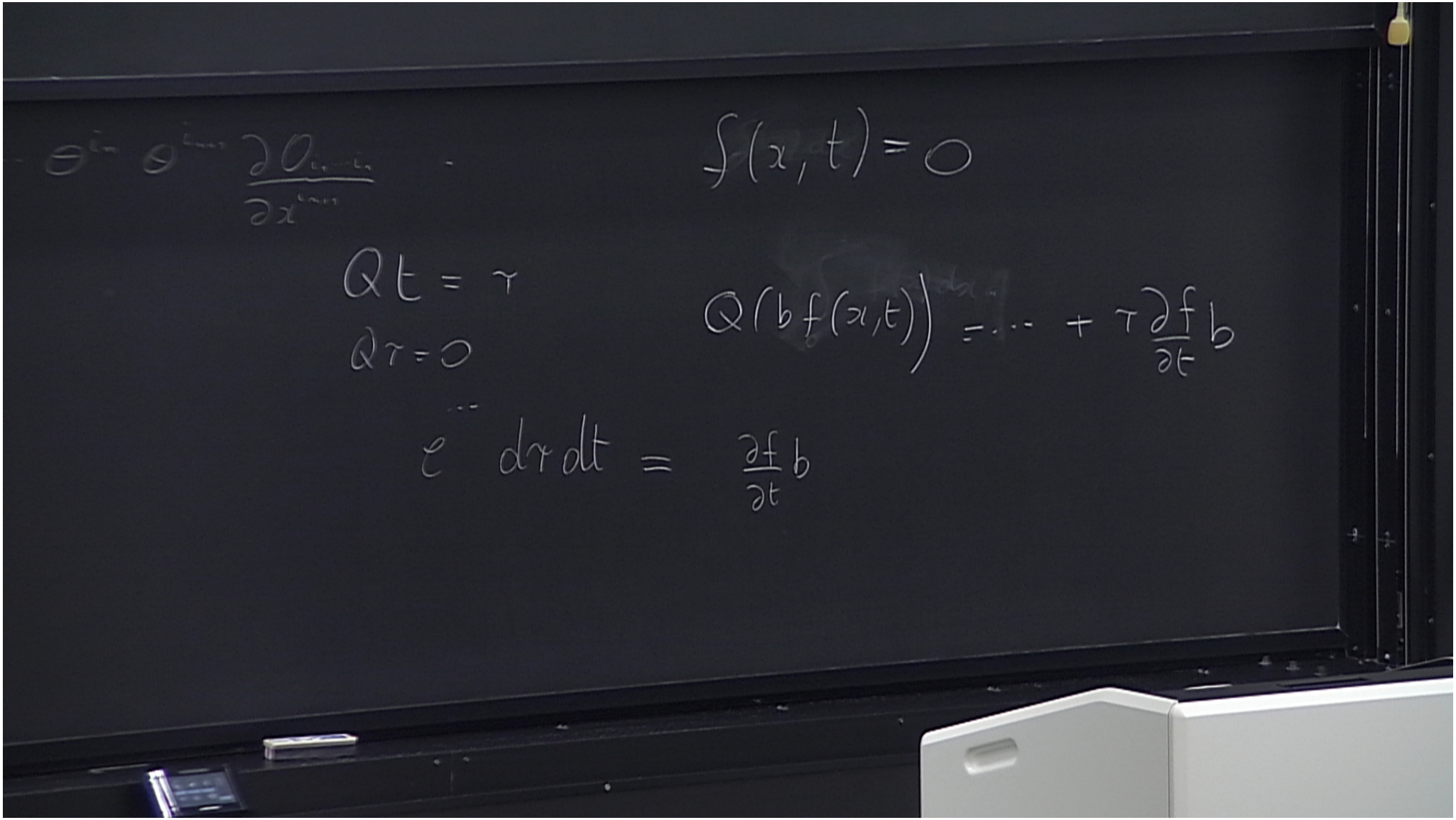

$v_f \quad v_g \quad [v_f, v_g] = v_{[f,g]}$
$\int dx\, \delta(f(x))\, \det[\partial_i f]$
$\int e^{iS_{BRST}(x,c,b,B)+S_x} db\, dB\, dc\, dx \qquad S_{BRST} = iQ(b_- f^-(x))$

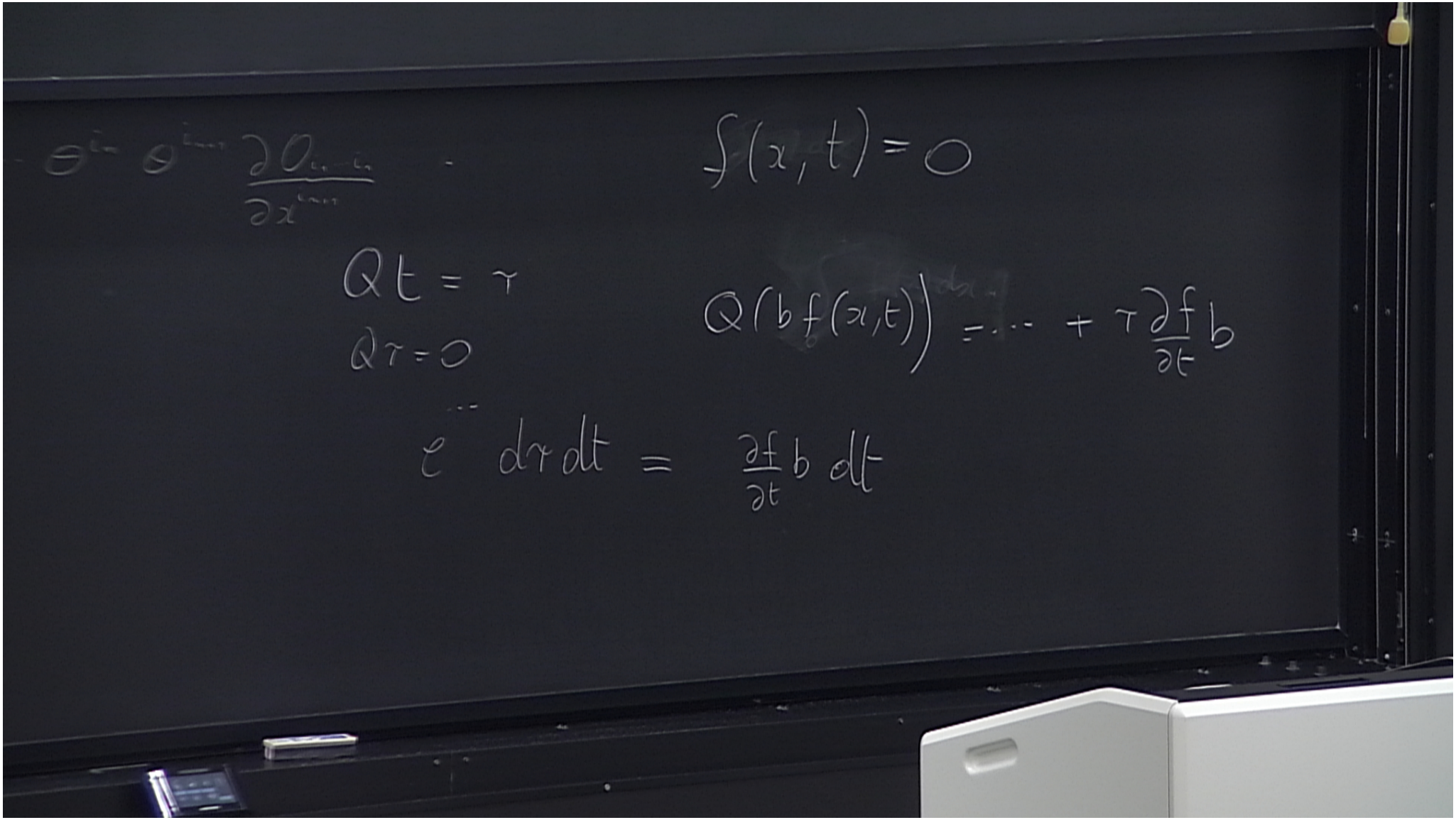

$v_f \quad v_g \quad [v_f, v_g] = v_{[f,g]}$
$\int dx\, \delta(f(x))\, \det[v_a^i \partial_i f]$
$\int e^{iS_{BRST}(x,c,b,B)+S_x} db\, dB\, dc\, dx$
$S_{BRST} = iQ(b_m f^m(x))$
$= iBf + b_m c^a v_a^i \partial_i f$


$v_f \quad v_g \quad [v_f, v_g] = v_{[f,g]}$
$\int e^{S[x]} dx \; \delta(f(x)) \det[v_a^i \partial_i f]$
$\int e^{iS_{BRST}(x,c,b,B)+S[x]} db\, dB\, dc\, dx$
$S_{BRST} = iQ(b_m f^m(x))$
$= iBf + b_m c^a v_a^i \partial_i f$


$\frac{\partial \theta_{i_1 \ldots i_n}}{\partial x^{i_{n+1}}}$
$f(x,t) = 0$


Qt = τ
Qτ = 0


$\frac{\partial \theta_{i_1 \ldots i_n}}{\partial x^{i_{n+1}}}$
$f(x,t) = 0$
$Qt = \tau$
$Q\tau = 0$
$Q(bf(x,t)) = \ldots + \tau \frac{\partial f}{\partial t} b$
$\int d\tau dt = \frac{\partial f}{\partial t} b$


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$e \, d\tau \, dt = \frac{\partial f}{\partial t} b \, dt$