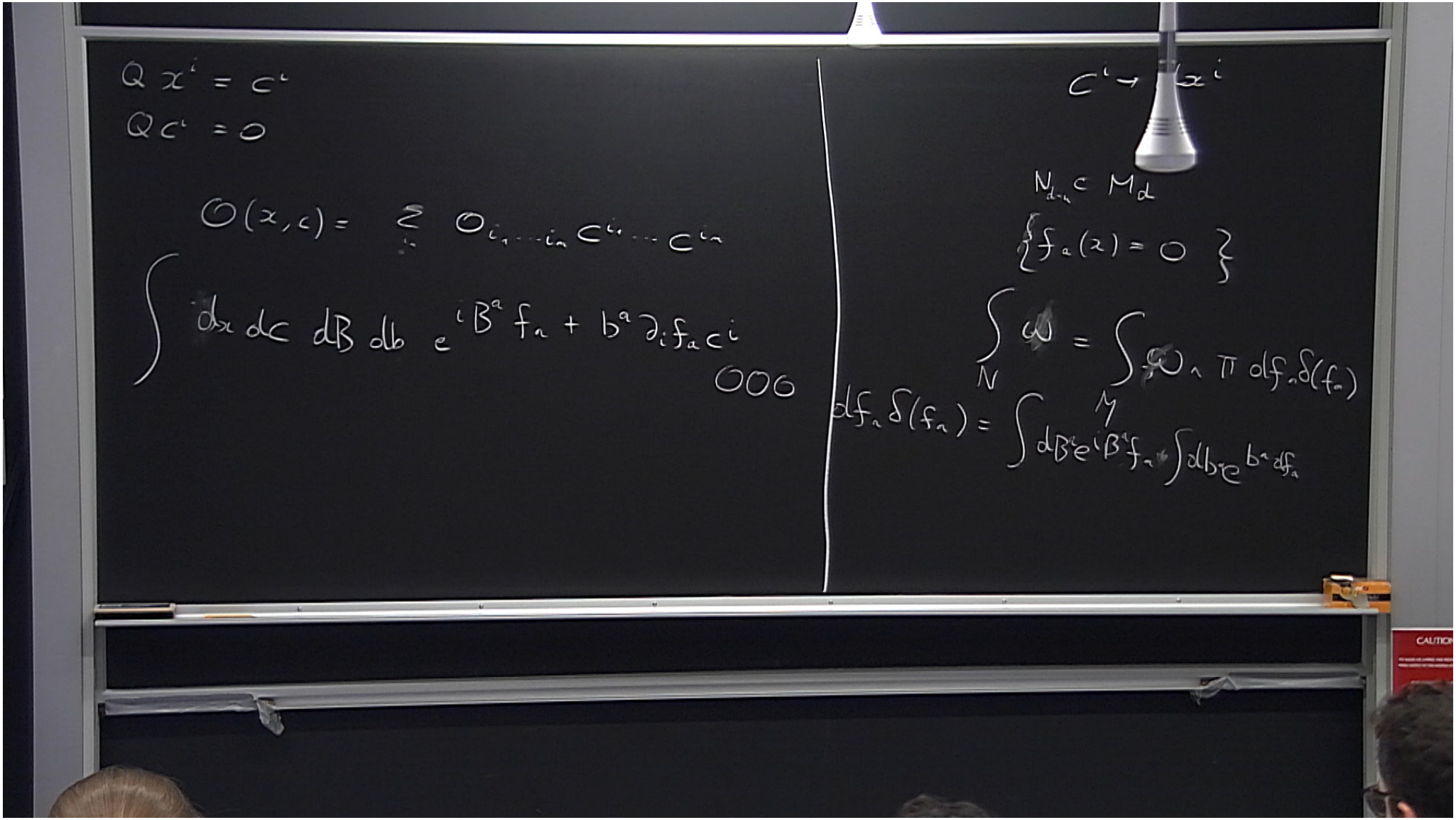
Title: PSI 2018/2019 - String Theory Review - Lecture 5

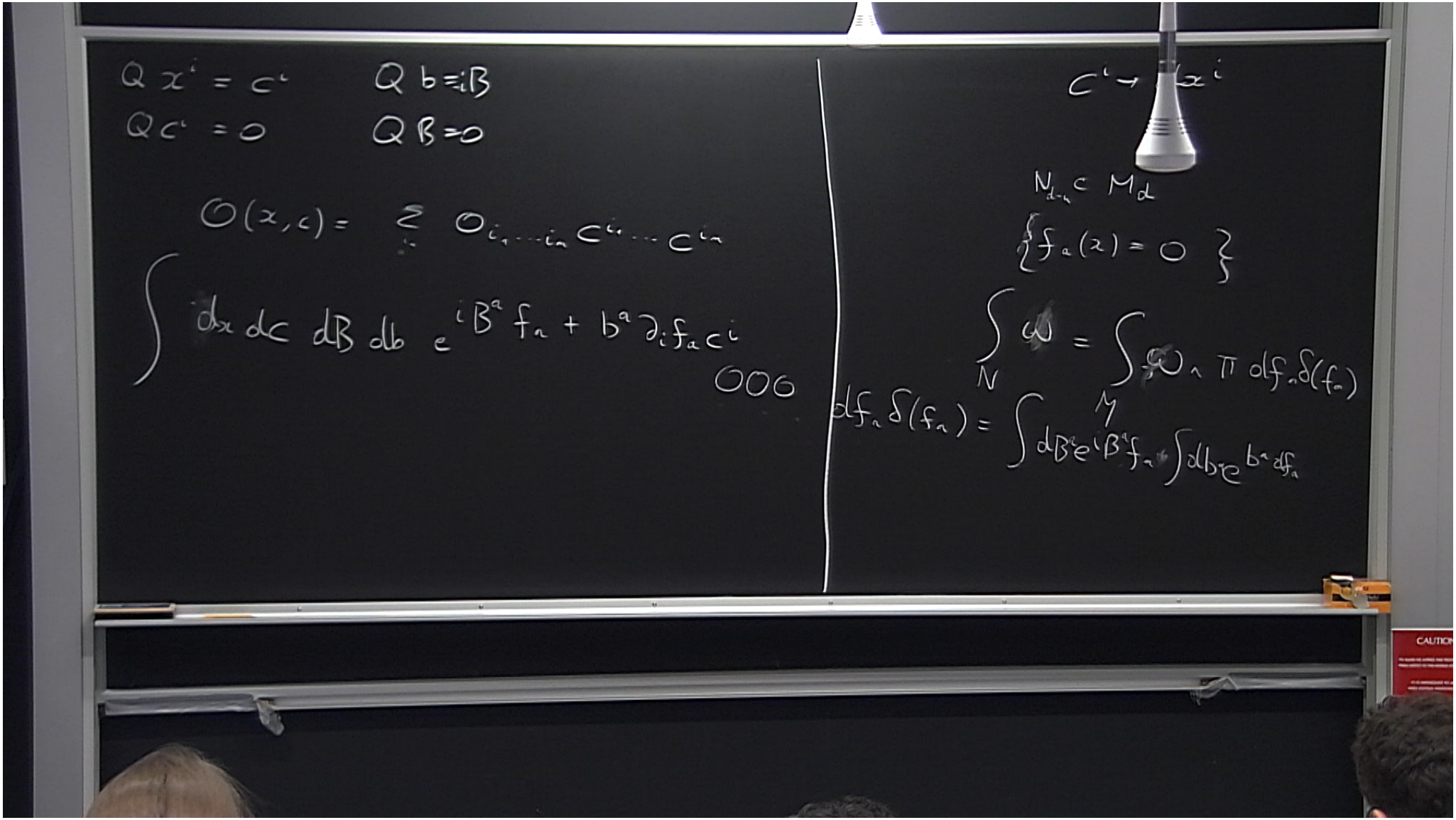
Speakers: Davide Gaiotto

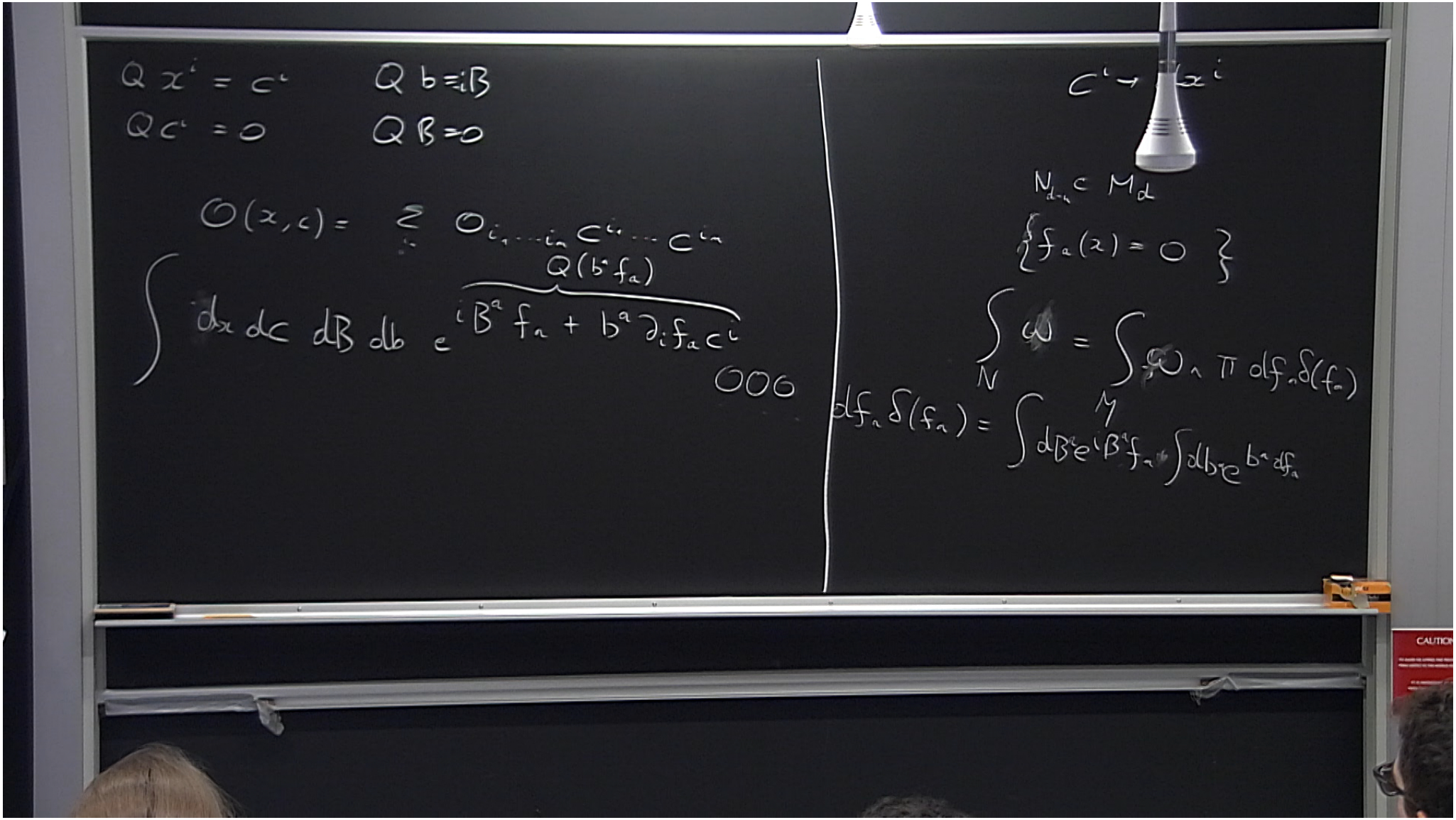
Collection: PSI 2018/2019 - String Theory Review (Gaiotto)

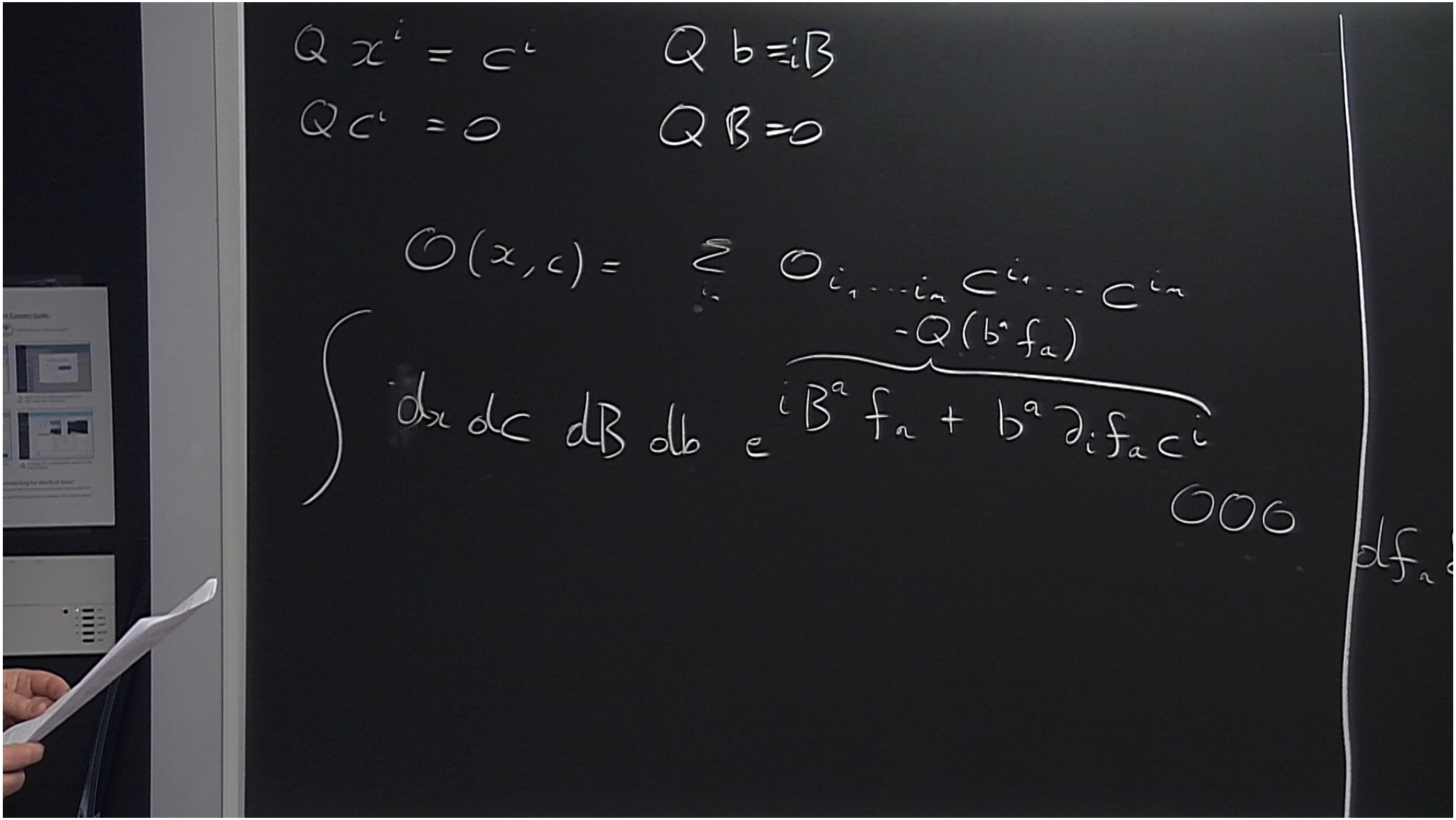
Date: March 29, 2019 - 10:15 AM

URL: http://pirsa.org/19030087

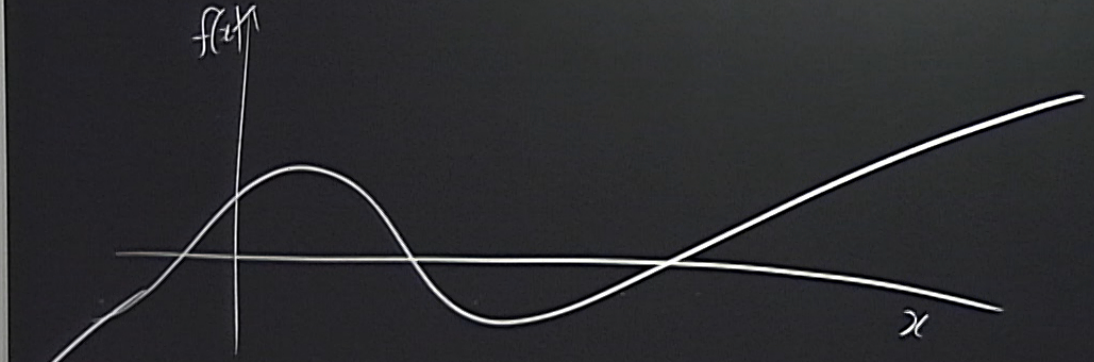

$Q x^i = c^i$
$Q c^i = 0$
$C^i \to x^i$
$O(x,c) = \sum_{i} O_{i_1 \cdots i_n} c^{i_1} \cdots c^{i_n}$
$N_{d-n} \subset M_d$
$\{ f_a(x) = 0 \}$
$\int dx\, dc\, dB\, db\; e^{i B^a f_a + b^a \partial_i f_a c^i}$
000
$\int_N \omega = \int_M \omega_n \pi\, df_a \delta(f_a)$
$df_a \delta(f_a) = \int dB^a e^{i B^a f_a} \int db\, e^{b^a df_a}$

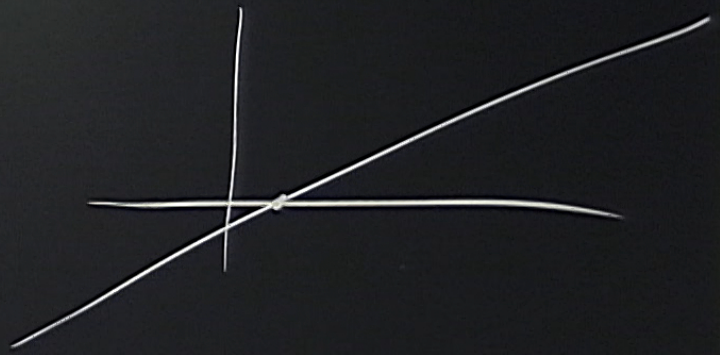

$Q x^i = c^i$
$Q c^i = 0$
$Q b = iB$
$Q B = 0$
$C^i \to x^i$
$N_{d-n} \subset M_d$
$\{ f_a(x) = 0 \}$
$O(x,c) = \sum O_{i_1 \dots i_n} c^{i_1} \dots c^{i_n}$
$\int dx\, dc\, dB\, db\, e^{iB^a f_a + b^a \partial_i f_a c^i}$
$O O O$
$\int_N \omega = \int_M \omega \wedge \Pi\, df_a \delta(f_a)$
$df_a \delta(f_a) = \int dB^a e^{iB^a f_a} \int db\, e^{b^a df_a}$

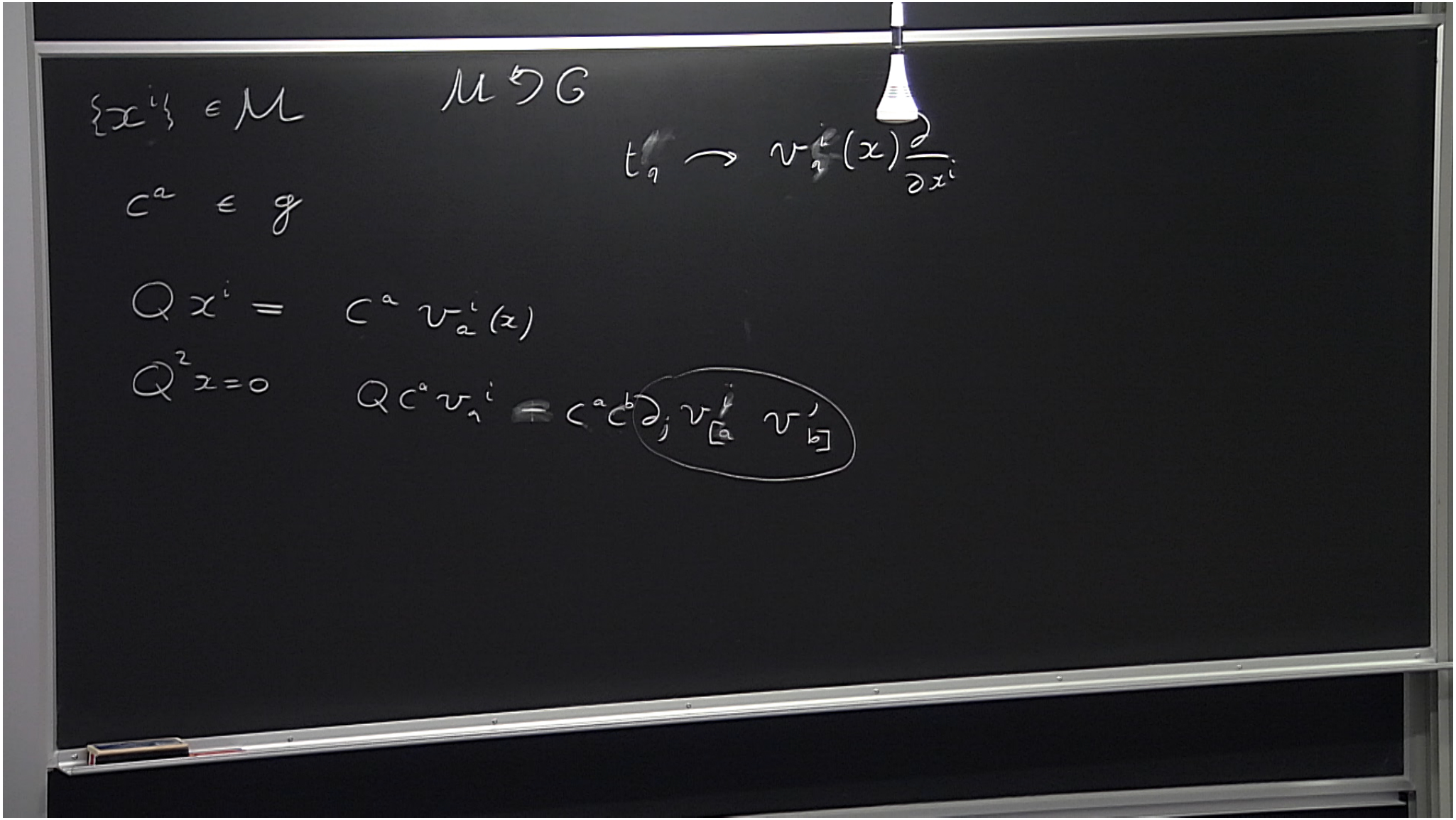

$Q x^i = c^i$
$Q b = iB$
$Q c^i = 0$
$Q B = 0$
$O(x,c) = \sum O_{i_1 \dots i_n} c^{i_1} \cdots c^{i_n}$
$\int dx\, dc\, dB\, db\, e^{i B^a f_a + b^a \partial_i f_a c^i}$
$Q(b^a f_a)$
OOO
$c^i \to dx^i$
$N_{d-n} \subset M_d$
$\{ f_a(x) = 0 \}$
$\int_N \omega = \int_M \omega \wedge \Pi\, df_a \delta(f_a)$
$df_a \delta(f_a) = \int dB^a e^{i B^a f_a} \int db\, e^{b^a df_a}$

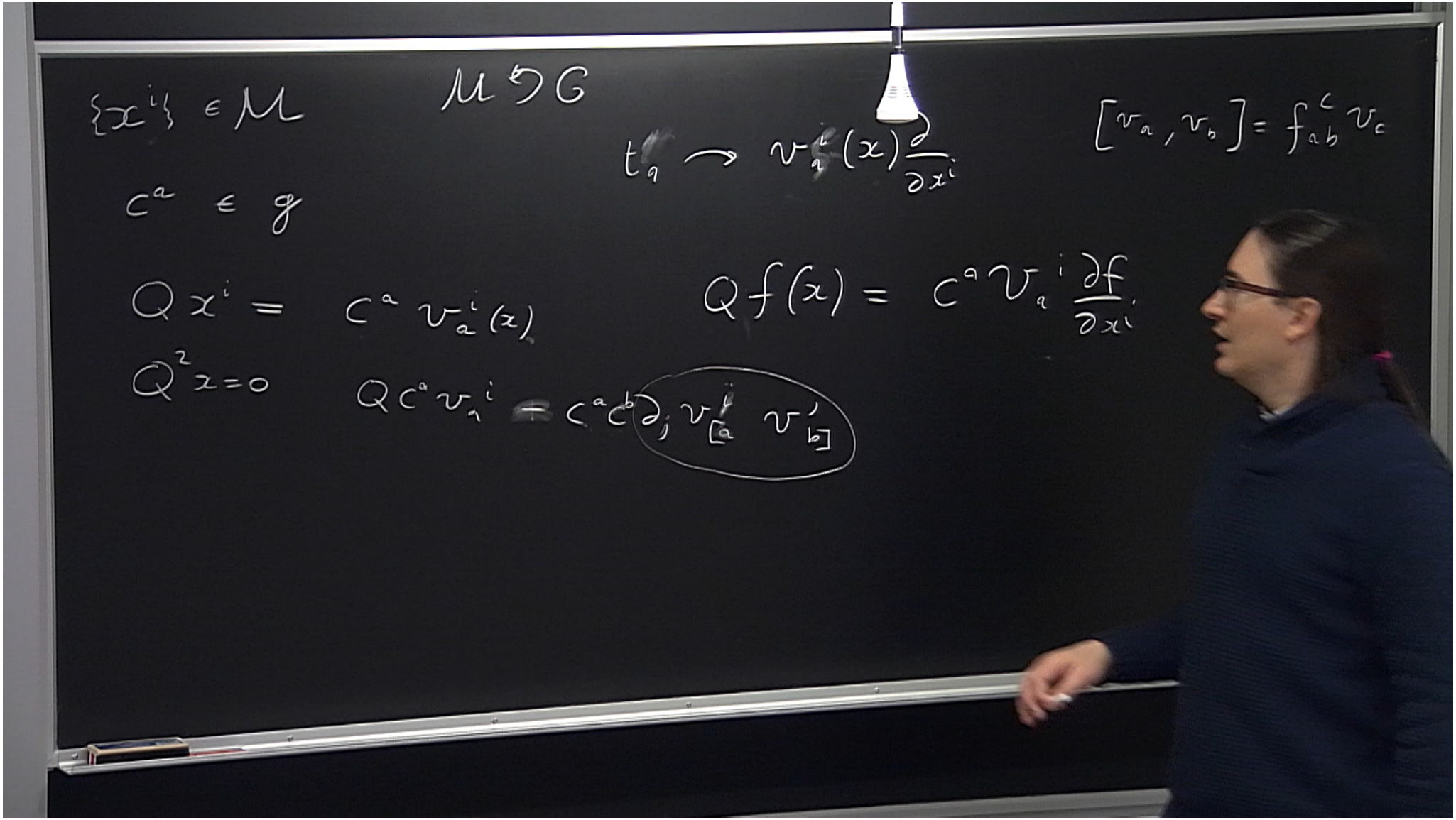

$Q x^i = c^i$
$Q b = iB$
$Q c^i = 0$
$Q B = 0$
$O(x,c) = \sum_{i_1 \dots i_n} O_{i_1 \dots i_n} c^{i_1} \dots c^{i_n}$
$-Q(b^a f_a)$
$\int dx\, dc\, dB\, db\, e^{iB^a f_a + b^a \partial_i f_a c^i}$
OOO
df_a

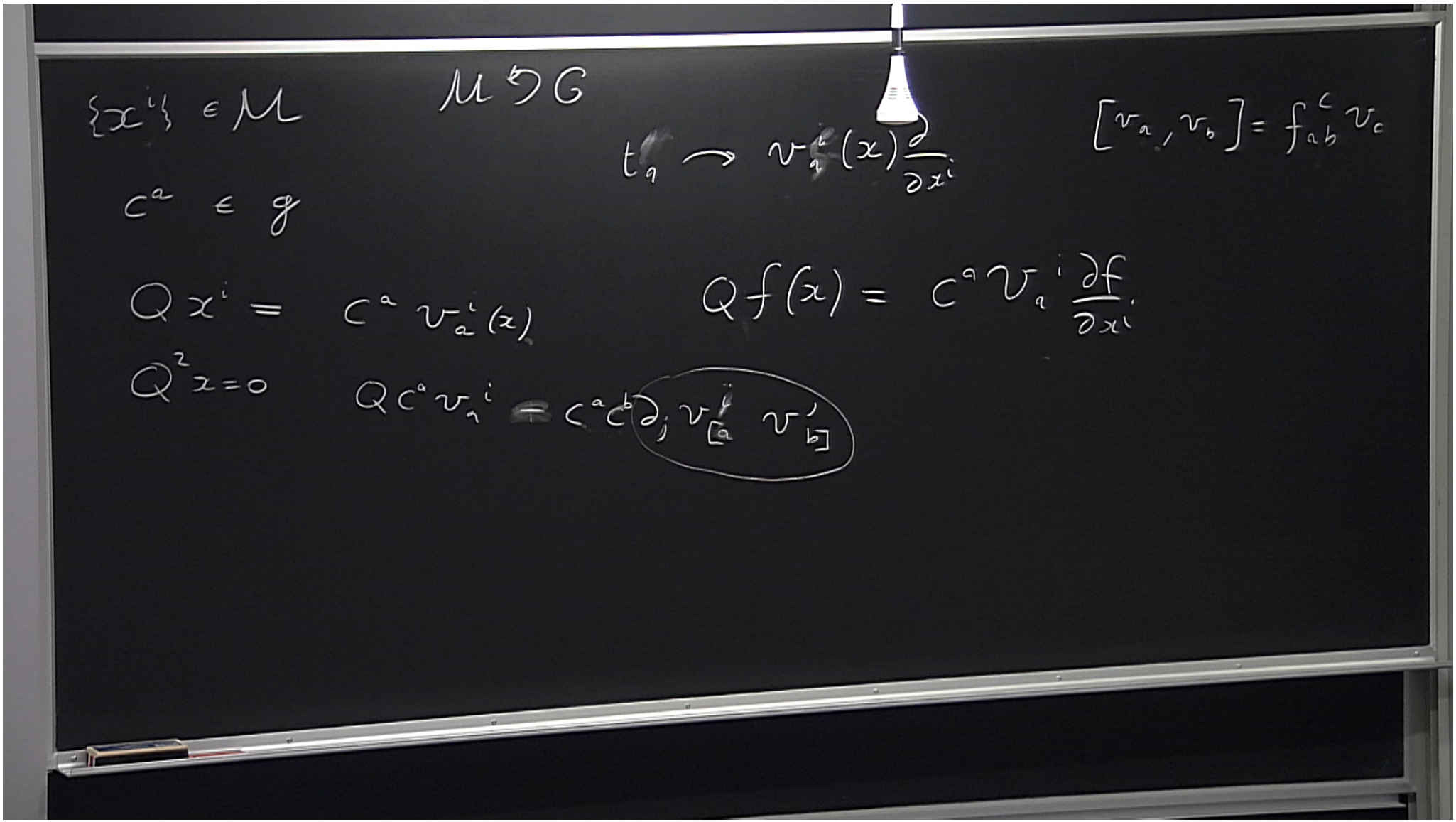
$$\int_{-\infty}^{\infty} \frac{\partial f}{\partial x}\, \delta(f(x))\, dx = \sum_{f(x_i)=0} \operatorname{sign}\left(\frac{\partial f}{\partial x}\right)$$






$\{x^i\} \in \mathcal{M}$
$\mathcal{M} \circlearrowleft G$
$t_a \to v_a^i(x) \frac{\partial}{\partial x^i}$
$c^a \in \mathfrak{g}$
$Q x^i = c^a v_a^i(x)$
$Q^2 x = 0$
$Q c^a v_a^i = c^a c^b \partial_j v_{[a}^i v_{b]}^j$


$\{x^i\} \in M$
$M \circlearrowleft G$
$t_a \to v_a^i(x) \frac{\partial}{\partial x^i}$
$[v_a, v_b] = f_{ab}^c v_c$
$c^a \in g$
$Q x^i = c^a v_a^i(x)$
$Q f(x) = c^a v_a^i \frac{\partial f}{\partial x^i}$
$Q^2 x = 0$
$Q c^a v_a^i = c^a c^b \partial_j v_{[a}^i v_{b]}^j$


$\{x^i\} \in M$
$M \circlearrowleft G$
$t_a \to v_a^i(x) \frac{\partial}{\partial x^i}$
$[v_a, v_b] = f_{ab}^c v_c$
$c^a \in g$
$Q x^i = c^a v_a^i(x)$
$Q f(x) = c^a v_a^i \frac{\partial f}{\partial x^i}$
$Q^2 x = 0$
$Q c^a v_a^i = c^a c^b \partial_j v_{[a}^i v_{b]}^j$

c^i $\quad Q\, b = iB$

$0 \quad\quad Q\, B = 0$

$x(x')$

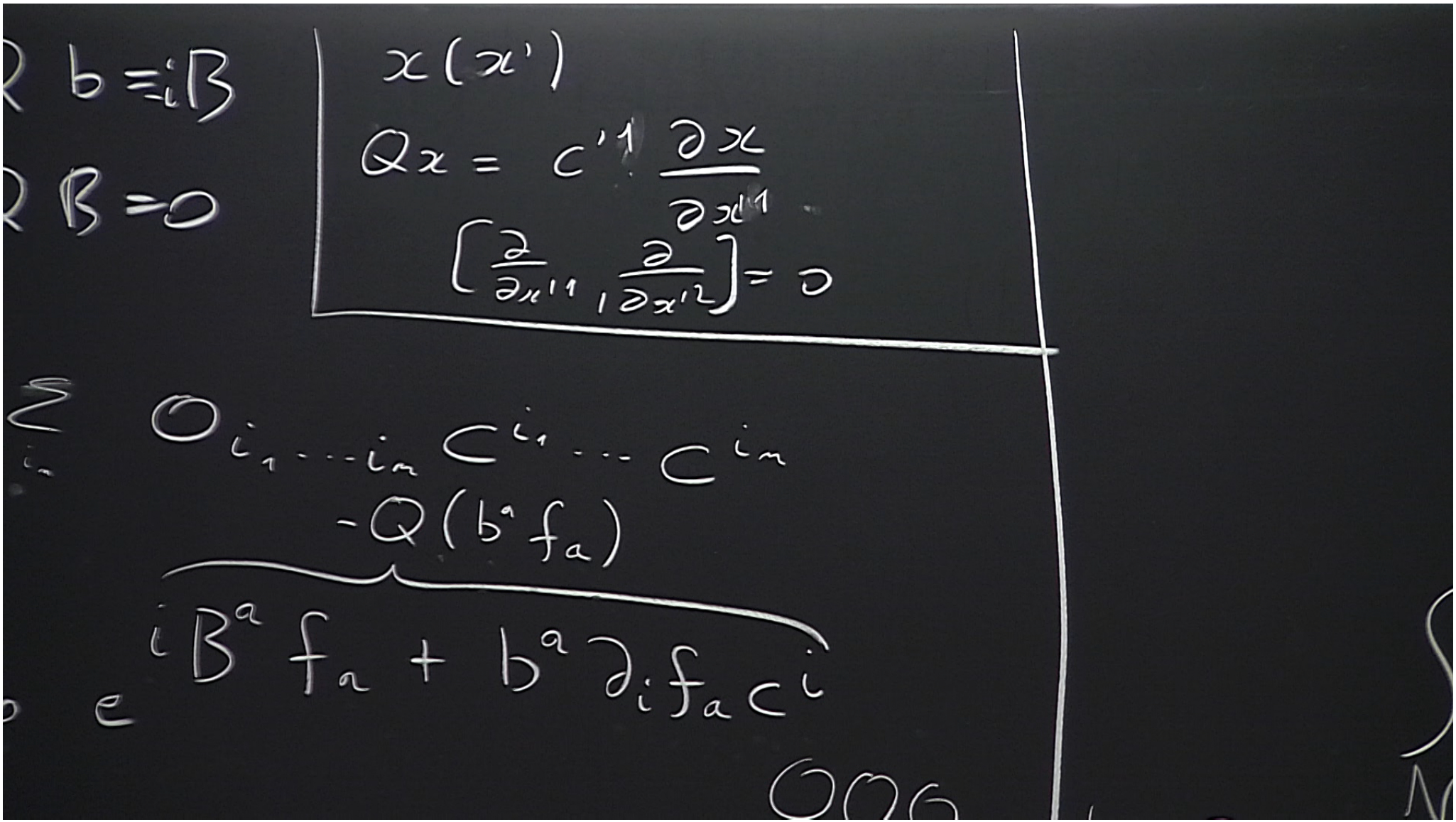
$Qx = c'^1 \frac{\partial x}{\partial x'^1}$

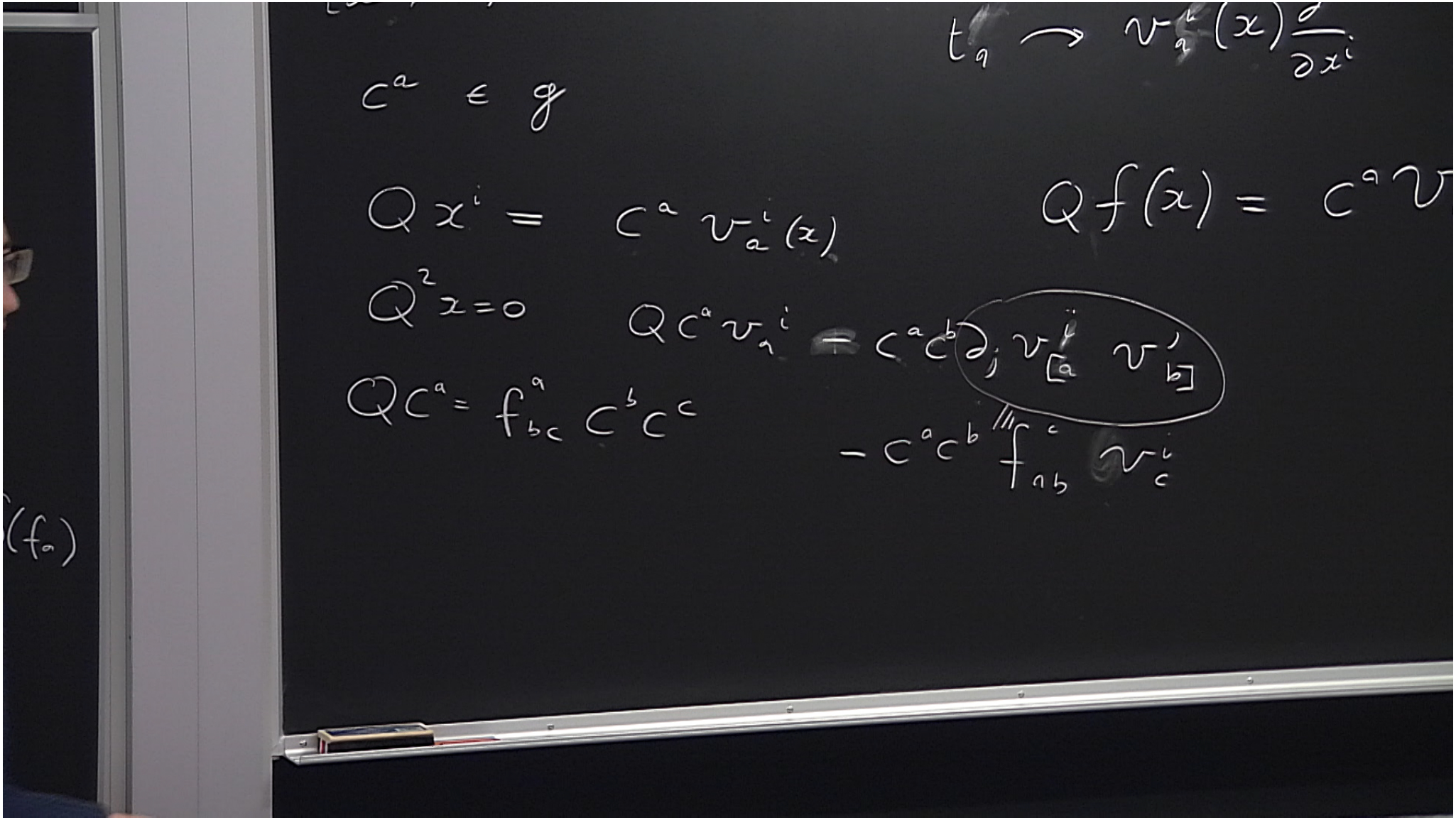
$$O(x,c) = \sum_{i_n} O_{i_1 \cdots i_m} c^{i_1} \cdots c^{i_m}$$

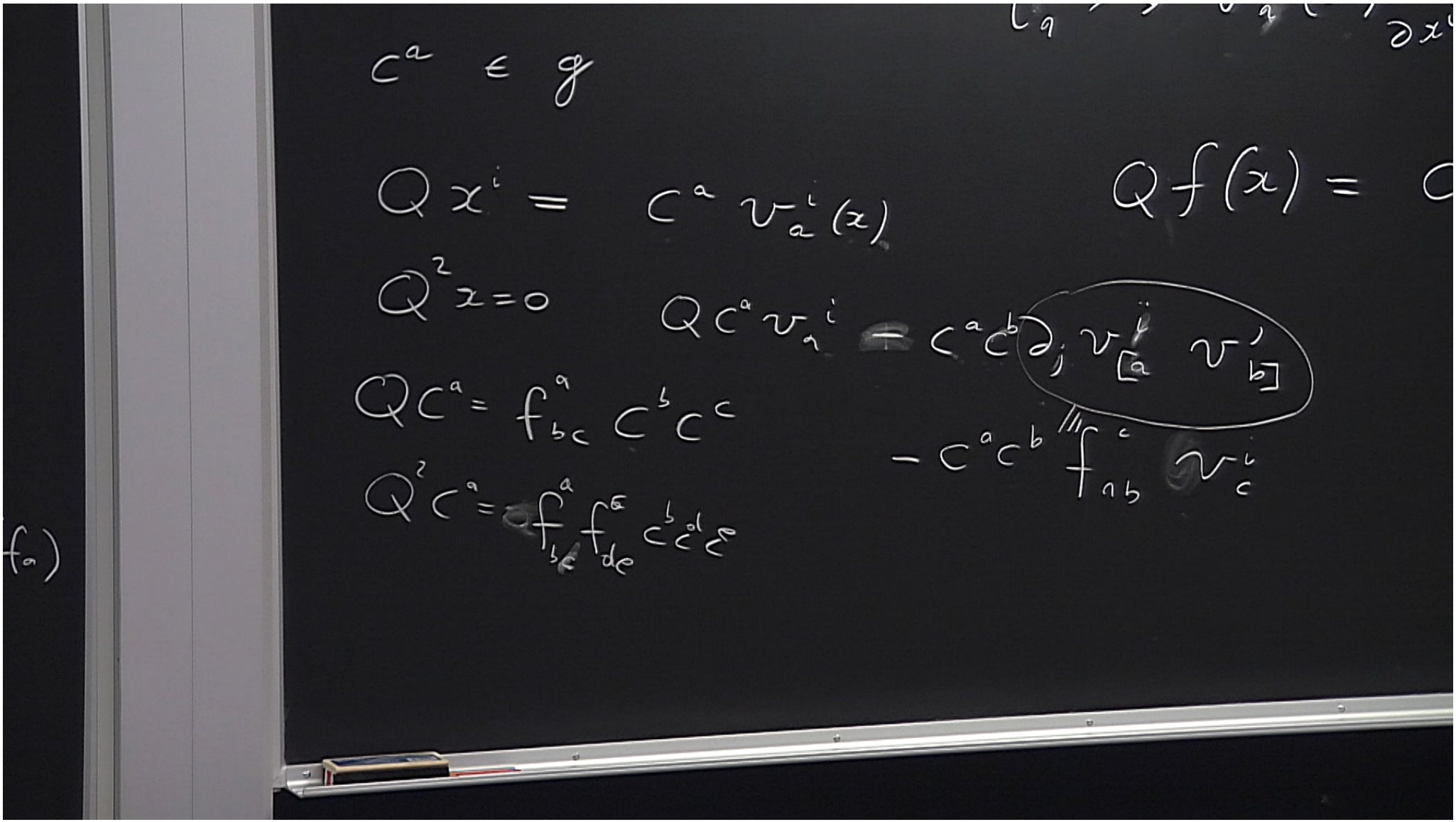
$$dc\, dB\, db\, e^{\overbrace{iB^a f_a + b^a \partial_i f_a c^i}^{-Q(b^a f_a)}}$$

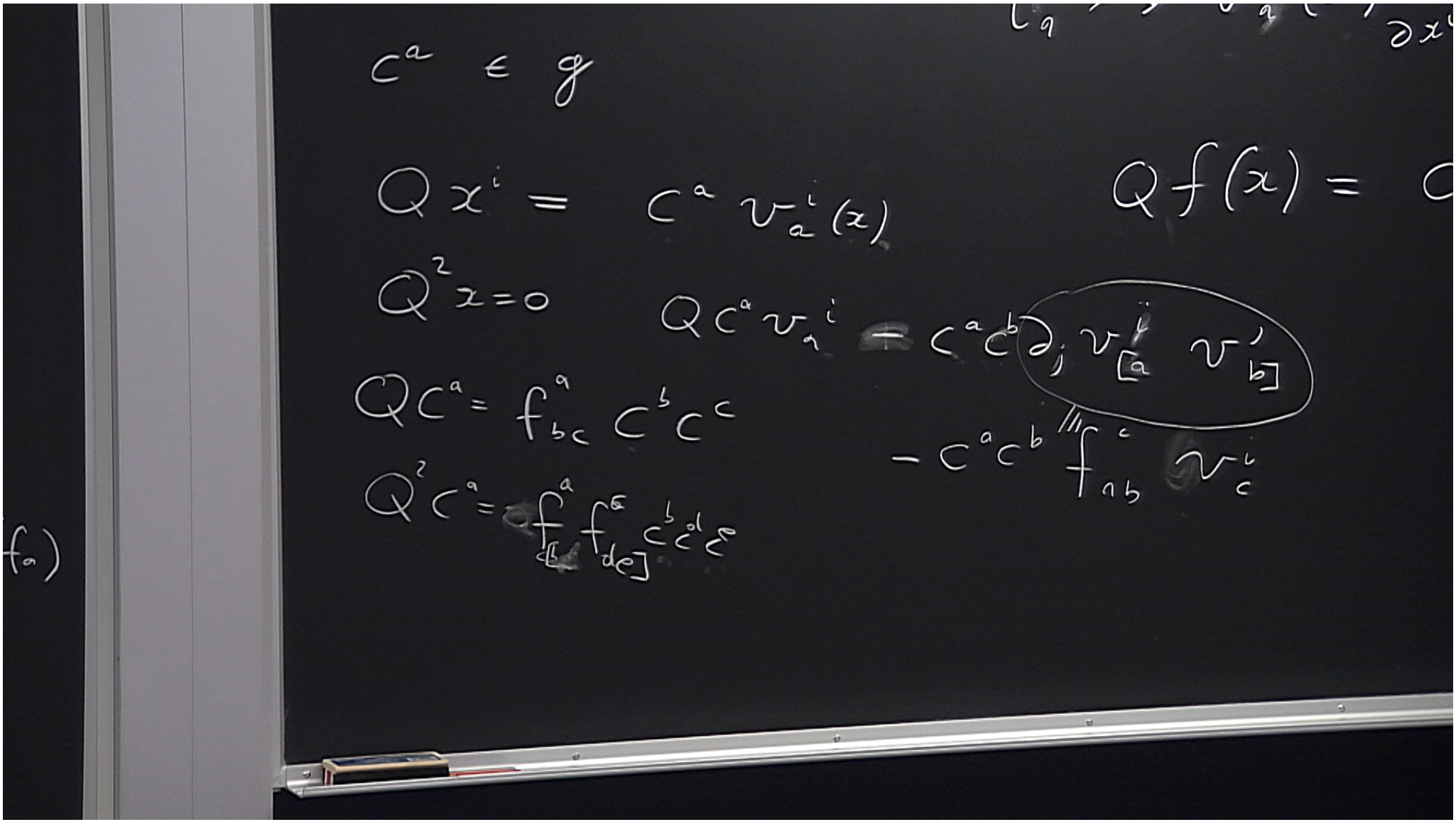
OOG

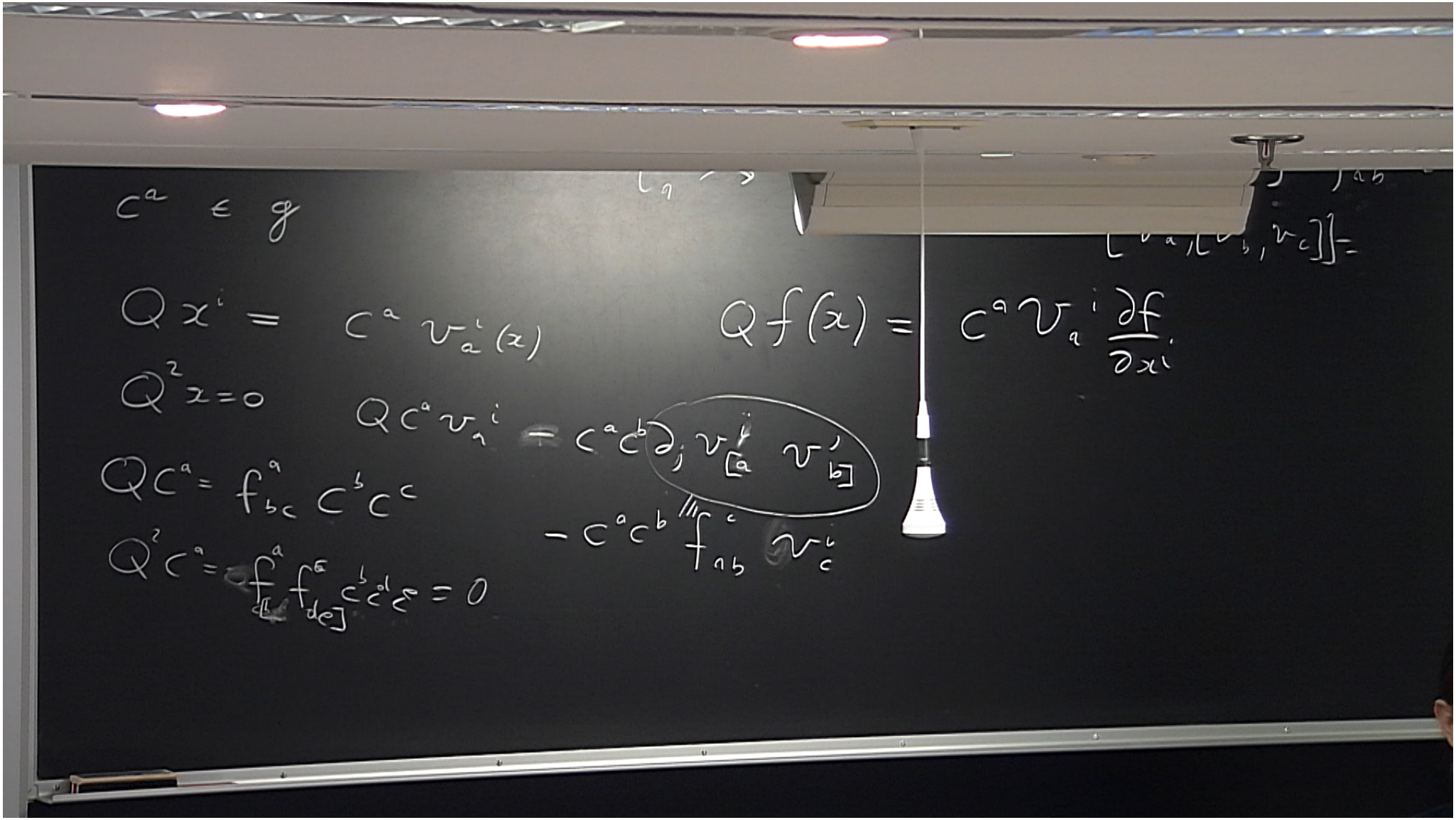
$$\int df_a \delta(f_a) =$$


b = iB
B = 0
x(x')
Qx = c'1 ∂x / ∂x'1
[∂/∂x'1 , ∂/∂x'2] = 0
O i1 ... in c^i1 ... c^in
-Q(b^a f_a)
e
iB^a f_a + b^a ∂_i f_a c^i

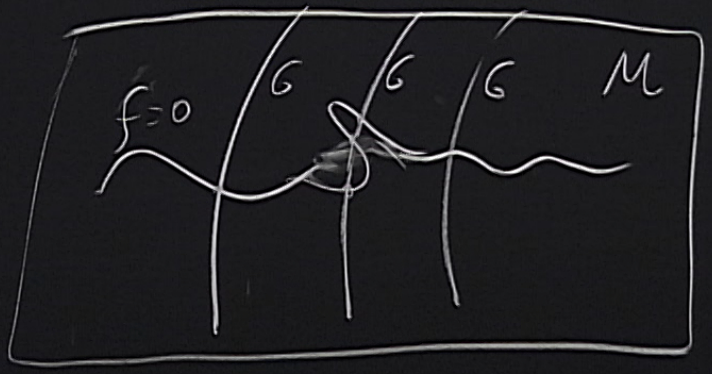

$t_a \to v_a^i(x) \frac{\partial}{\partial x^i}$
$c^a \in g$
$Q x^i = c^a v_a^i(x)$
$Q f(x) = c^a v$
$Q^2 x = 0$
$Q c^a v_a^i = c^a c^b \partial_j v_{[a}^i v_{b]}^j$
$Q c^a = f_{bc}^a c^b c^c$
$- c^a c^b f_{ab}^c v_c^i$


$c^a \in g$
$Q x^i = c^a v_a^i(x)$
$Q^2 x = 0$
$Q f(x) =$
$Q c^a v_a^i = c^a c^b \partial_j v_{[a}^i v_{b]}^j$
$Q c^a = f_{bc}^a c^b c^c$
$- c^a c^b f_{ab}^c v_c^i$
$Q^2 c^a = f_{bc}^a f_{de}^a c^b c^d c^e$


$c^a \in \mathfrak{g}$
$Q x^i = c^a v_a^i(x)$
$Q^2 x = 0$
$Q c^a = f^a_{bc} c^b c^c$
$Q^2 c^a = f^a_{[b} f^e_{de]} c^b c^d c^e$
$Q f(x) =$
$Q c^a v_a^i = c^a c^b \partial_j v^i_{[a} v^j_{b]}$
$- c^a c^b f^c_{ab} v^i_c$

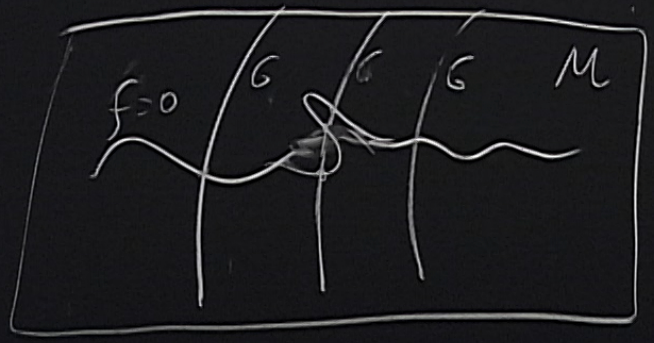

$c^a \in g$
$Qx^i = c^a v_a^i(x)$
$Q^2 x = 0$
$Qf(x) = c^a v_a^i \frac{\partial f}{\partial x^i}$
$Qc^a = f^a_{bc} c^b c^c$
$Q^2 c^a = f^a_{[bc} f^e_{d]e} c^b c^d c^e = 0$
$Qc^a v_a^i = c^a c^b \partial_j v^i_{[a} v^j_{b]}$
$- c^a c^b f^c_{ab} v^i_c$

$$\int dx\, dc\, d\beta\, db\; e^{Q(f^a b_a)}\; O_1 \cdots O_m$$

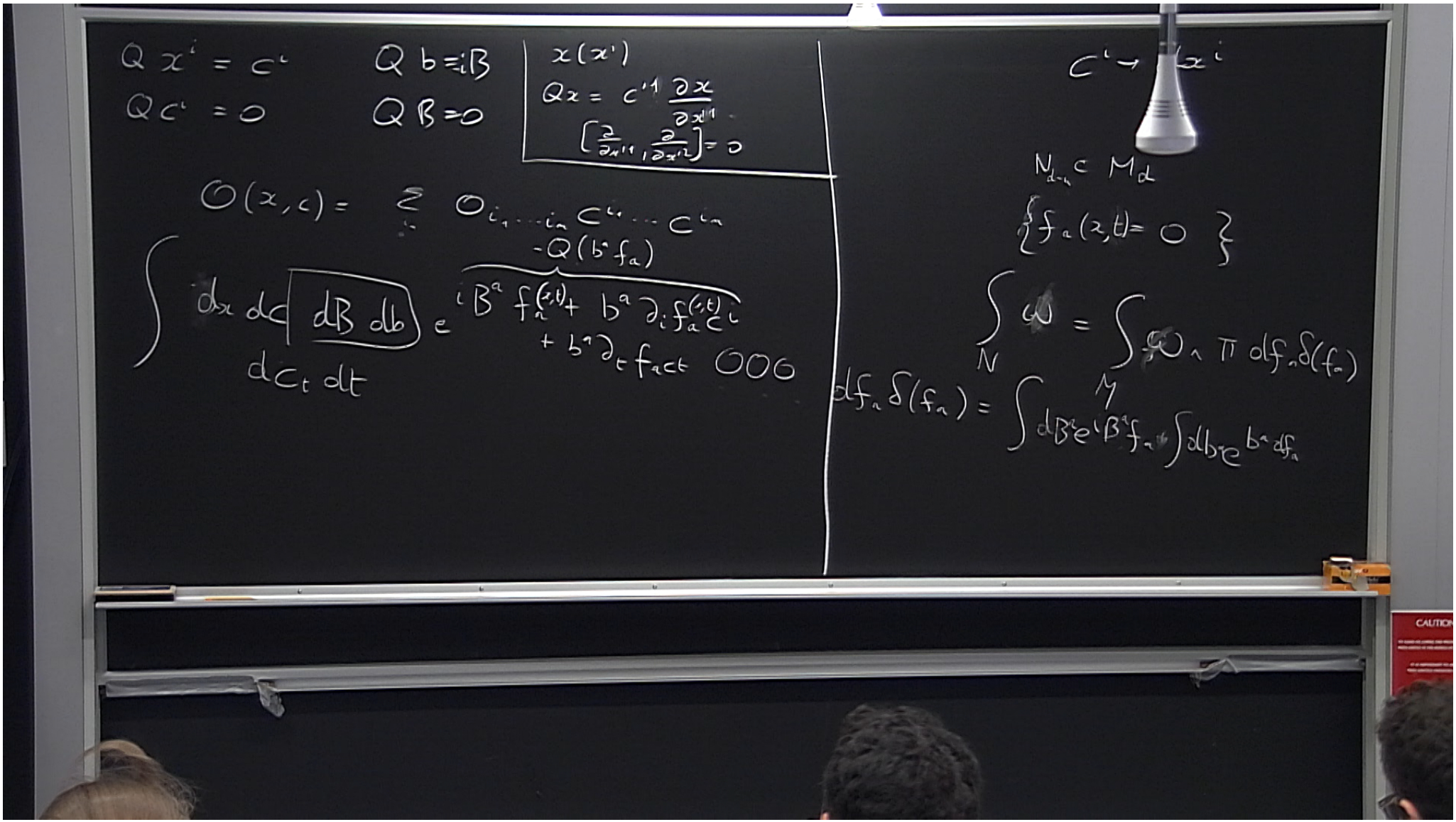


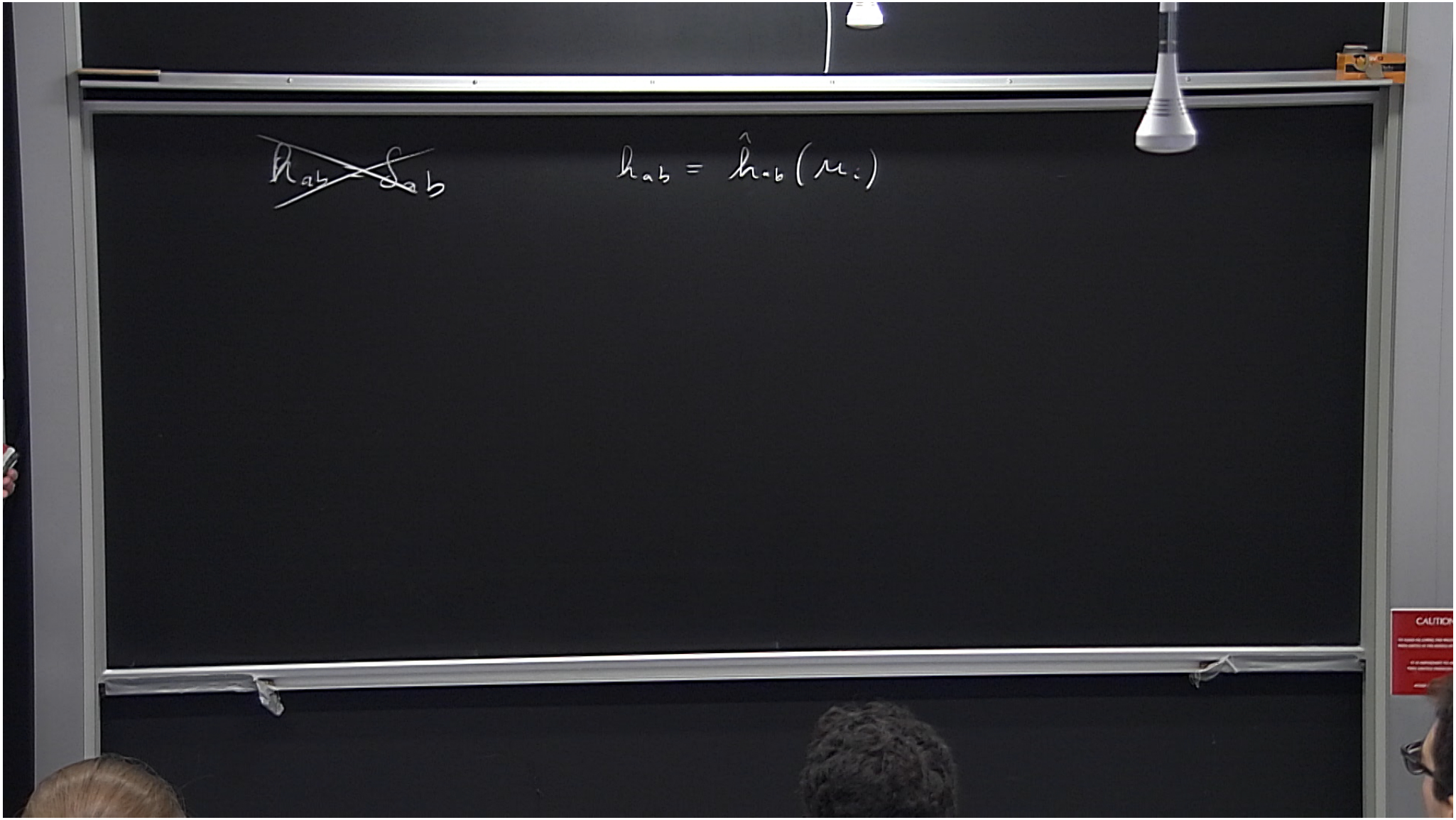
GAUGE - INVARIANT

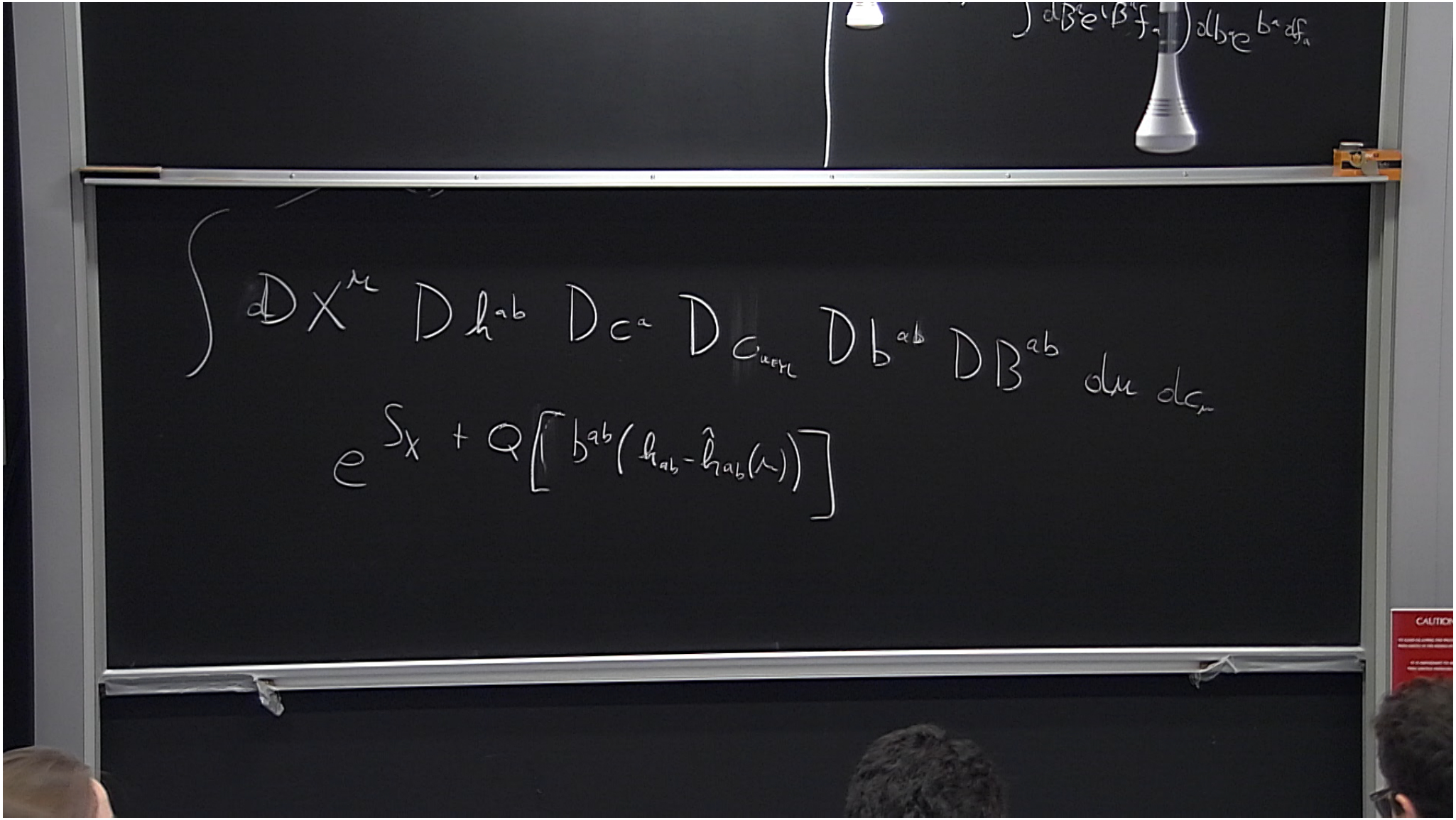
$$\int dx\, dc\, d\beta\, db\, e^{Q(f^a b_a) + S(x)} O_1 \cdots O_m = \int_{\mathcal{C}} d\mu\, \delta(f)\, df e^{S} O_1 \cdots O_m$$

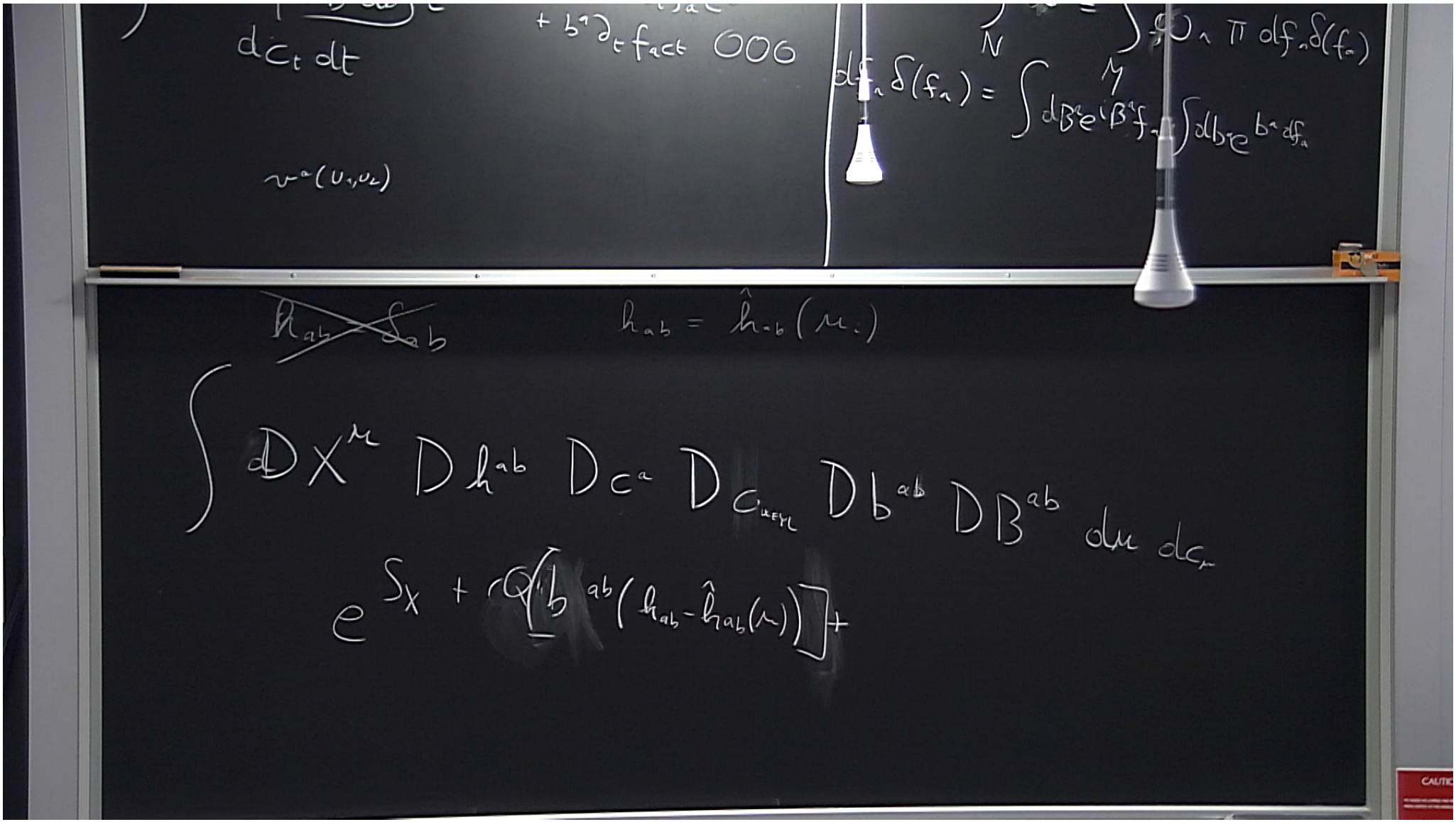


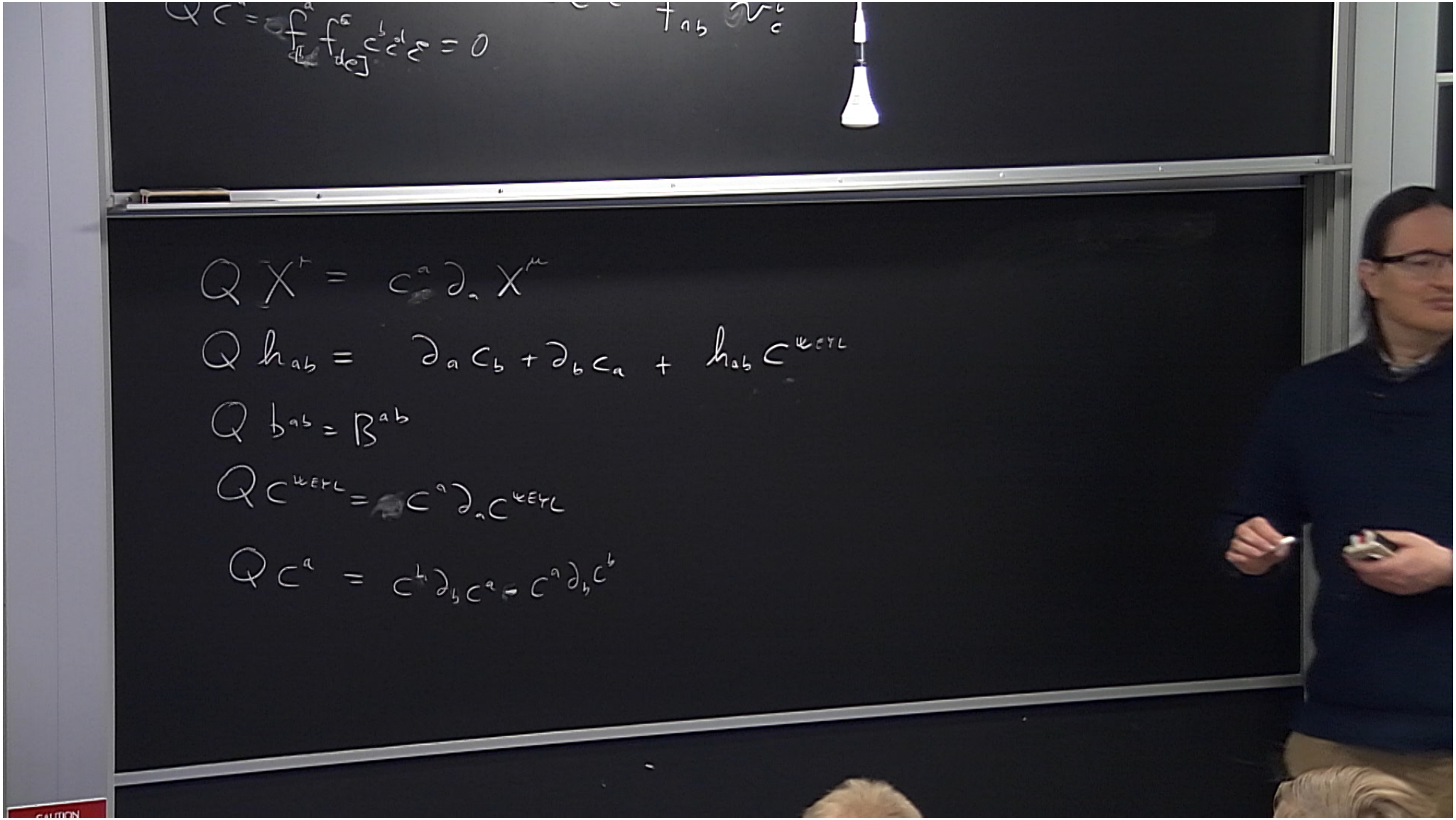
CAUTION

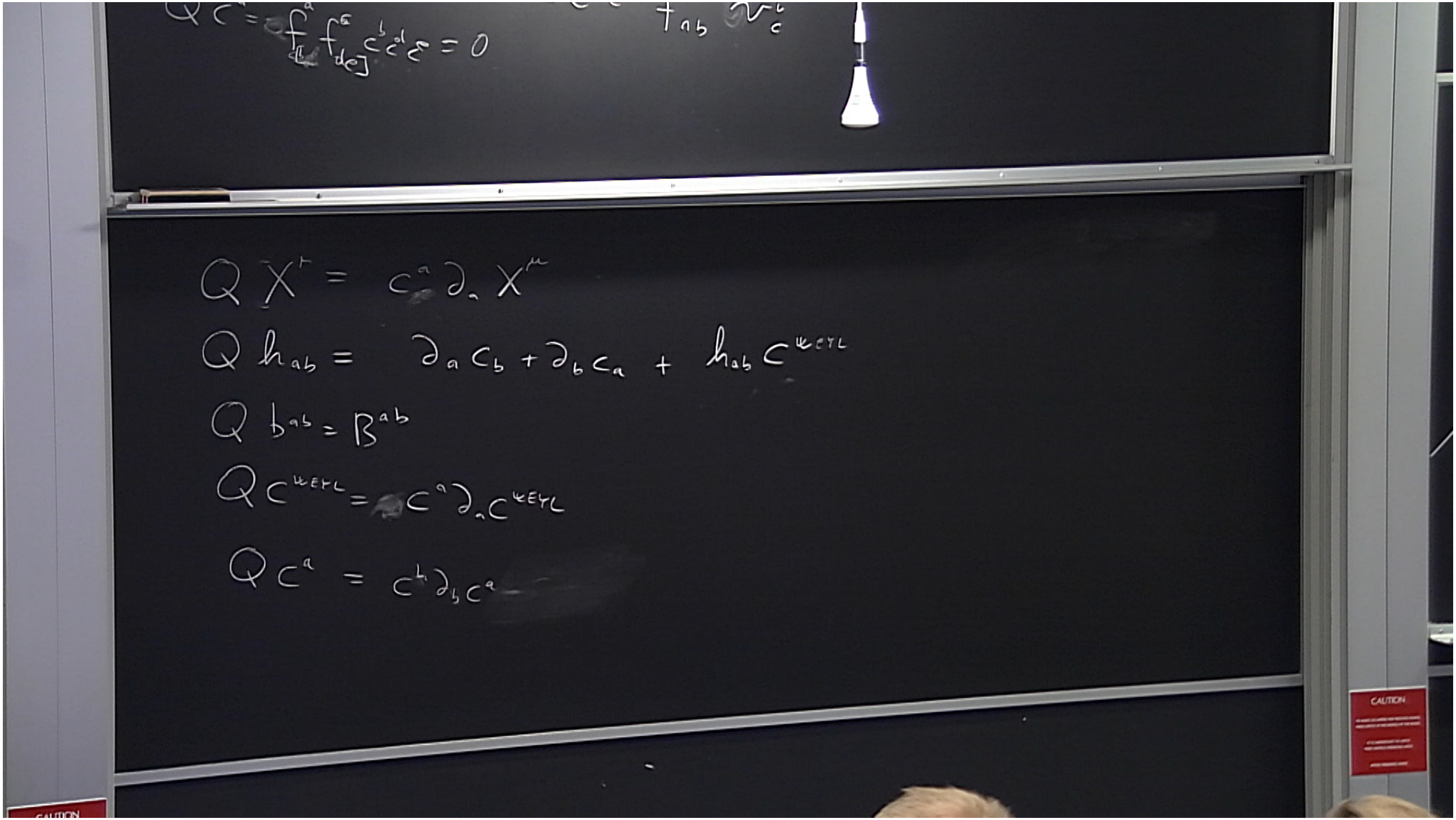

$Q x^i = c^i$
$Q c^i = 0$
$Q b = iB$
$QB = 0$
$x(x')$
$Qx = c'^i \frac{\partial x}{\partial x'^i}$
$\left[\frac{\partial}{\partial x'^1}, \frac{\partial}{\partial x'^2}\right] = 0$
$c^i \to x^i$
$N_{d-n} \subset M_d$
$\{f_a(x,t) = 0\}$
$O(x,c) = \sum_{i_1 \dots i_n} O_{i_1 \dots i_n} c^{i_1} \dots c^{i_n}$
$-Q(b^a f_a)$
$\int dx\, dc\, dB\, db\, dc_t\, dt\; e^{iB^a f_a(x,t) + b^a \partial_i f_a(x,t) c^i + b^a \partial_t f_a c_t} OOO$
$\int_N \omega = \int_M \omega \wedge \Pi\, df_a \delta(f_a)$
$df_a \delta(f_a) = \int dB^a e^{iB^a f_a} \int db^a e^{b^a df_a}$

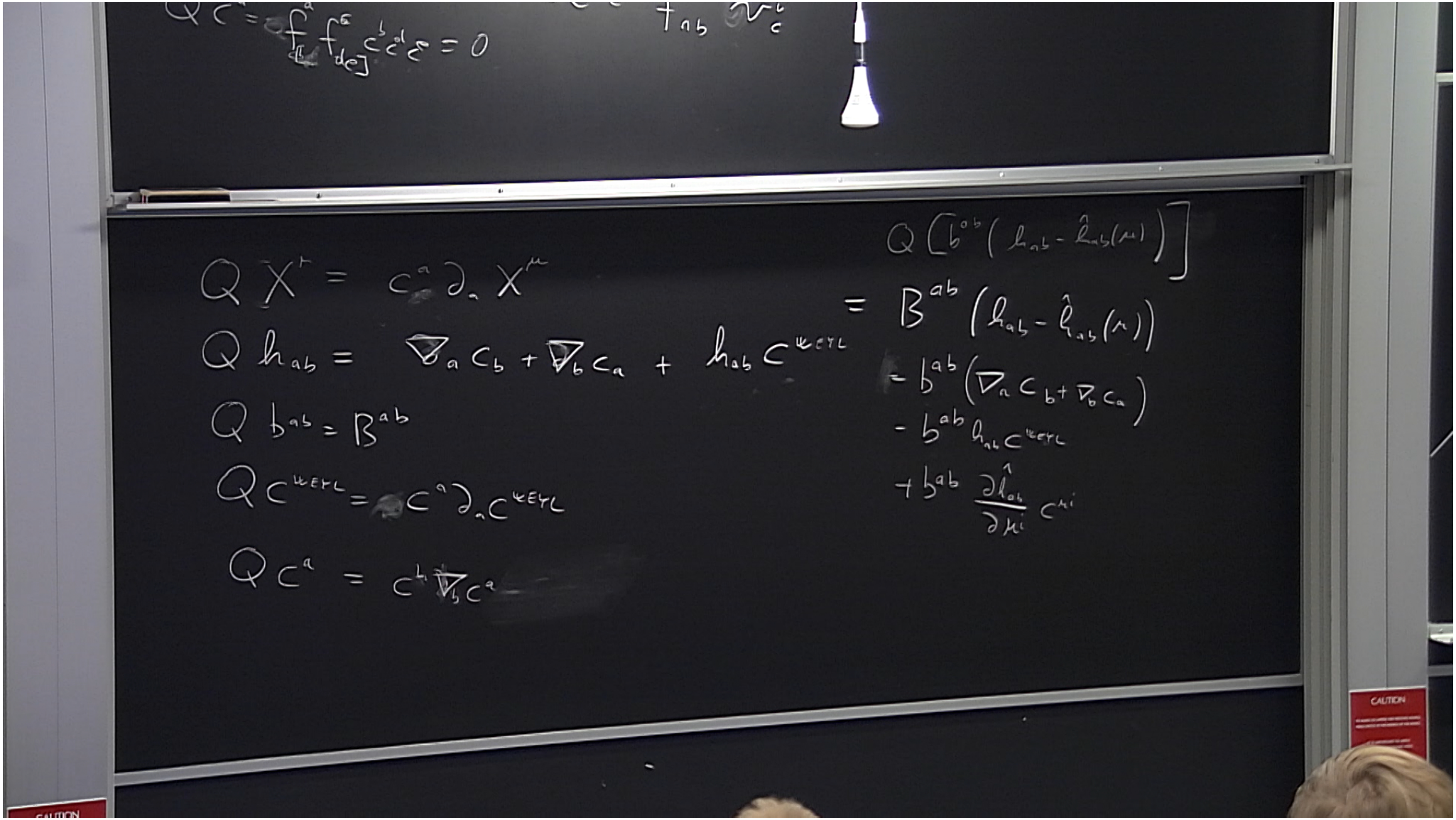

$h_{ab} = \hat{h}_{ab}(\mu_i)$

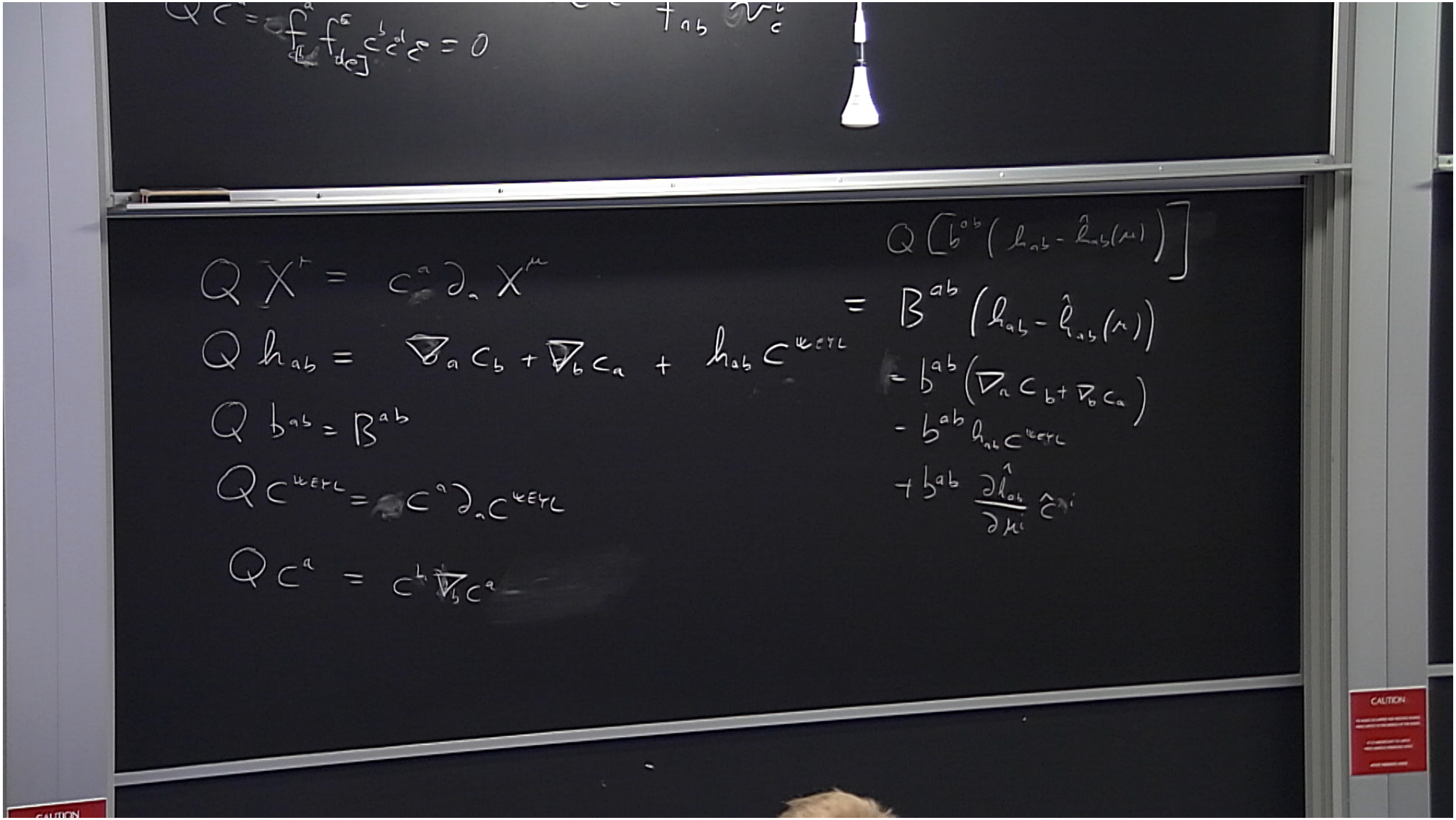

$\int dD X^\mu \, D h^{ab} \, D c^a \, D C_{\mu\nu\rho} \, D b^{ab} \, D B^{ab} \, d\mu \, d\alpha$
$e^{S_X + Q\left[b^{ab}(h_{ab} - \hat{h}_{ab}(\mu))\right]}$

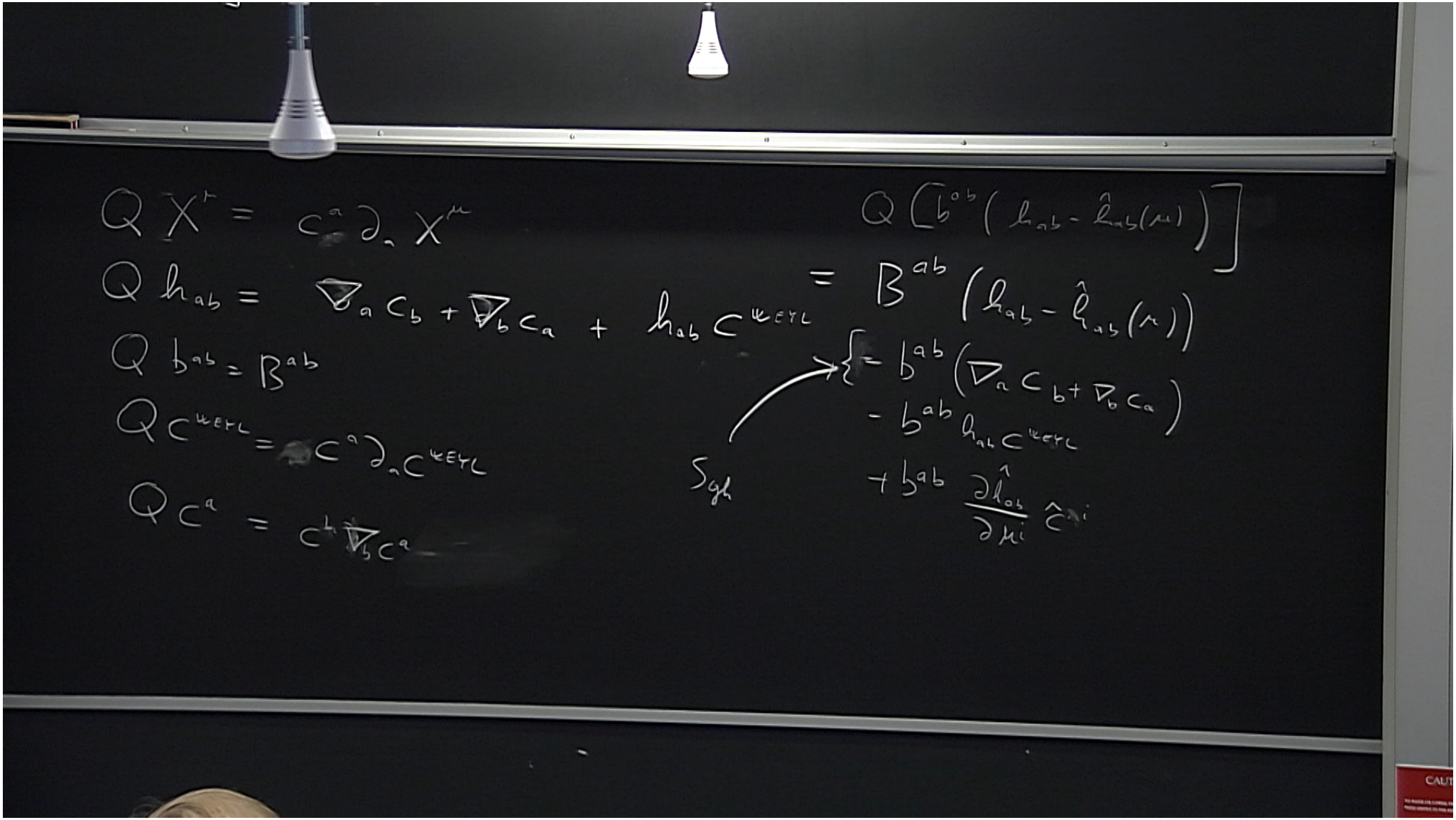

$dC_t\,dt$
$+ b^a \partial_t f_{act}$ OOO
$v^a(U_1, U_2)$
$\int df_a \delta(f_a) = \int dB^a e^{iB^a f_a} \int db_a e^{b^a df_a}$
$h_{ab} \to \hat{h}_{ab}$
$h_{ab} = \hat{h}_{ab}(\mu_i)$
$\int \mathcal{D}X^\mu \mathcal{D}h^{ab} \mathcal{D}c^a \mathcal{D}c_{ikl} \mathcal{D}b^{ab} \mathcal{D}B^{ab}\, d\mu\, dc_n$
$e^{S_X + i\left[b^{ab}(h_{ab} - \hat{h}_{ab}(\mu))\right]}$

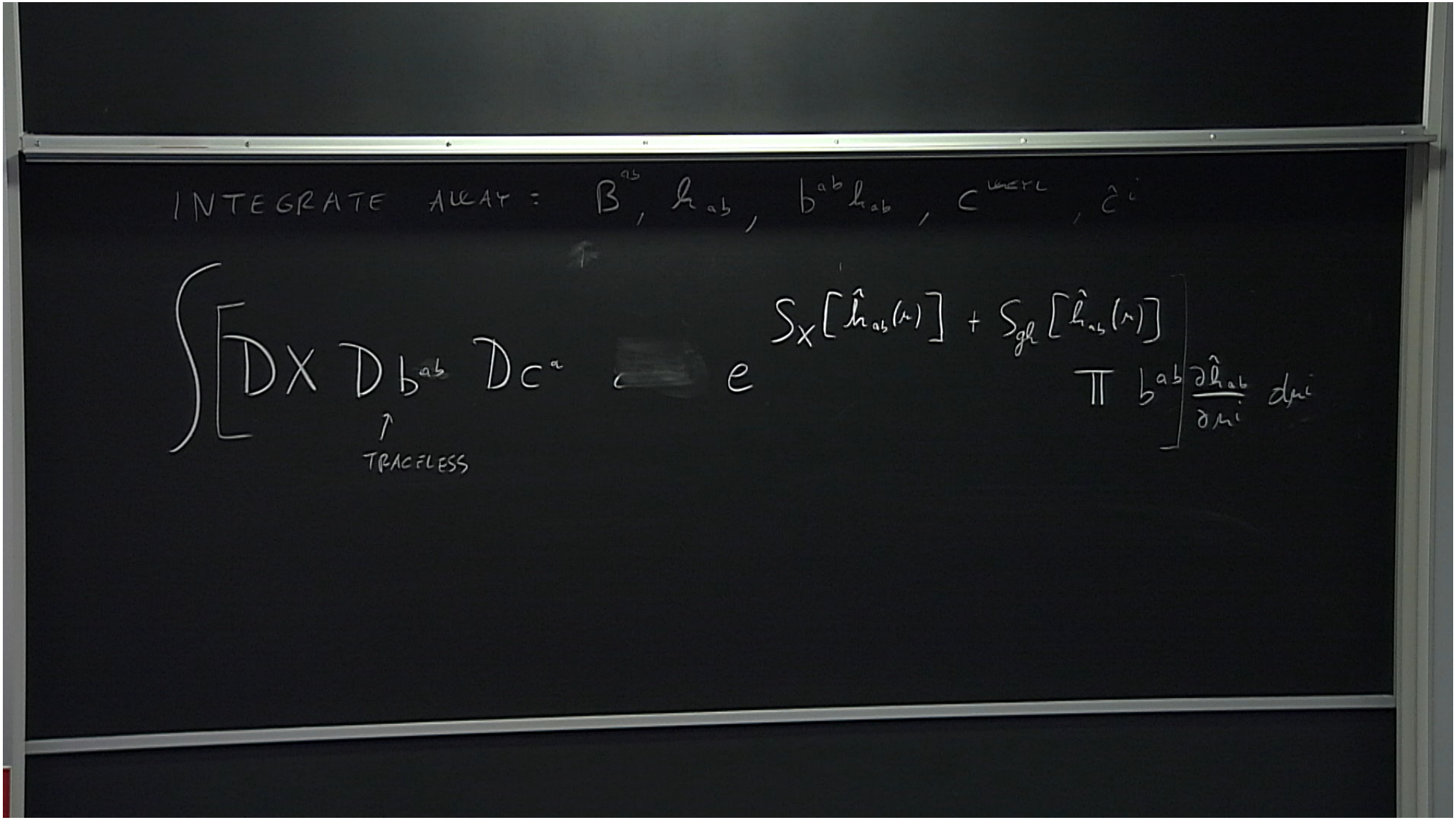

$f^{ab}_{[c} f^{e}_{d]e} c^{c} c^{d} \varepsilon = 0$
$f_{ab} \lambda^{b}_{c}$
$Q X^{\mu} = c^{a} \partial_{a} X^{\mu}$
$Q h_{ab} = \partial_{a} c_{b} + \partial_{b} c_{a} + h_{ab} c^{WEYL}$
$Q b_{ab} = B_{ab}$
$Q c^{WEYL} = c^{a} \partial_{a} c^{WEYL}$
$Q c^{a} = c^{b} \partial_{b} c^{a} - c^{a} \partial_{b} c^{b}$

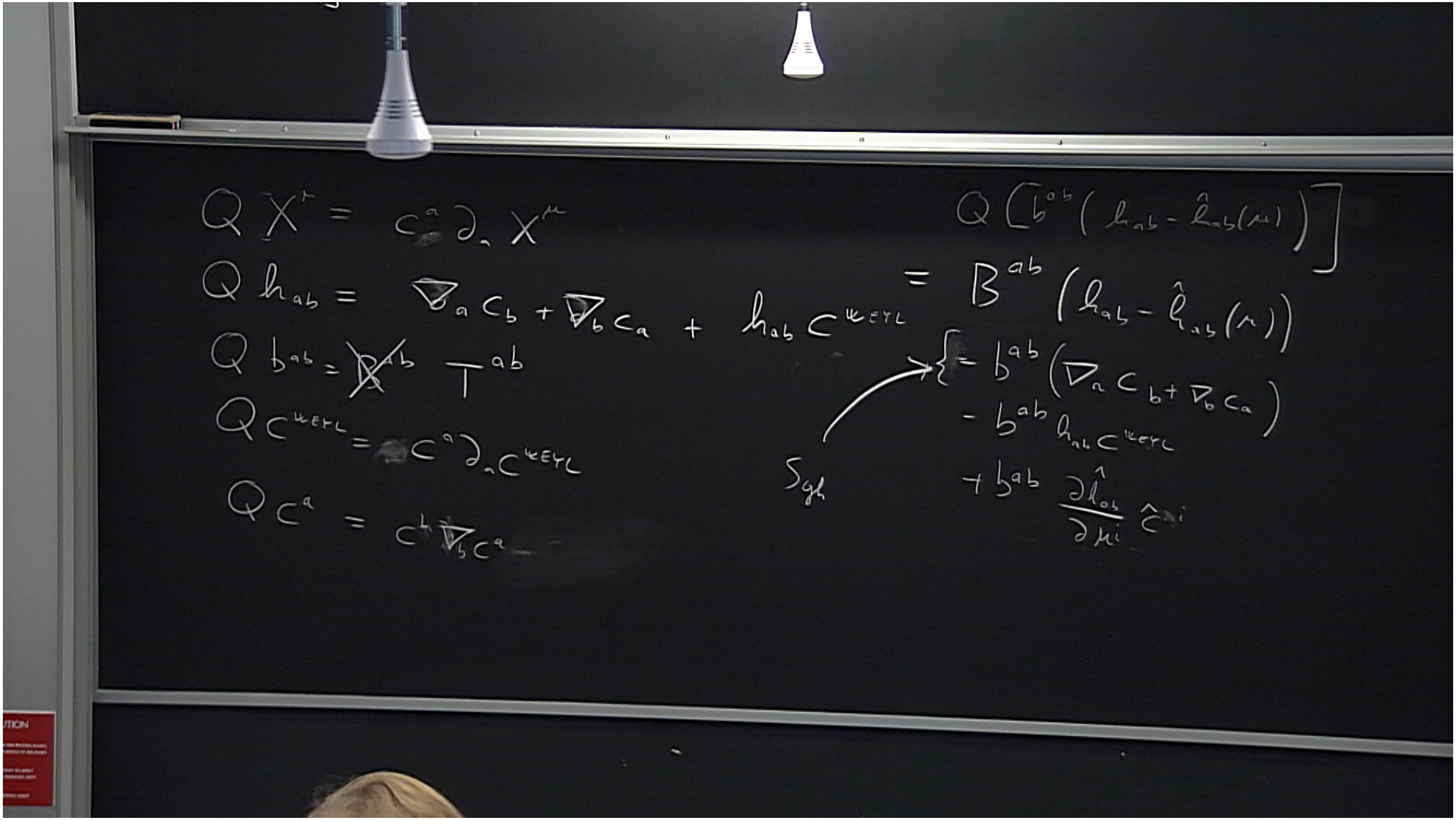

$Q X^\mu = c^a \partial_a X^\mu$
$Q h_{ab} = \partial_a c_b + \partial_b c_a + h_{ab} c^{\text{WEYL}}$
$Q b_{ab} = B_{ab}$
$Q c^{\text{WEYL}} = c^a \partial_a c^{\text{WEYL}}$
$Q c^a = c^b \partial_b c^a$

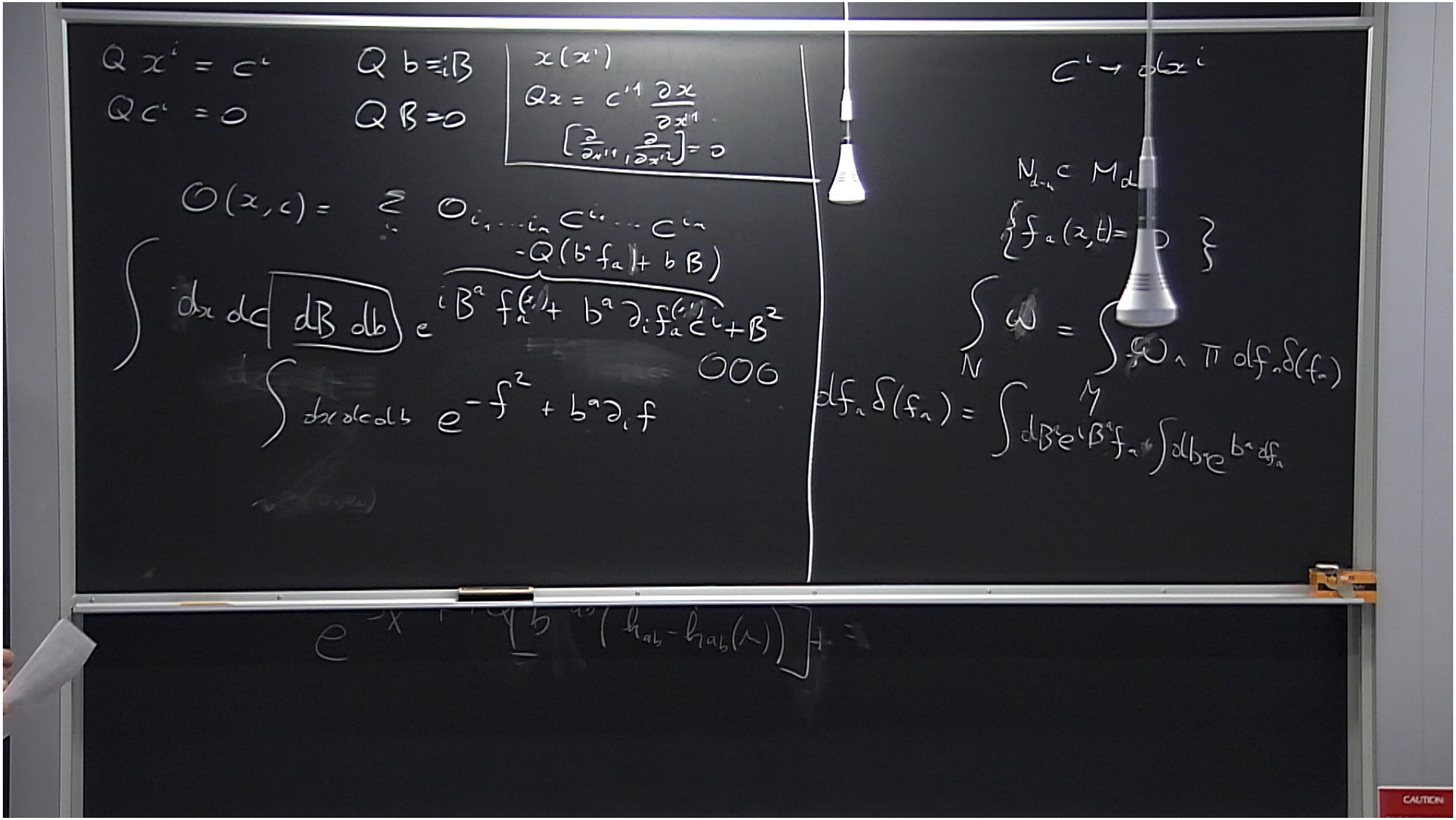

$Q X^\mu = c^a \partial_a X^\mu$
$Q h_{ab} = \nabla_a c_b + \nabla_b c_a + h_{ab} c^{\text{KEYL}}$
$Q b^{ab} = B^{ab}$
$Q c^{\text{KEYL}} = c^a \partial_a c^{\text{KEYL}}$
$Q c^a = c^b \nabla_b c^a$
$Q\left[b^{ab}\left(h_{ab} - \hat{h}_{ab}(\mu)\right)\right]$
$= B^{ab}\left(h_{ab} - \hat{h}_{ab}(\mu)\right)$
$- b^{ab}\left(\nabla_a c_b + \nabla_b c_a\right)$
$- b^{ab} h_{ab} c^{\text{KEYL}}$
$+ b^{ab} \frac{\partial \hat{h}_{ab}}{\partial \mu^i} c^{\mu^i}$

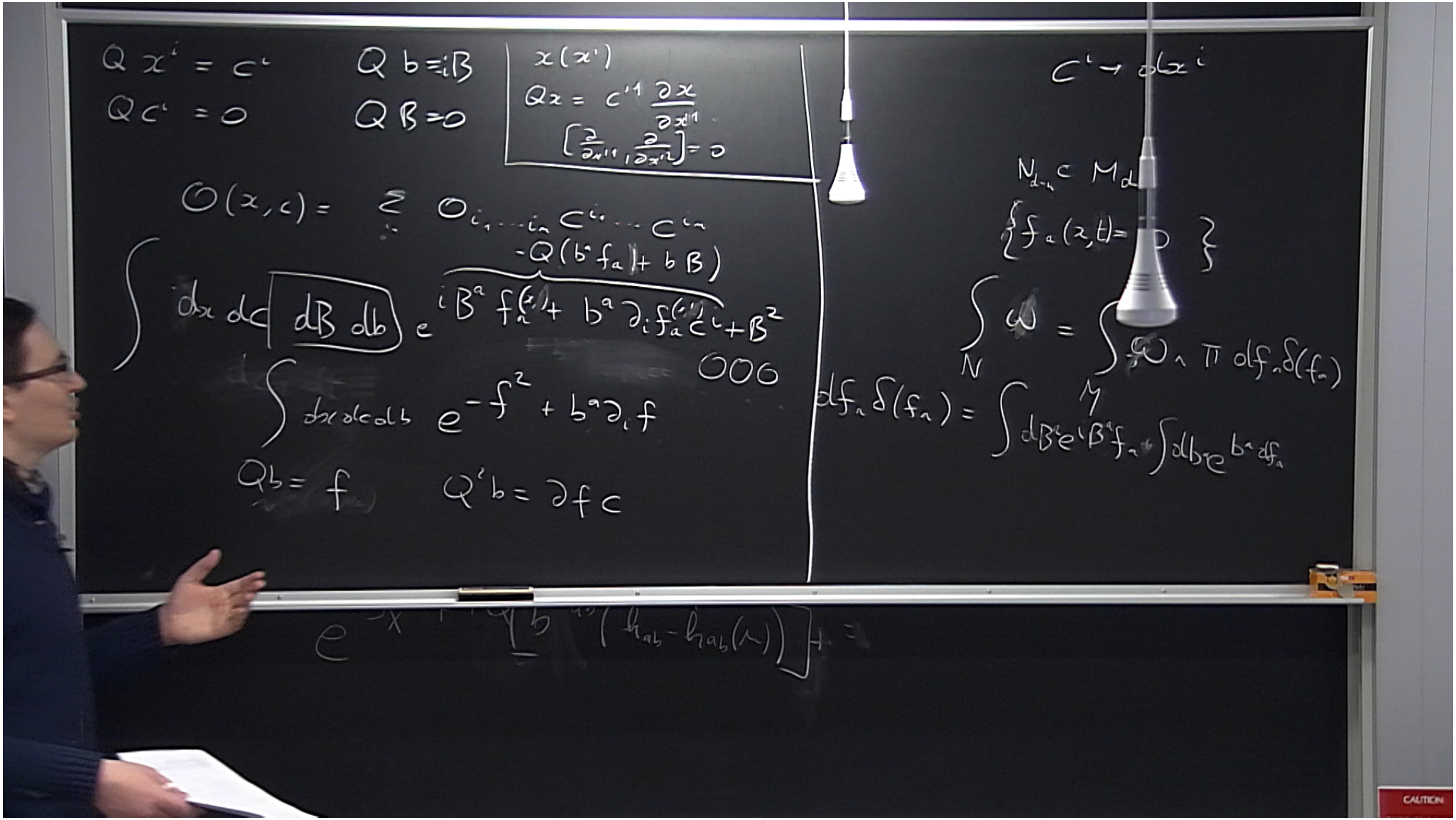

$Q X^\mu = c^a \partial_a X^\mu$
$Q h_{ab} = \nabla_a c_b + \nabla_b c_a + h_{ab} c^{\text{UEYL}}$
$Q b^{ab} = B^{ab}$
$Q c^{\text{UEYL}} = c^a \partial_a c^{\text{UEYL}}$
$Q c^a = c^b \nabla_b c^a$
$Q\left[b^{ab}\left(h_{ab} - \hat{h}_{ab}(\mu)\right)\right]$
$= B^{ab}\left(h_{ab} - \hat{h}_{ab}(\mu)\right)$
$- b^{ab}\left(\nabla_a c_b + \nabla_b c_a\right)$
$- b^{ab} h_{ab} c^{\text{UEYL}}$
$+ b^{ab} \frac{\partial \hat{h}_{ab}}{\partial \mu^i} \hat{c}^i$
CAUTION
CAUTION

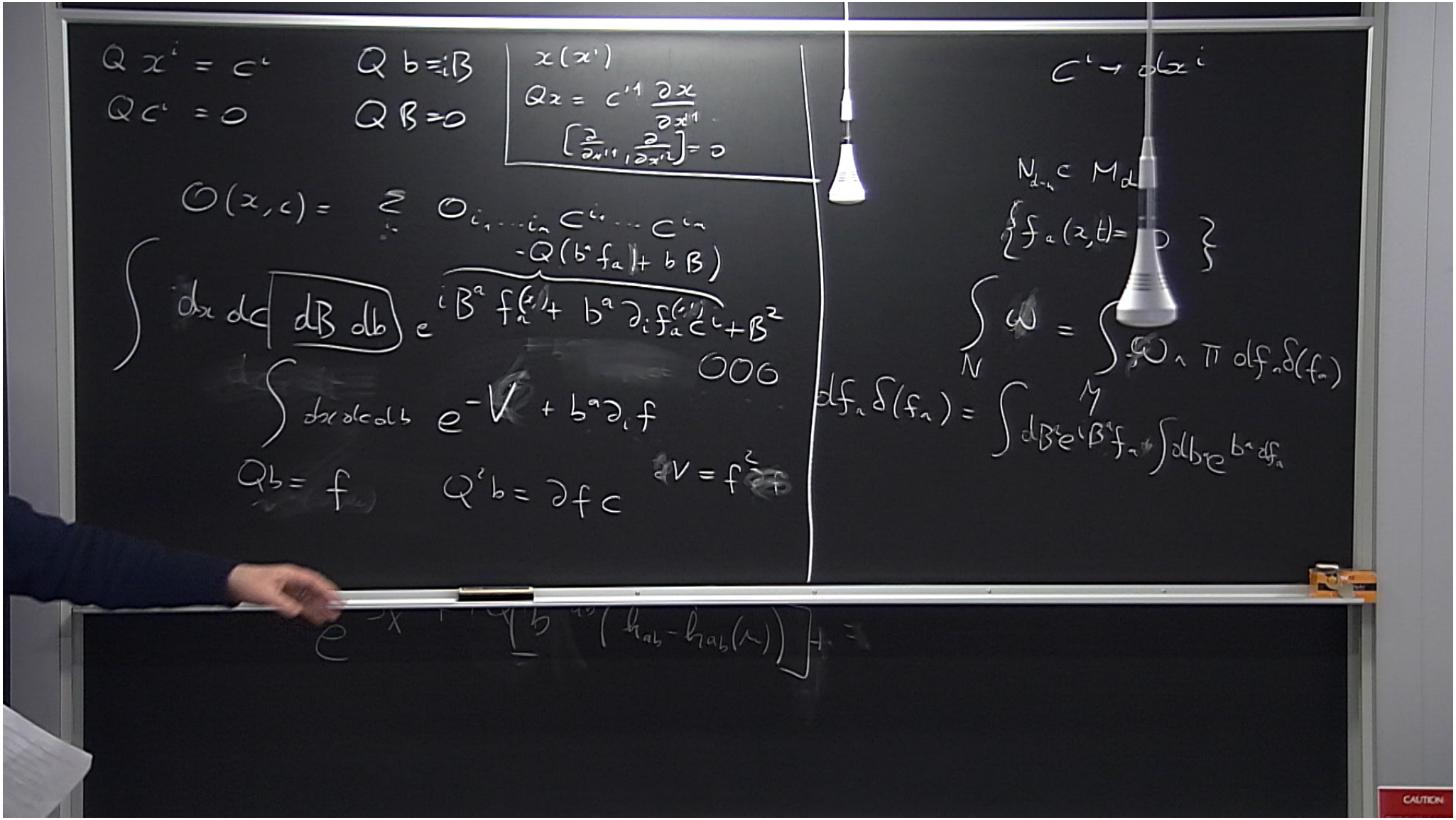

$Q X^\mu = c^a \partial_a X^\mu$
$Q h_{ab} = \nabla_a c_b + \nabla_b c_a + h_{ab} c^{\text{WEYL}}$
$Q b^{ab} = B^{ab}$
$Q c^{\text{WEYL}} = c^a \partial_a c^{\text{WEYL}}$
$Q c^a = c^b \nabla_b c^a$
$Q\left[b^{ab}\left(h_{ab} - \hat{h}_{ab}(\mu)\right)\right]$
$= B^{ab}\left(h_{ab} - \hat{h}_{ab}(\mu)\right)$
$- b^{ab}\left(\nabla_a c_b + \nabla_b c_a\right)$
$- b^{ab} h_{ab} c^{\text{WEYL}}$
$+ b^{ab} \frac{\partial \hat{h}_{ab}}{\partial \mu_i} \hat{c}^i$
S_{gh}

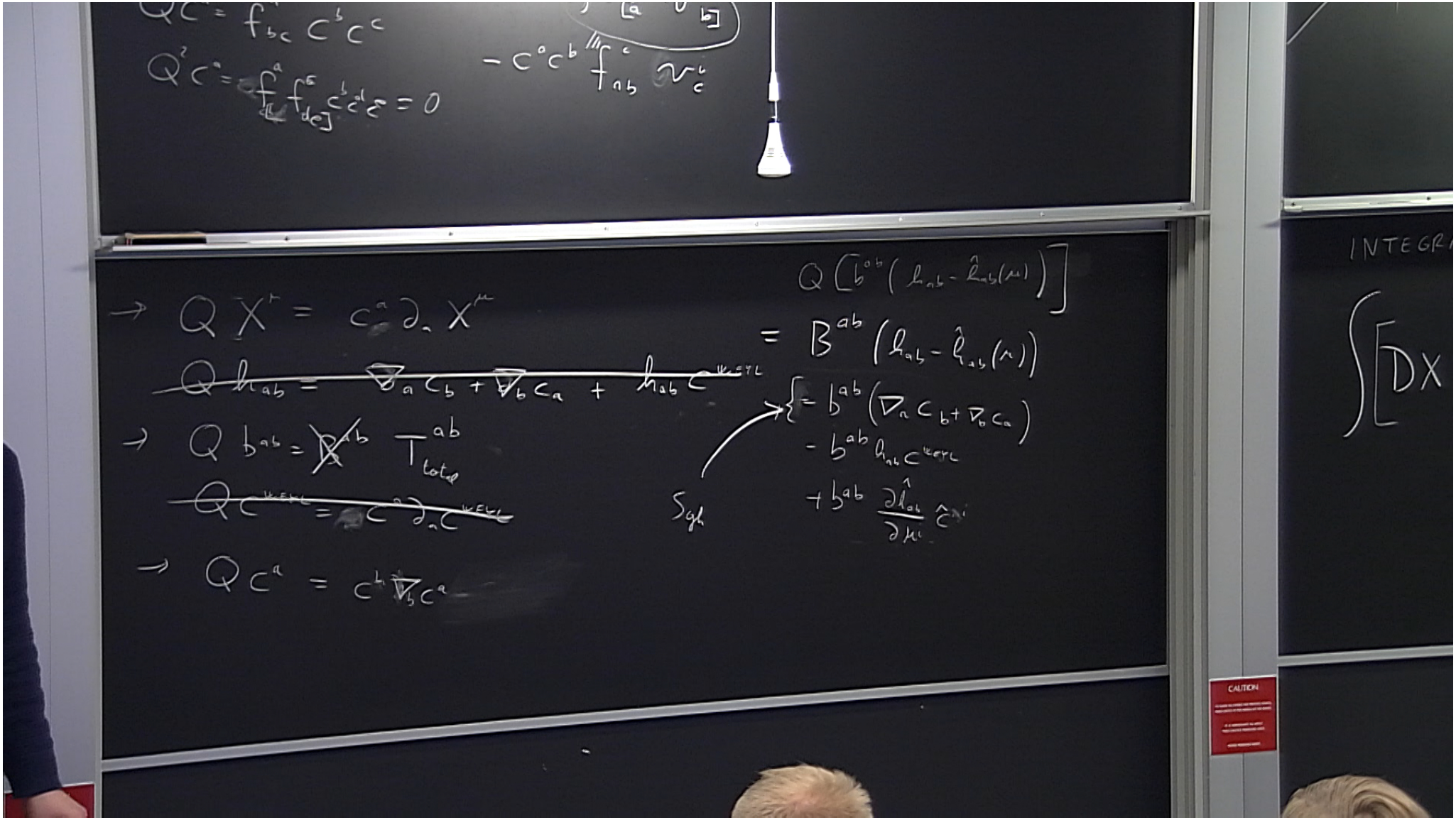

INTEGRATE ALREADY : B^{ab}, h_{ab}, $b^{ab}h_{ab}$, C^{UNEVEN}, $\hat{c}^i$
$\int [DX\, Db^{ab}\, Dc^a\, c\,\cdots\, e^{S_X[\hat{h}_{ab}(\lambda)] + S_{gh}[\hat{h}_{ab}(\lambda)]} \prod b^{ab} \frac{\partial \hat{h}_{ab}}{\partial \lambda^i} d\lambda^i$
TRACELESS

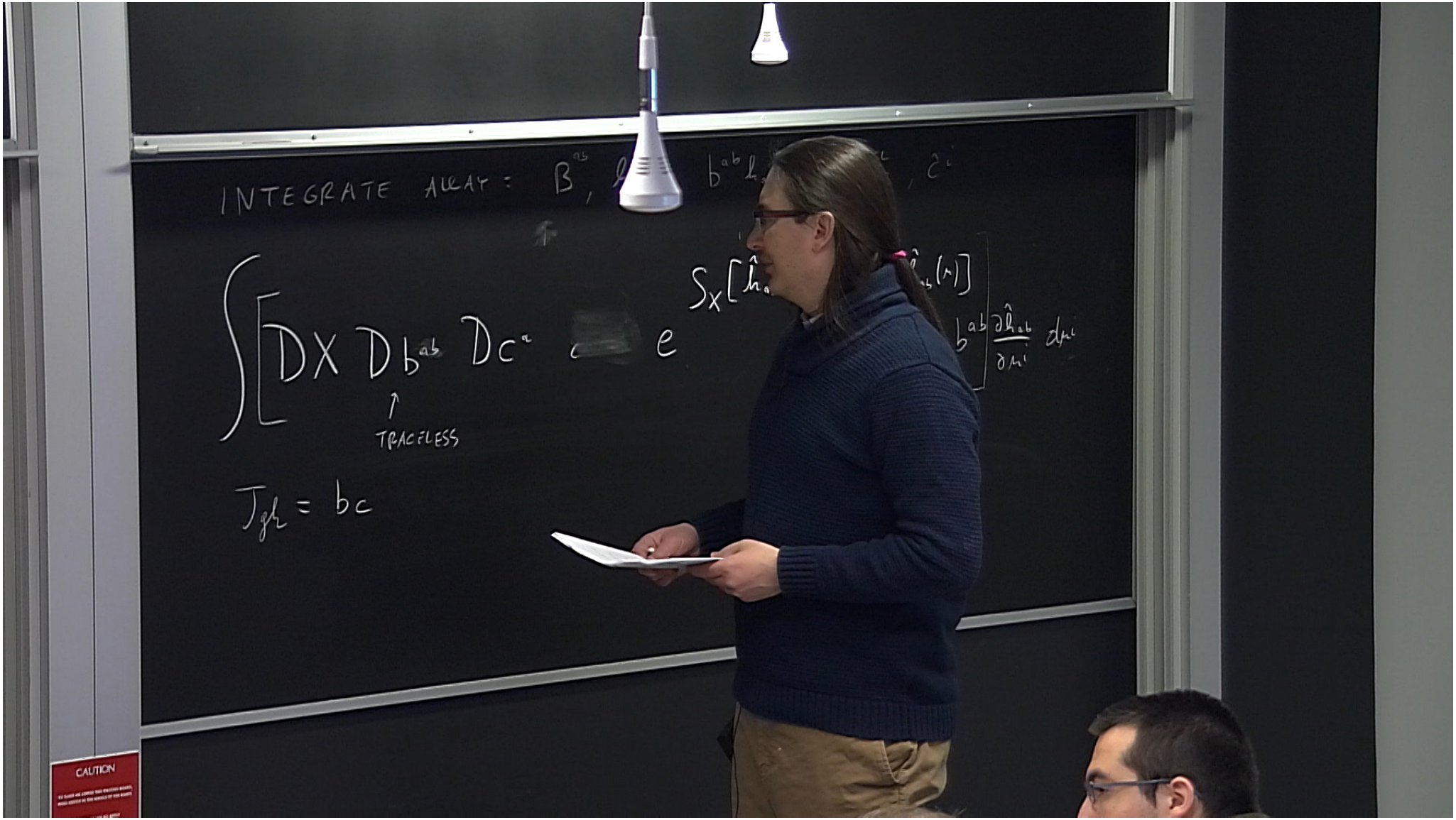

$Q X^\mu = c^a \partial_a X^\mu$
$Q h_{ab} = \nabla_a c_b + \nabla_b c_a + h_{ab} c^{WEYL}$
$Q b^{ab} = T^{ab}$
$Q c^{WEYL} = c^a \partial_a c^{WEYL}$
$Q c^a = c^b \nabla_b c^a$
$Q\left[b^{ab}\left(h_{ab} - \hat{h}_{ab}(\mu)\right)\right]$
$= B^{ab}\left(h_{ab} - \hat{h}_{ab}(\mu)\right)$
S_{gh}
$- b^{ab}\left(\nabla_a c_b + \nabla_b c_a\right)$
$- b^{ab} h_{ab} c^{WEYL}$
$+ b^{ab} \frac{\partial \hat{h}_{ab}}{\partial \mu_i} \hat{c}^i$

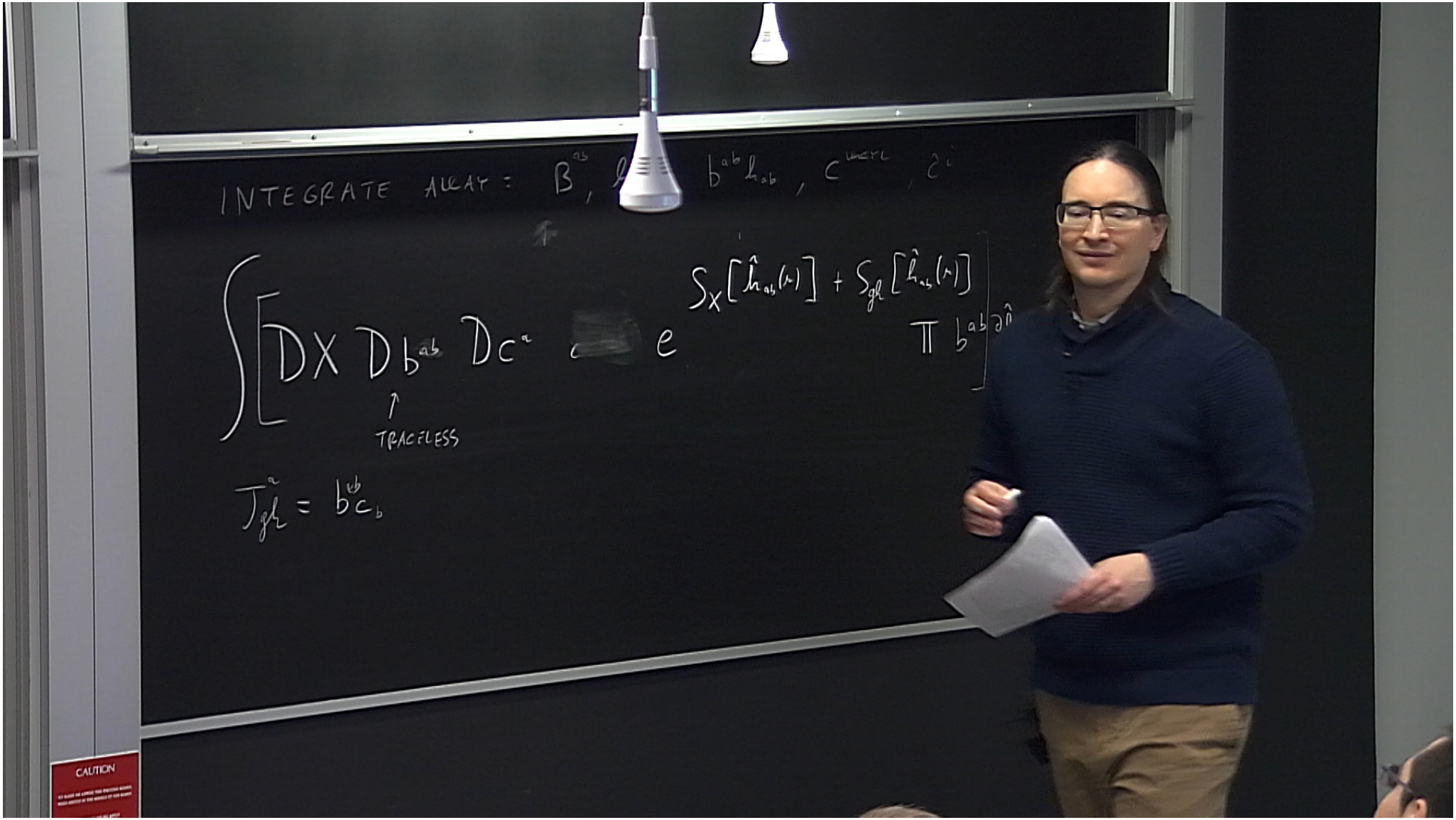

$Q x^i = c^i$
$Q c^i = 0$
$Q b = iB$
$QB = 0$
$x(x')$
$Qx = c'^1 \frac{\partial x}{\partial x'^1}$
$[\frac{\partial}{\partial x'^1}, \frac{\partial}{\partial x'^2}] = 0$
$c^i \to dx^i$
$O(x,c) = \sum O_{i_1 \dots i_n} c^{i_1} \dots c^{i_n}$
$-Q(b^a f_a + b B)$
$\int dx\, dc\, dB\, db\, e^{iB^a f_a^{(i)} + b^a \partial_i f_a^{(i)} c^i + B^2}$
$\int dx\, dc\, db\, e^{-f^2 + b^a \partial_i f}$
$N_{d-n} \subset M_d$
$\{ f_a(x,t) = 0 \}$
$\int_N \omega = \int_M \omega \wedge \Pi\, df_a \delta(f_a)$
$df_a \delta(f_a) = \int dB^a e^{iB^a f_a} \int db^a e^{b^a df_a}$

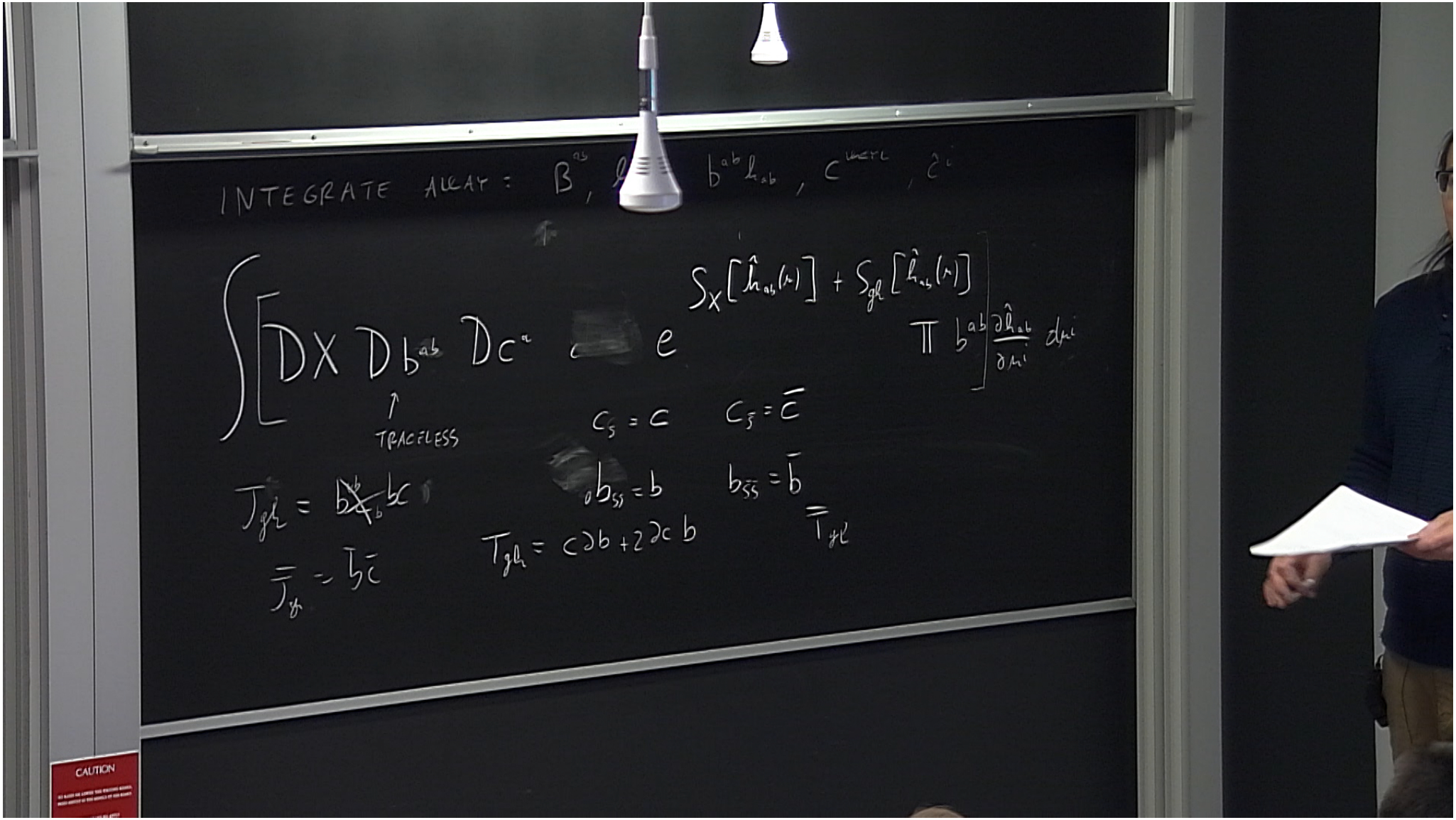

Q x^i = c^i
Q c^i = 0
Q b = iB
Q B = 0
x(x')
Qx = c'^i ∂x/∂x'^i
[∂/∂x'^i, ∂/∂x'^j] = 0
c^i → dx^i
O(x,c) = Σ O_{i_1 ... i_n} c^{i_1} ... c^{i_n}
-Q(b^a f_a + b B)
dB db
e^{iB^a f_a^i + b^a ∂_i f_a^j c^i + B^2}
000
∫ dx dc dB db e^{-f^2 + b^a ∂_i f}
Qb = f
Q^2 b = ∂f c
N_{d-n} ⊂ M_d
{f_a(x,t) = 0}
∫_N ω = ∫_M ω ∧ Π df_a δ(f_a)
df_a δ(f_a) = ∫ dB^a e^{iB^a f_a} ∫ db^a e^{b^a df_a}
CAUTION

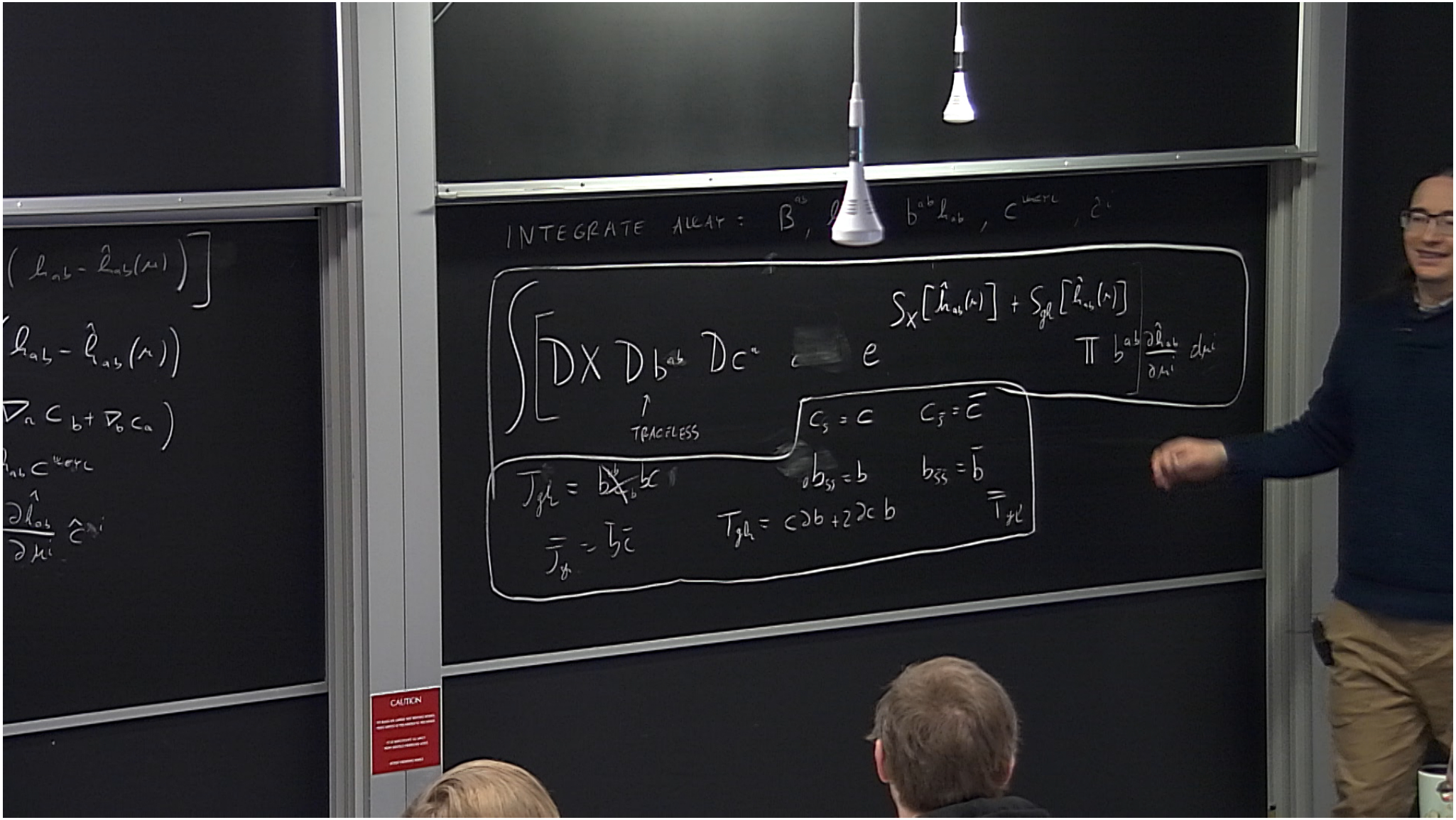

Q x^i = c^i
Q c^i = 0
Q b = iB
Q B = 0
x(x')
Qx = c'^1 ∂x/∂x'^1
[∂/∂x'^1, ∂/∂x'^2] = 0
c^i → dx^i
O(x,c) = Σ O_{i_1...i_n} c^{i_1} ... c^{i_n}
-Q(b^a f_a + b B)
∫ dx dc dB db e^{iB^a f_a^i + b^a ∂_i f_a^j c^i + B^2}
∫ dx dc db e^{-V + b^a ∂_i f}
Qb = f
Q^2 b = ∂f c
δV = f^2 f
N_{d-n} ⊂ M_d
{f_a(x,t) = 0}
∫_N ω = ∫_M ω ∧ Π df_a δ(f_a)
df_a δ(f_a) = ∫ dB^a e^{iB^a f_a} ∫ db^a e^{b^a df_a}


$Q C^a = f_{bc}{}^a C^b C^c$
$Q^2 C^a = f_{[de]}{}^a f_{bc}{}^d C^b C^c C^e = 0$
$- C^a C^b f_{ab}{}^c \gamma_c^b$
$Q X^\mu = C^a \partial_a X^\mu$
$Q h_{ab} = \nabla_a C_b + \nabla_b C_a + h_{ab} C^{UEVL}$
$Q b^{ab} = T^{ab}_{total}$
$Q C^{UEVL} = C^a \partial_a C^{UEVL}$
$Q C^a = C^b \nabla_b C^a$
$Q [b^{ab} (h_{ab} - \hat{h}_{ab}(\mu))]$
$= B^{ab} (h_{ab} - \hat{h}_{ab}(\mu))$
$S_{gh} = \{ - b^{ab} (\nabla_a C_b + \nabla_b C_a)$
$- b^{ab} h_{ab} C^{UEVL}$
$+ b^{ab} \frac{\partial \hat{h}_{ab}}{\partial \mu} \hat{C}^\mu$
INTEGR
$\int [DX$
CAUTION


INTEGRATE ALL AT :
TRACELESS
CAUTION


INTEGRATE ALL AT :
TRACELESS
CAUTION


INTEGRATE ALL AT :
TRACELESS
CAUTION


INTEGRATE ALL OF :
TRACELESS
CAUTION