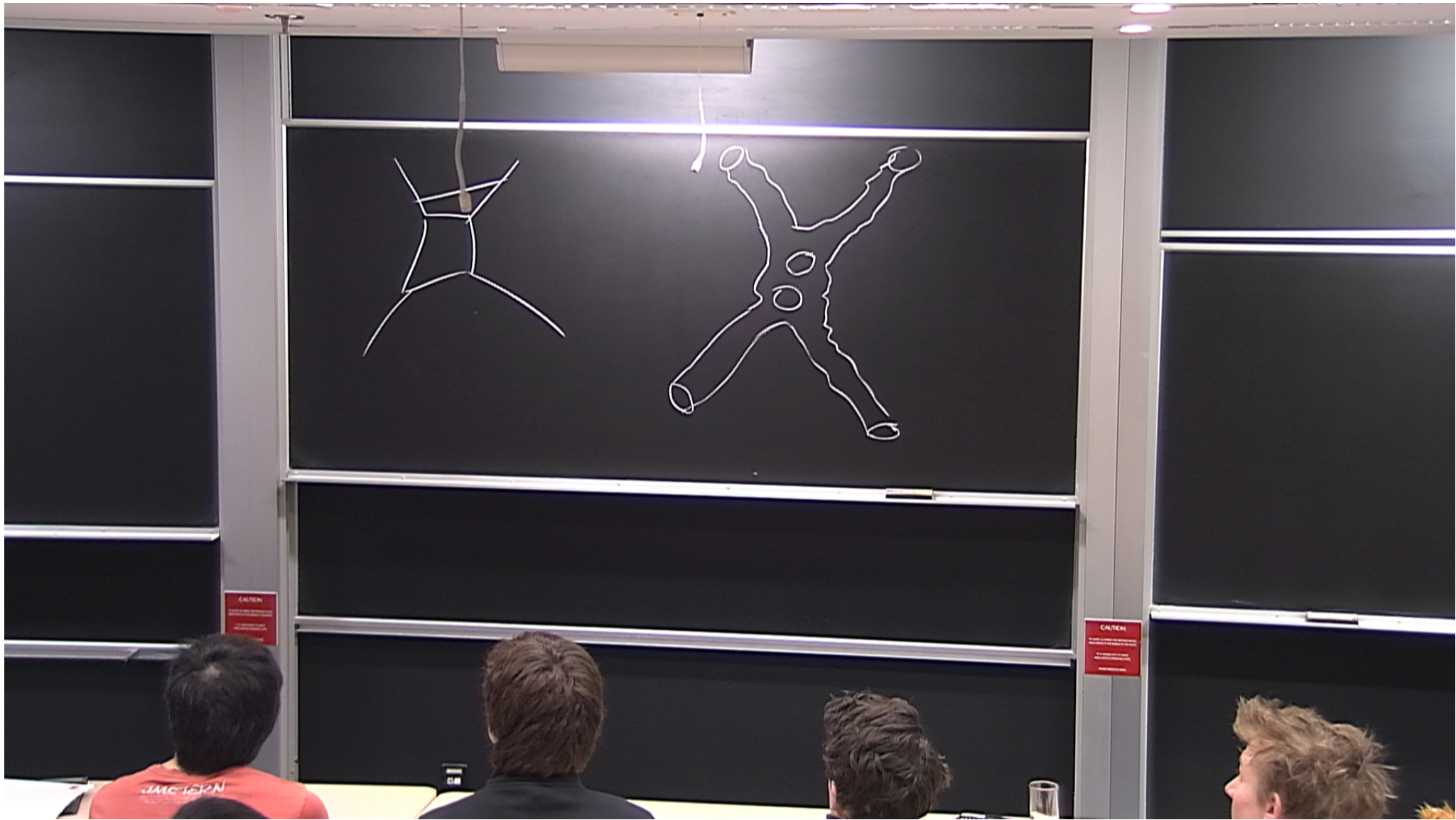


Title: String Theory Review-2

Date: Jan 27, 2015 10:15 AM

URL: <http://pirsa.org/15010081>

Abstract:



SCALAR QFT

$$\sum_{\Gamma}^{\text{QFT}} = \int_{\Gamma \rightarrow \mathbb{R}^{d+1,1}} e^{-m L_{\Gamma}}$$

$$\sum_{\Sigma}^{\text{STRING}} = \int_{\Sigma \rightarrow \mathbb{R}^{d+1,1}} e^{-T A_{\Sigma}}$$

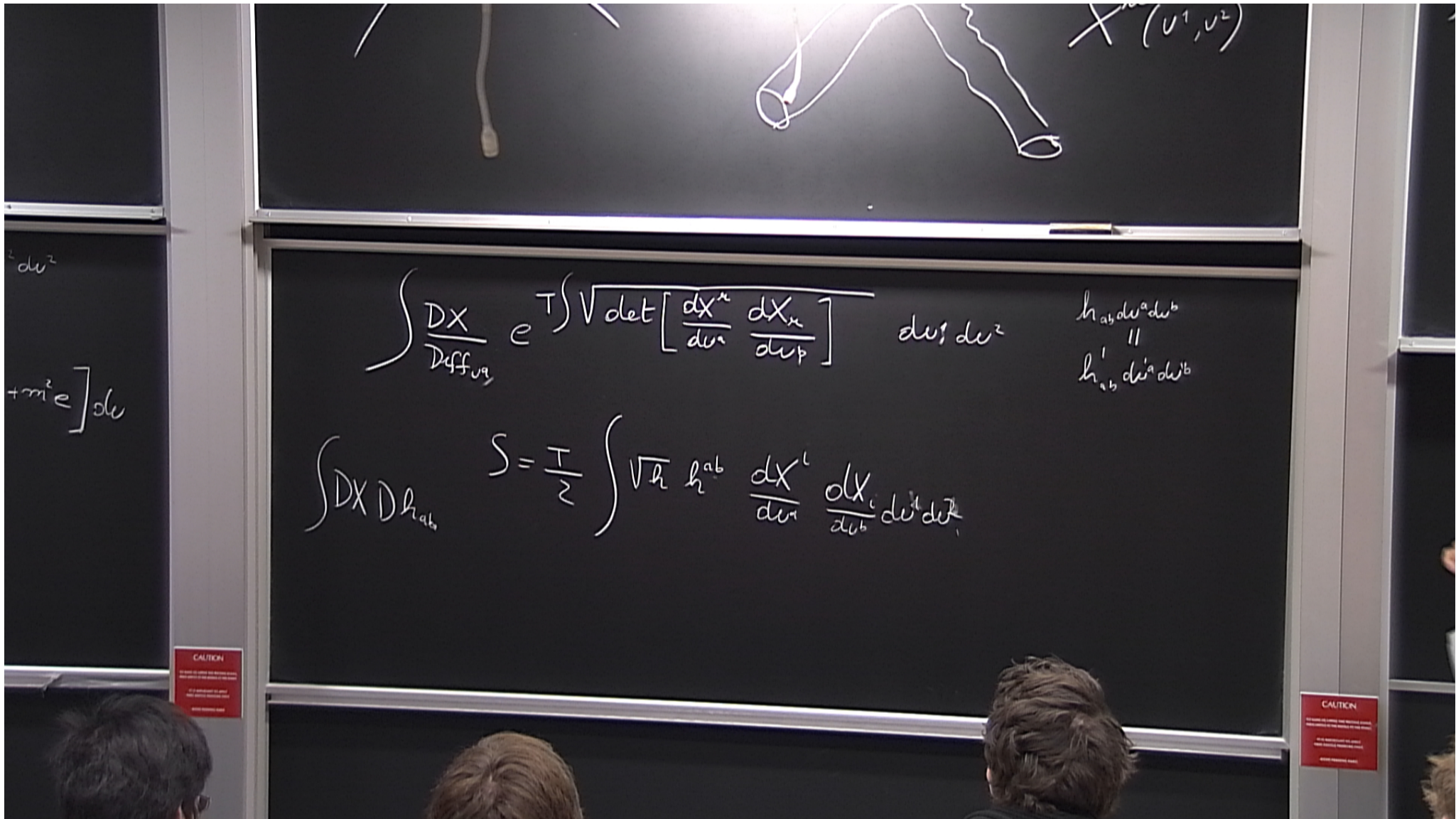
$Z \rightarrow R^{n+1}$

$$\int \frac{Dx}{\text{Diff}_u} e^{m \int \sqrt{\dot{x}^2} du} \quad x'(u) = \dot{x}(u) \quad e^{\int \dot{x}^2 du}$$
$$e' du' = e du$$
$$S' = \frac{1}{2} \int_0^1 \left[e^{-1} \frac{dx^a}{du} \frac{dx_a}{du} + m^2 e \right] du$$
$$\int_0^1 e du = L \quad e = L$$
$$\int dL \int \frac{Dx}{\text{Diff}_u} e^{-S}$$

CAUTION

$$\int \frac{DX}{\text{Diff}_{0,9}} e^T \sqrt{\det \left[\frac{dx^\mu}{du^1} \frac{dx_\mu}{du^2} \right]} du^1 du^2$$

$$S = \frac{T}{2} \int \sqrt{h} h^{ab} \frac{dx^l}{du^1} \frac{dx_i}{du^2} du^1 du^2$$



$$\int \frac{DX}{\text{Diff}_{U^a}} e^T \sqrt{\det \left[\frac{dx^\mu}{du^a} \frac{dx^\nu}{du^b} \right]} du^1 du^2 \quad \begin{matrix} h_{ab} du^a du^b \\ || \\ h'_{ab} du^a du^b \end{matrix}$$

$$\int DX D h_{ab} \quad S = \frac{T}{2} \int \sqrt{h} h^{ab} \frac{dx^l}{du^a} \frac{dx^l}{du^b} du^1 du^2$$

du^2
 $+m^2 e \int du$

$X^0 (v^1, v^2)$

CAUTION
 Do not lean on the chalkboard.
 It is prohibited to place
 any objects on the board.
 Thank you for your
 cooperation.

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$$\int \frac{DX}{\text{Diff}_{u^a}} e^T \sqrt{\det \left[\frac{dx^\mu}{du^a} \frac{dx^\nu}{du^b} \right]} du^1 du^2$$

$$h_{ab} du^a du^b$$

$$\parallel$$

$$h'_{ab} du^a du^b$$

$$\int DX Dh_{ab} \quad S = \frac{T}{2} \int \sqrt{h} h^{ab} \frac{dx^a}{du^1} \frac{dx^b}{du^2} du^1 du^2$$

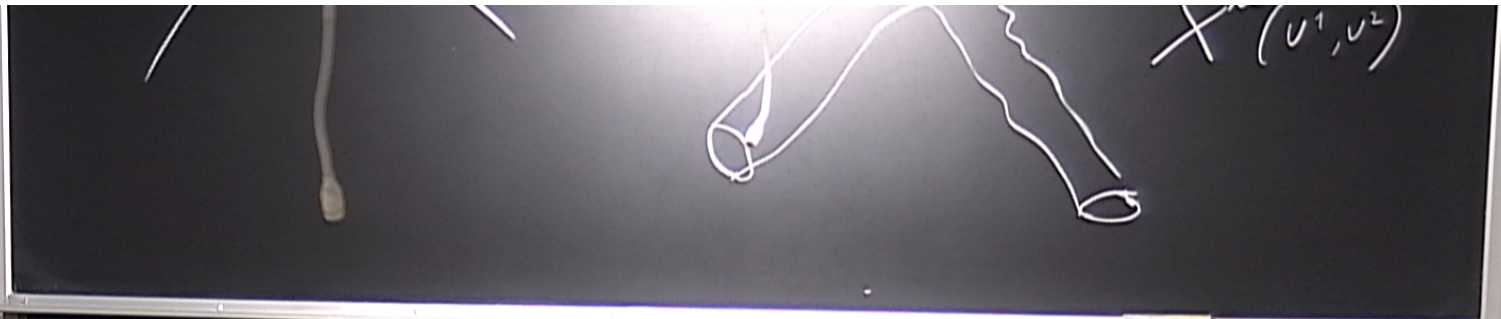
$$L_{ab} = \frac{1}{p_{ab}^2 + m^2} =$$

$$S(\dots)$$

$$) \quad e^2 du^2$$

$$\left[\frac{dx^a}{du} \frac{dx_n}{du} + m^2 e \right] du$$

$$= L$$



$$\int \frac{DX}{\text{Diff}_{u^a}} e^T \sqrt{\det \left[\frac{dx^a}{du^a} \frac{dx_n}{du^b} \right]} du^1 du^2$$

$$h_{ab} du^a du^b$$

$$\parallel$$

$$h'_{ab} du^a du^b$$

$$\int DX \sqrt{h_{ab}} e^S S = \frac{T}{2} \int \sqrt{h} h^{ab} \frac{dx^a}{du^a} \frac{dx^b}{du^b} du^1 du^2$$

CAUTION

CAUTION

$$) \quad e^2 du^2$$

$$\left[\frac{dx^a}{du} \frac{dx_n}{du} + m^2 e \right] du$$

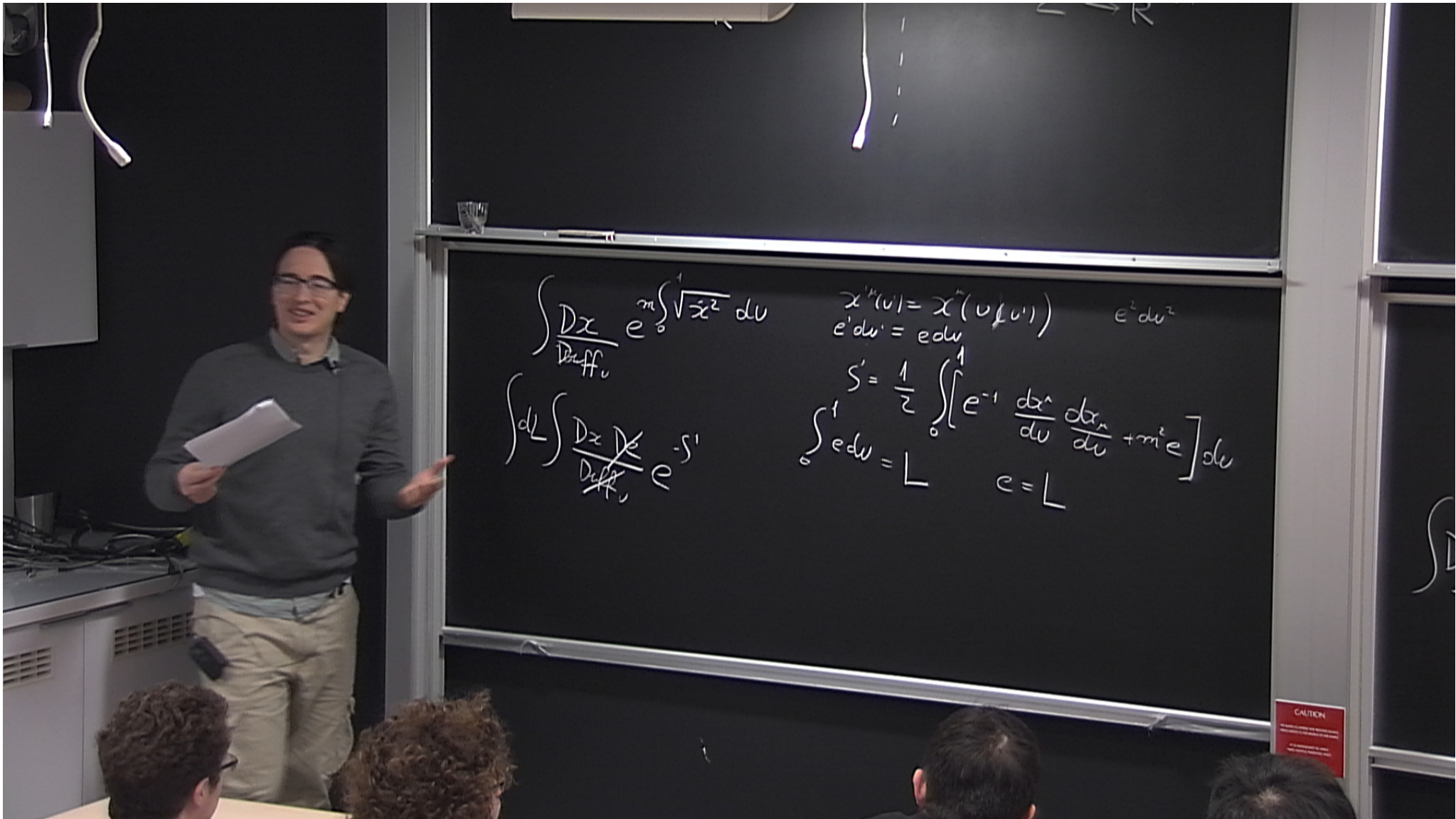
$$\int \frac{DX}{\text{Diff}_{U^a}} e^T \sqrt{\det \left[\frac{dx^\mu}{du^a} \frac{dx^\nu}{du^b} \right]} du^1 du^2$$

$$h_{ab} du^a du^b$$

$$\parallel$$

$$h'_{ab} du^a du^b$$

$$\int \frac{DX Dh_{ab}}{\text{Diff}_{U^a}} e^S S = \frac{T}{2} \int \sqrt{h} h^{ab} \frac{dx^l}{du^a} \frac{dx_i}{du^b} du^a du^b$$



$$\int \frac{Dx}{D\tau} e^{-m \int \sqrt{\dot{x}^2} du}$$

$$x^\mu(u) = x^\mu(v, u) \quad e^2 du^2$$

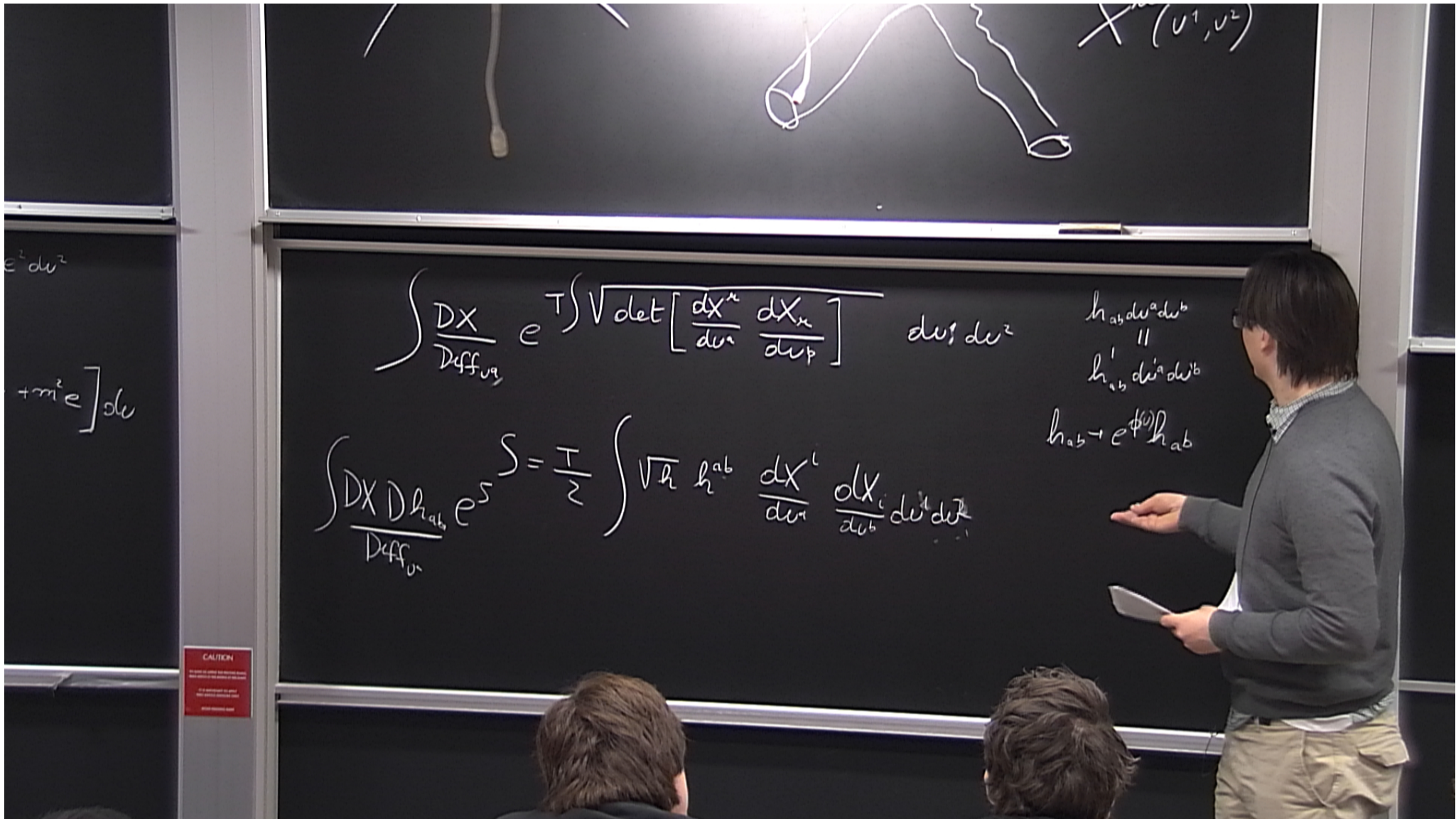
$$e' du' = e du$$

$$\int dL \int \frac{Dx}{D\tau} e^{-S}$$

$$S = \frac{1}{2} \int_0^1 \left[e^{-1} \frac{dx^\mu}{du} \frac{dx_\mu}{du} + m^2 e \right] du$$

$$\int_0^1 e du = L$$

$$e = L$$



$$\int \frac{DX}{\text{Diff}_{U_3}} e^{\mathcal{T}} \sqrt{\det \left[\frac{dx^\mu}{du^a} \frac{dx^\nu}{du^b} \right]} du^1 du^2$$

$$\begin{aligned}
 &h_{ab} du^a du^b \\
 &\parallel \\
 &h'_{ab} du^a du^b \\
 &h_{ab} \rightarrow e^{\phi} h_{ab}
 \end{aligned}$$

$$\int \frac{DX Dh_{ab}}{\text{Diff}_{U_3}} e^{\mathcal{S}} = \frac{\mathcal{I}}{2} \int \sqrt{|h|} h^{ab} \frac{dx^\mu}{du^a} \frac{dx^\nu}{du^b} du^1 du^2$$

$$\begin{aligned}
 &e^2 du^2 \\
 &+ m^2 e \Big] du
 \end{aligned}$$

CAUTION
 Please do not touch the board
 as it is not a good idea to touch the board

$$e^2 du^2$$

$$+m^2 e] du$$



$$\int \frac{DX}{\text{Diff}_{u^a}} e^T \sqrt{\det \left[\frac{dX^\mu}{du^a} \frac{dX^\nu}{du^b} \right]} du^1 du^2$$

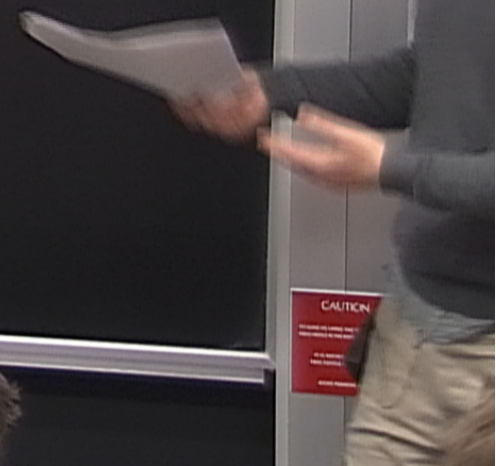
$$h_{ab} du^a du^b$$

$$\parallel$$

$$h'_{ab} du^a du^b$$

$$h_{ab} \rightarrow e^{\phi(u)} h_{ab}$$

$$\int \frac{DX D h_{ab}}{\text{Diff}_{u^a} \times \text{Weyl}} e^S S = \frac{T}{2} \int \sqrt{h} h^{ab} \frac{dX^l}{du^a} \frac{dX_i}{du^b} du^1 du^2$$

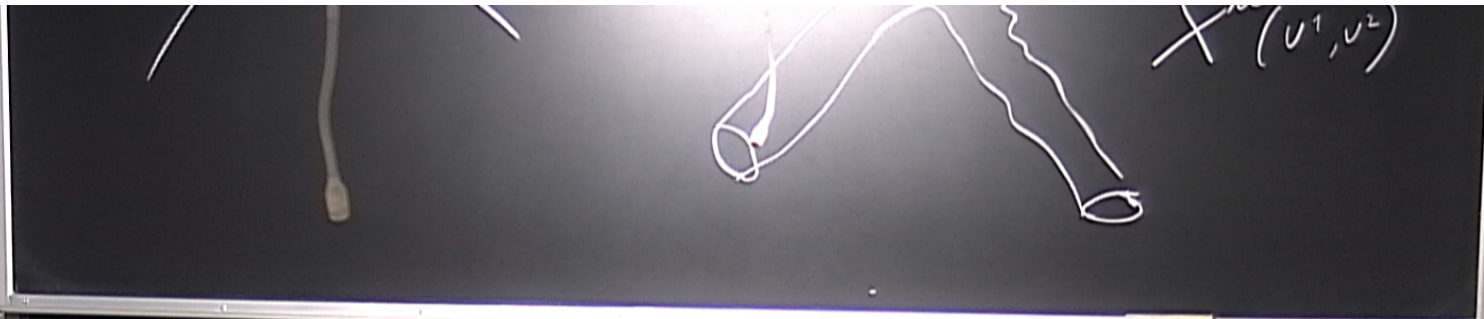


CAUTION

CAUTION

$$e^2 du^2$$

$$+m^2 e] du$$



$X^{\mu}(u^1, u^2)$

$$\int \frac{DX}{\text{Diff}_{u^a}} e^T \sqrt{\det \left[\frac{dX^{\mu}}{du^a} \frac{dX^{\nu}}{du^b} \right]} du^1 du^2$$

$$h_{ab} du^a du^b$$

$$\parallel$$

$$h'_{ab} du^a du^b$$

$$h_{ab} \rightarrow e^{\phi(u)} h_{ab}$$

$$\int \frac{DX D h_{ab}}{\text{Diff}_{u^a} \times \text{Weyl}} e^S = \frac{T}{2} \int \sqrt{|h|} h^{ab} \frac{dX^l}{du^a} \frac{dX_l}{du^b} du^1 du^2$$

CAUTION

CAUTION

$$e^2 du^2 + m^2 e \int du$$



$$\int \frac{DX}{\text{Diff}_{u^a}} e^T \sqrt{\det \left[\frac{dx^\mu}{du^a} \frac{dx^\nu}{du^b} \right]} du^1 du^2$$

$$h_{ab} du^a du^b$$

$$\parallel$$

$$h'_{ab} du^a du^b$$

$$h_{ab} \rightarrow e^{\phi(u)} h_{ab}$$

$$\int \frac{DX D h_{ab}}{\text{Diff}_{u^a} \times \text{Weyl}} e^S = \frac{T}{2} \int \sqrt{h} h^{ab} \frac{dx^\mu}{du^a} \frac{dx^\nu}{du^b} du^a du^b$$

CAUTION
 ATTENTION
 ATTENTION

CAUTION
 ATTENTION
 ATTENTION

$$X (v^1, v^2)$$

$h_{ab} dv^a dv^b$
 $h'_{a'b'} dv'^a dv'^b$
 $h'_{a'b'} = e^{\phi} h_{ab}$

$$\delta(\dots) = \int e^{i\phi} \delta(\dots)$$

$$\int dx^a dx^b \dots \int dx^c dx^d \dots$$

$$\int dx^a dx^b \dots \int dx^c dx^d \dots$$

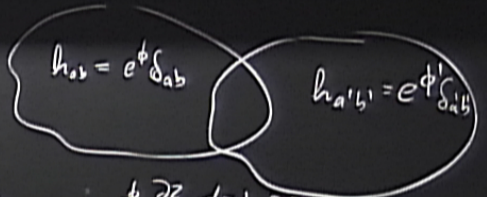
$$h_{ab} \stackrel{\text{Diff}}{=} e^{\phi} \delta_{ab}$$

$$\delta_{ab} \quad v^1 + i v^2 = z$$

$$h_{ab} dv^a dv^b = e^{\phi} dz d\bar{z} = e^{\phi} \frac{\partial z}{\partial z'} dz' \frac{\partial \bar{z}}{\partial \bar{z}'} d\bar{z}'$$

$$z(z')$$

$$e^{\phi'} = e^{\phi} \left| \frac{\partial z}{\partial z'} \right|^2$$



X (u¹, u²)

$$\delta(\dots) = \int e^{i\phi} \delta(\dots)$$

$$\int d^4x_c \int D\mathcal{X}(u) e^{i\phi} \sqrt{\dot{\mathcal{X}}^2} du$$

x(0) = x_a

$$h_{ab} du^a du^b$$

||

$$h'_{ab} du'^a du'^b$$

||

$$h_{ab} \rightarrow e^{\phi} h_{ab}$$

$$h_{ab} \stackrel{\text{Diff}}{=} e^{\phi} \delta_{ab}$$

||

$$u^1 + i u^2 = z$$

$$h_{ab} = e^{\phi} \delta_{ab}$$

$$h_{a'b'} = e^{\phi'} \delta_{a'b'}$$

$$h_{ab} du^a du^b = e^{\phi} dz d\bar{z} = e^{\phi} \frac{\partial z}{\partial z'} dz' \frac{\partial \bar{z}}{\partial \bar{z}'} d\bar{z}'$$

$$z(z')$$

$$e^{\phi'} = e^{\phi} \left| \frac{\partial z}{\partial z'} \right|^2$$

CAUTION

$$X (v^1, v^2)$$

$$\delta(\dots) = \int e^{i\phi_a(\dots)}$$

$$\int dx_c \left(\frac{x(1) - x(0)}{\sqrt{\dot{x}^2}} du \right) e^{i\phi_a}$$

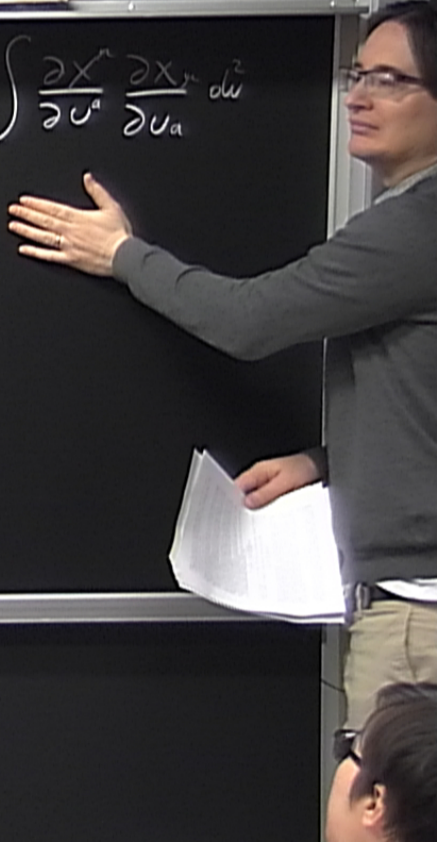
$$h_{ab} dv^a dv^b$$

$$\parallel$$

$$h'_{ab} dv^a dv^b$$

$$h_{ab} \rightarrow e^{\phi} h_{ab}$$

$$\left. \begin{aligned} \frac{Dh_{ab}}{\text{Diff x Veye}} &= \int dM_g \\ &\int DX e^{\frac{I}{2}} \int \frac{\partial X^a}{\partial u^a} \frac{\partial X^b}{\partial u^a} du^2 \end{aligned} \right\}$$



$$X (v^1, v^2)$$

$$\delta(\dots) = \int e^{i\phi_a(\dots)}$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\phi_a}$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\phi_a}$$

$$x(1) = x_b, x(0) = x_a$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\phi_a}$$

$$h_{ab} dv^a dv^b$$

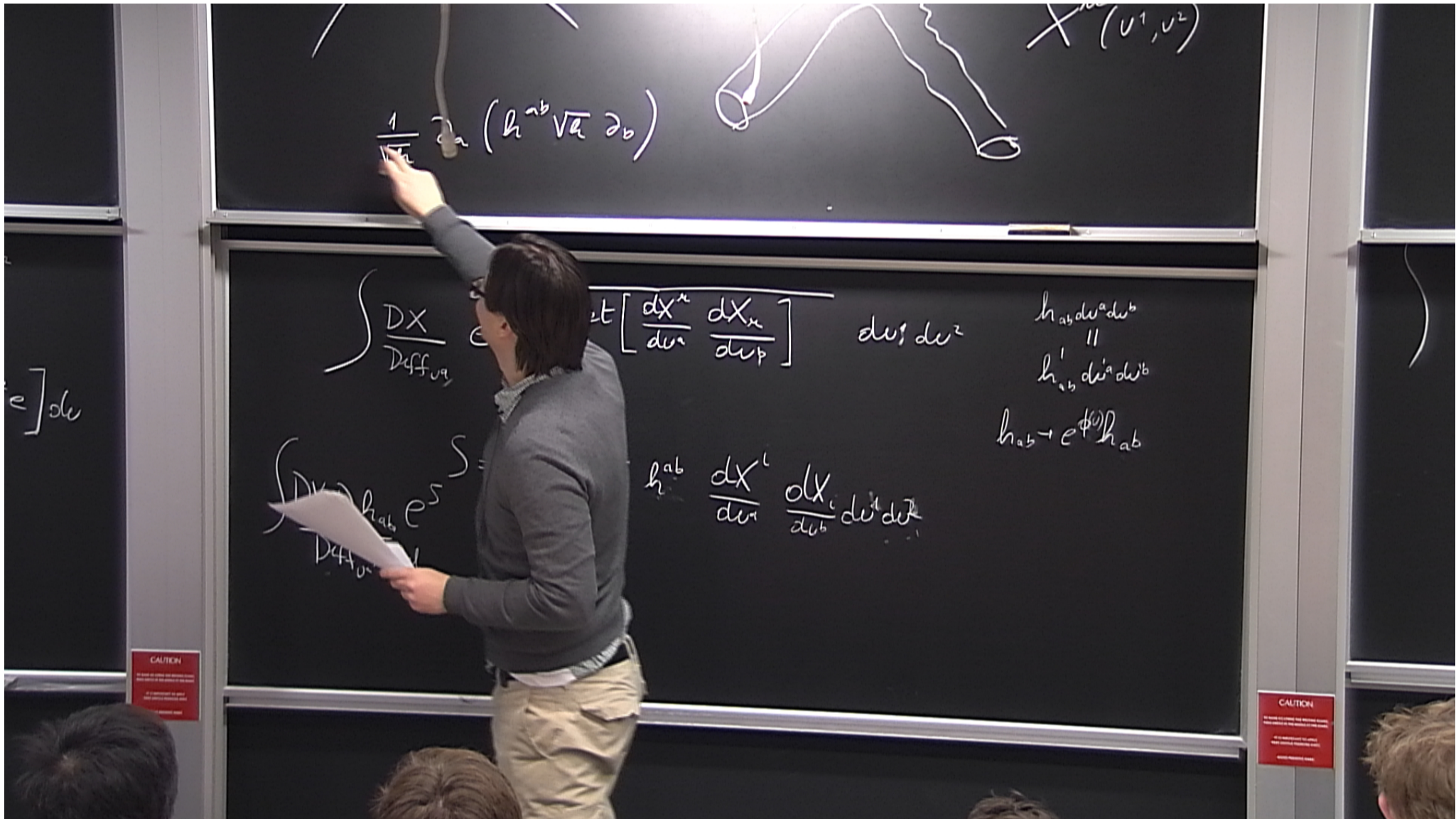
$$h'_{ab} dv^a dv^b$$

$$h_{ab} \rightarrow e^{\phi} h_{ab}$$

$$\frac{Dh_{ab}}{Dt} = \dots$$

$$\int dx e^{\frac{I}{2}} \left(\frac{\partial x^n}{\partial v^a} \frac{\partial x^n}{\partial v^a} \right) dv^2$$

CAUTION
DO NOT TOUCH THE BOARD
WHEN IT IS BEING USED



$$\frac{1}{\sqrt{|g|}} \partial_a (h^{ab} \sqrt{|g|} \partial_b)$$



$$\int \frac{DX}{\text{Diff}_0} e^{iS} \left[\frac{dx^\mu}{d\tau} \frac{dx^\nu}{d\tau} \right] d\tau^1 d\tau^2$$

$$h_{ab} dx^a dx^b$$

$$h'_{ab} dx^a dx^b$$

$$h_{ab} \rightarrow e^{\phi^{(i)}} h_{ab}$$

$$\int \frac{DX}{\text{Diff}_0} h_{ab} e^{iS} = \int h^{ab} \frac{dx^\mu}{d\tau} \frac{dx^\nu}{d\tau} d\tau^1 d\tau^2$$

$$\frac{1}{\sqrt{h}} \partial_a (h^{ab} \sqrt{h} \partial_b) \psi = E \psi$$

$X^{\mu} (v^1, v^2)$

$$\int \frac{DX}{\text{Diff}_{0,3}} e^{\int T} \sqrt{\det \left[\frac{dX^a}{du^1} \frac{dX^b}{du^2} \right]} du^1 du^2$$

$$h_{ab} du^a du^b$$

$$\parallel$$

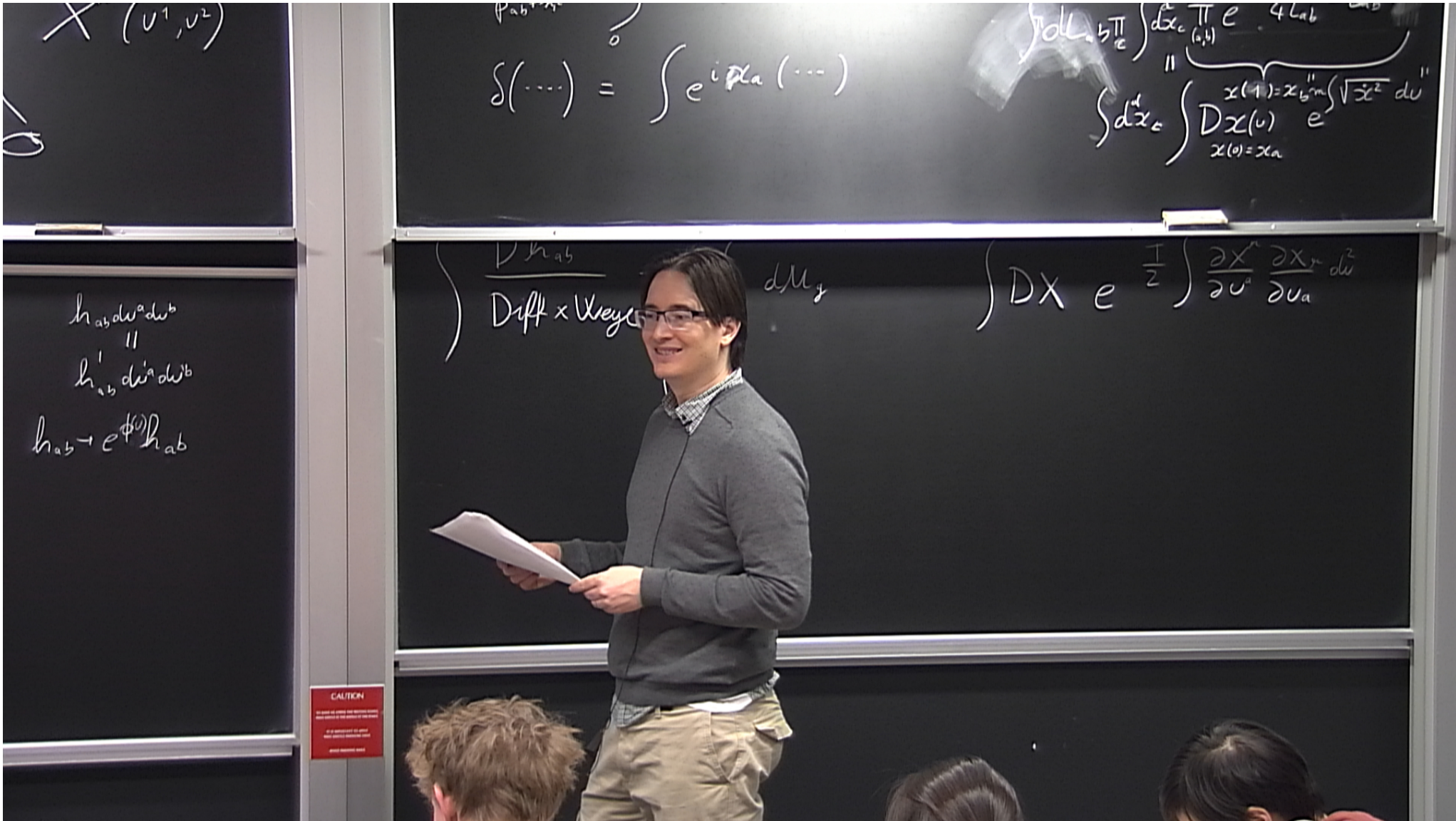
$$h'_{ab} du^a du^b$$

$$h_{ab} \rightarrow e^{\phi^{(i)}} h_{ab}$$

$$\int \frac{DX Dh_{ab}}{\text{Diff}_{0,3} \times \text{Weyl}} e^S = \frac{T}{2} \int \sqrt{h} h^{ab} \frac{dX^l}{du^1} \frac{dX_c}{du^2} du^1 du^2$$

CAUTION

CAUTION



$$\frac{1}{\sqrt{h}} \partial_a (h^{ab} \sqrt{h} \partial_b) \psi = E \psi$$

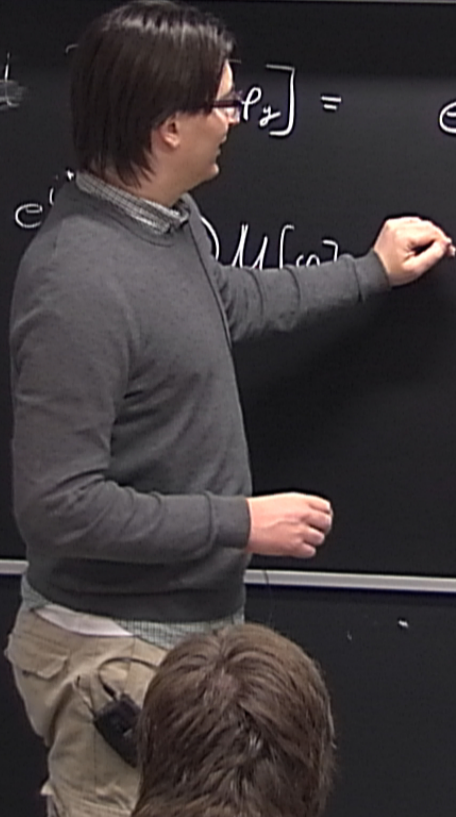


$$e^2 du^2$$

$$\left[\frac{dx_n}{du} + m^2 e \right] du$$

$$e^{i \int_y^x p_x} = e^{i f_y[\varphi]} D\mathcal{M}(\varphi) \quad \varphi \rightarrow \varphi_y$$

$$e^{i \int_y^x p_x} D\mathcal{M}(\varphi) = F(\varphi_y) - F(\varphi) = f_y(\varphi)$$



CAUTION

CAUTION

$$\frac{1}{\sqrt{h}} \partial_a (h^{ab} \sqrt{g} \partial_b) \psi = E \psi$$

$X^\mu (u^1, u^2)$

$$\begin{aligned}
 \mathcal{D} \mathcal{M}[\varphi_2] &= e^{f_2[\varphi]} \mathcal{D} \mathcal{M}(\varphi) & \varphi \rightarrow \varphi_2 \\
 & e^{F[\varphi]} \mathcal{D} \mathcal{M}[\varphi] & f(\varphi_2) = f_y(\varphi_2) + f_y[\varphi] \\
 & & F(\varphi_2) - F(\varphi) = f_y(\varphi)
 \end{aligned}$$

$$\begin{aligned}
 & e^2 du^2 \\
 & \left[\frac{dx_n}{du} + m^2 e \right] du
 \end{aligned}$$

CAUTION

CAUTION

$$\frac{1}{\sqrt{h}} \partial_a (h^{ab} \sqrt{a} \partial_b) \psi = E \psi$$

$X^\mu (u^1, u^2)$

$$e^2 du^2$$

$$\left[\frac{dx_n}{du} + m^2 e \right] du$$

$$D\mathcal{M}[\varphi_2] = e^{f_2[\varphi]} D\mathcal{M}(\varphi) \quad \varphi \rightarrow \varphi_2$$

$$e^{iF[\varphi]} D\mathcal{M}[\varphi] \quad F(\varphi_2) - F(\varphi) = f_2(\varphi)$$

$$f(\varphi_2) = f_2(\varphi) + f_3[\varphi]$$

CAUTION

CAUTION

$$X(u^1, u^2)$$

$$\delta(\dots) = \int e^{i\pi a(\dots)}$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\pi \int dx_c} \quad \text{4 Lab}$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\pi \int dx_c} \quad \begin{matrix} x(1) = x_{b,m} \\ x(0) = x_a \end{matrix}$$

$$f_y(\varphi) = f_y(\varphi_1) f_y(\varphi)$$

$$\left. \begin{matrix} \text{Diff x Weyl} \\ \int dx_c \end{matrix} \right\} = \int d\mu_g \left(\int DX e^{\frac{i}{2} \int \frac{\partial X}{\partial u^a} \frac{\partial X}{\partial u^b} h^{ab}} \right)$$

$$\left[DX D h_{ab} \right]_{h_{ab} = e^{\phi} h_{ab}} = \frac{(d-2d)}{e} \int \frac{\partial \phi}{\partial u^a} \frac{\partial \phi}{\partial u^b} h^{ab} \sqrt{h}$$

CAUTION
DO NOT TOUCH THE BOARD
WHEN THE LECTURER IS SPEAKING

$$X (v^1, v^2)$$

$$\delta(\dots) = \int_0^{\dots} e^{i\pi a(\dots)}$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\pi \int dx_c} \quad \text{4 Lab}$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\pi \int dx_c} \quad \text{with } x(1) = x_{b''}, x(0) = x_a$$

$$f_y(\varphi) = f_y(\varphi_1) f_y(\varphi)$$

$$\left(\frac{Dx}{Dt} \right) = \int dx_c \left(\frac{dx_c}{dt} \right) e^{i\pi \int dx_c} \quad \frac{\partial X}{\partial v^a} \frac{\partial X}{\partial v^a} du^2$$

$$\left[DX D h_{ab} \right]_{h_{ab} = e^{\phi} h_{ab}} = \frac{(d-2Q)}{e} \int \frac{\partial \phi}{\partial v^a} \frac{\partial \phi}{\partial v^b} h^{ab} \sqrt{|h|} + \sqrt{|h|} e^{\phi} + \dots \phi R$$

CAUTION
 DO NOT STAND IN FRONT OF THE BOARD
 OR IN FRONT OF THE BOARD
 WHILE THE BOARD IS BEING USED

$$X (v^1, v^2)$$

$$\delta(\dots) = \int e^{i\alpha a(\dots)}$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\alpha a(x_c, t)}$$

$$\int dx_c \left(\frac{dx_c}{dt} \right) e^{i\alpha a(x_c, t)}$$

$$f_y(\varphi) = f_y(\varphi) f_y[\varphi]$$

$$\int d\mu_g \int D\phi \int DX e^{\frac{i}{2} \left(\frac{\partial X^a}{\partial u^a} \frac{\partial X^b}{\partial u^a} \eta_{ab} + S_\phi \right)}$$

$$\left[DX D h_{ab} \right]_{h_{ab} \rightarrow e^\phi h_{ab}} = e^{\frac{i(d-2c)}{2} \int \frac{\partial \phi}{\partial u^a} \frac{\partial \phi}{\partial u^a} h^{ab} \sqrt{h} + i \int \phi R} DX D h$$

CAUTION

