

Title: Superstring Cosmology Mini-Course: Part 3

Date: Feb 01, 2006 11:00 PM

URL: <http://pirsa.org/06020005>

Abstract: From Monday, January 30th to Thursday, February 2nd, Senarath (Shanta) de Alwis will give a four lecture mini-course on 'Potentials for light moduli in N=1 supergravity and string theory'. In these lectures, Shanta will be describing some of the technical ingredients used in recent constructions of inflation in string theory. The lectures will be given at a level appropriate for advanced graduate students and will be held in the Bob Room at 11:00am each day.

The topics to be covered include:

Derivation of the potential for chiral scalars in N=1 supergravity;

Weyl anomalies and the generation of non-perturbative terms in the superpotential;

Derivation of moduli potentials from fluxes in type IIB and heterotic string theory;

Derivation of potentials for light moduli by integrating out heavy moduli.

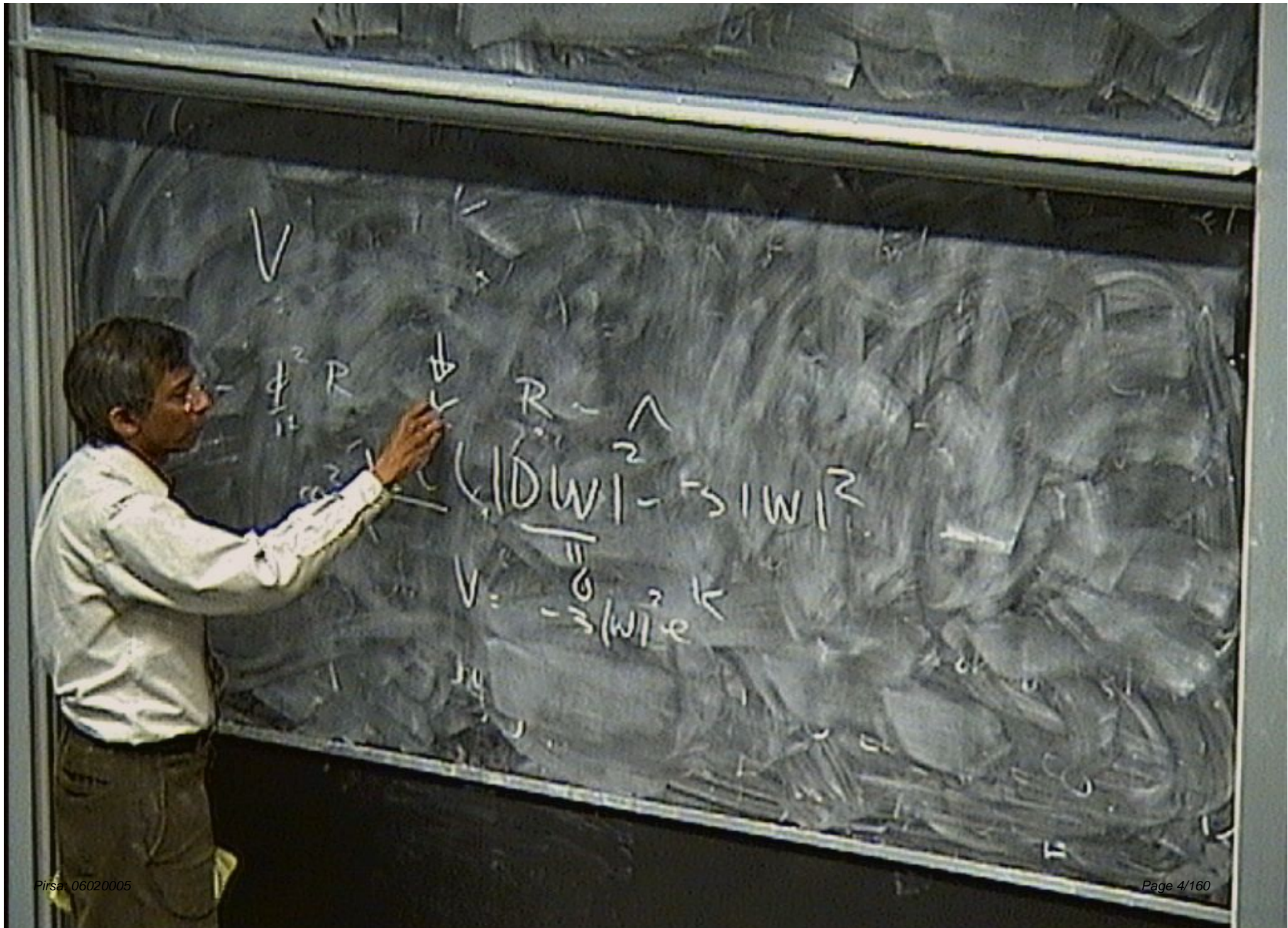
Shanta is a faculty member in the Physics Department at the University of Colorado, Boulder who is spending his sabbatical year here at Perimeter.



V

$$\begin{aligned}
 & - \frac{\phi^2}{12} R \quad K \quad R - \wedge \\
 & \frac{1}{12} \phi^2 \wedge \quad V \cdot e \quad (DWI)^2 - 5 |WI|^2 \\
 & V = \frac{0}{-3 |WI|^2} K
 \end{aligned}$$





$$V$$

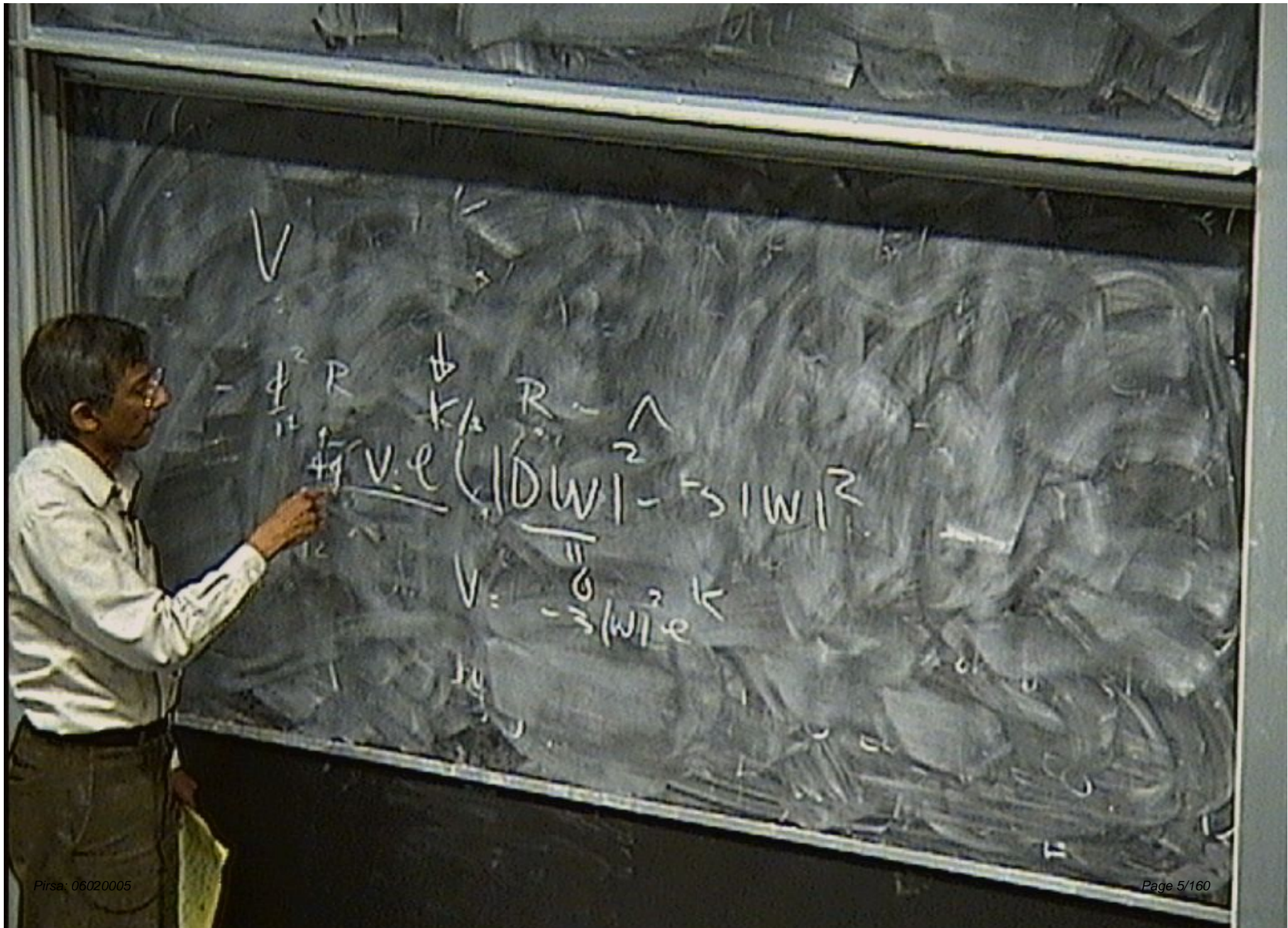
$$- \frac{\phi^2}{14} R$$

$$\downarrow$$

$$R - \hat{\Lambda}$$

$$\frac{1}{2} |D W|^2 - \frac{1}{2} |W|^2$$

$$V = \frac{1}{2} |W|^2 e^k$$



$$\begin{aligned}
 & V \\
 & - \frac{\phi^2 R}{11} \quad \downarrow \quad \frac{k}{k} R \quad - \quad \wedge \\
 & \frac{V \cdot e}{11} \quad \left(\frac{10W}{11} \right)^2 - 5|W|^2 \\
 & V = \frac{0}{-3|W|^2 e} \quad k
 \end{aligned}$$

V

$$-\frac{\phi^2 R}{12} \quad \downarrow \quad k_A R \quad \wedge$$

$$\frac{4}{12} \frac{V \cdot e}{k_A} \quad \left(\frac{1}{2} |DW|^2 - \frac{1}{2} |W|^2 \right)$$

$$\int E \cdot e \quad V = \frac{0}{-3|W|^2 e} \quad k$$

V

$$- \frac{\phi^2}{12} R \quad \downarrow \quad \downarrow \quad \downarrow \quad R \quad \wedge$$

$$\frac{4}{12} \frac{V \cdot e}{k_{11}} \left(|D| W |^2 - 5 |W|^2 \right)$$

$$\frac{\phi}{12} = e$$

$$\int E \cdot e^{-k_{13} V} = \frac{0}{-3 |W|^2 e^k}$$

$$\int \rightarrow \ln R$$

$$V \quad \frac{1}{R}$$

$$- \frac{\phi^2}{12} R \quad \downarrow \quad \frac{1}{k} R \quad \wedge$$

$$\frac{4}{12} \frac{V \cdot e}{k} \left(|D W|^2 - 5 |W|^2 \right)$$

$$\int E e^{-k_1 z} V = - \frac{6}{3 |W|^2 e} k$$

$$\frac{1}{R}$$

GKP

1.1.1

3

GKP

H

3



GKP

HKLT

VR

GKP

HKLT

II B

- on

CY_3

orientifold

with fluxes

GKP

H·KLT

II B. - on

CY₃

orientifold

S =

with fluxes

IV

GKP

HKLT

II B

on CY_3 orientifold
with fluxes

$$S = \int dx^{10} \left[R - \frac{1}{2\alpha'^2} \partial_M \sigma \partial^M \sigma \right]$$

$$- \frac{1}{2\alpha'} \frac{G_{MN} G_{PQ}}{2J} G^{MN}$$

$$\frac{1}{4\alpha'} F_{MN}^2 F_{PQR}^2$$

GKP + HKLT

II B. on CY_3 orientifold
with fluxes

$$S = \int dx^4 \sqrt{g} \left[R - \frac{1}{2\tau^2} \partial_M \tau \partial^M \tau \right]$$

$$- \frac{1}{2\tau^2} \frac{G_{MN} G^{MN}}{\tau^2}$$

$$+ \frac{1}{5!} \int C_4 \wedge G_2 \wedge G_2$$

$$- \frac{1}{4!5!} F^2_{MNPQ} F^2_{MNPQ}$$

GKP + HKLT

II B. on CY_3 orientifold
with fluxes

$$S = \int dx^0 \dots \left[R - \frac{1}{2\alpha'^2} \partial_M \tau \partial^M \tau \right]$$

$$- \frac{1}{2\alpha'^2} \frac{G_{MNPQ} G^{MNPQ}}{\tau^2}$$

$$- \frac{1}{4 \cdot 5!} F_{MNPQR}^2 F_{MNPQR}^2$$

$$\frac{1}{4!} \int C_4 \wedge G_2 \wedge G_2$$

$$G_3 = F_3 - \tau H_3$$

$$F_3 = dC_2, H_3 = dB_2$$

GKP + HKLT

II B on CY_3 orientifold
with fluxes

$$S = \int dx^D \sqrt{|g|} \left[R - \frac{1}{2\alpha'^2} \partial_M \tau \partial^M \tau \right]$$

$$- \frac{1}{2\alpha'^2} \frac{G_{MN} G^{MN}}{\tau^2}$$

$$+ \frac{1}{4!} \int C_4 \wedge G_2 \wedge G_2$$

$$- \frac{1}{4! 5!} F_2^2 F_2^2 F_5^2$$

$$\tau = C_0 + \tau_0 \tilde{\tau}$$

$$G_3 = F_3 - \tau H_3$$

$$F_3 = dC_2, \quad H_3 = dB_2$$

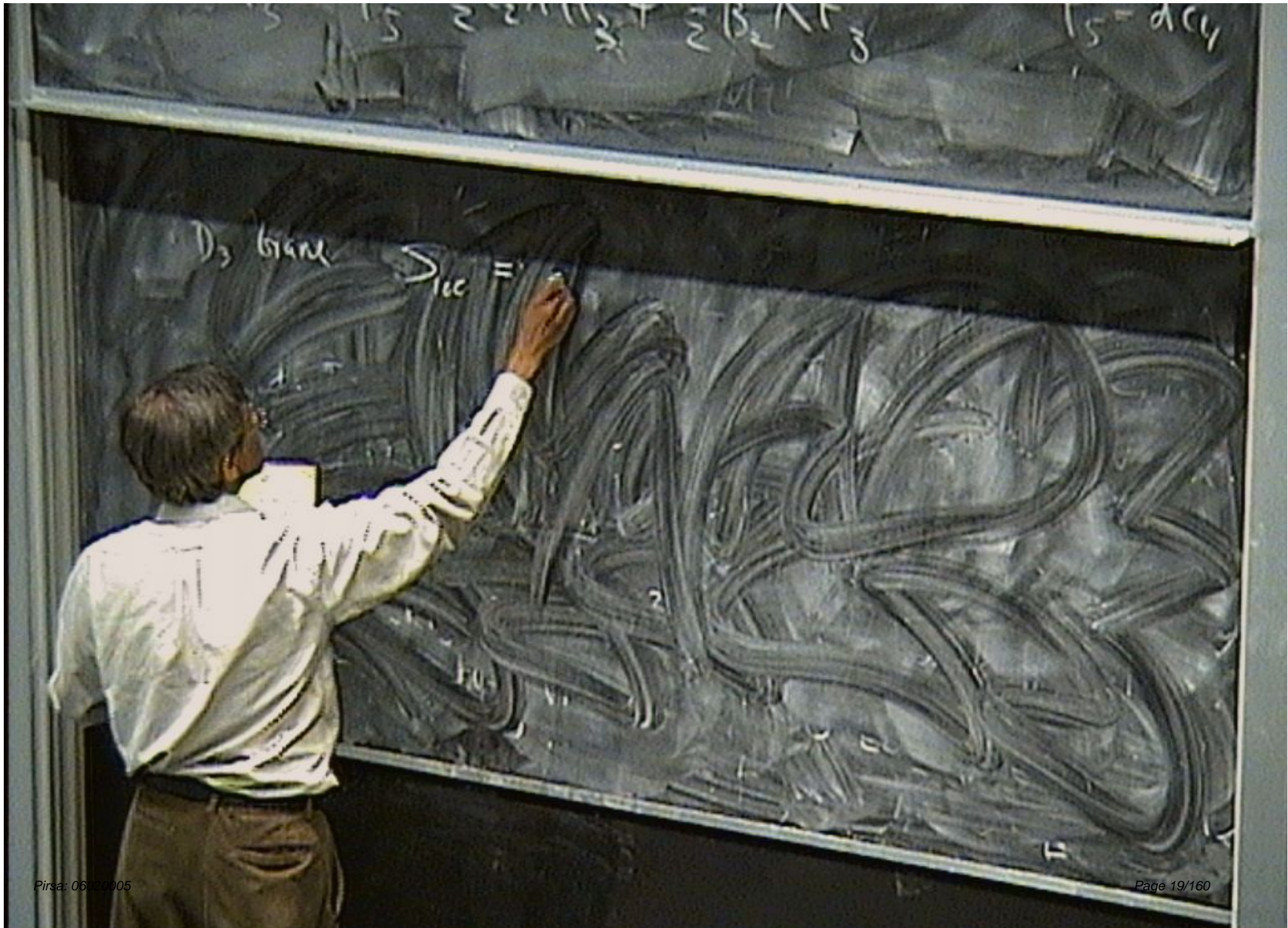
$$F_5 = -F_5$$

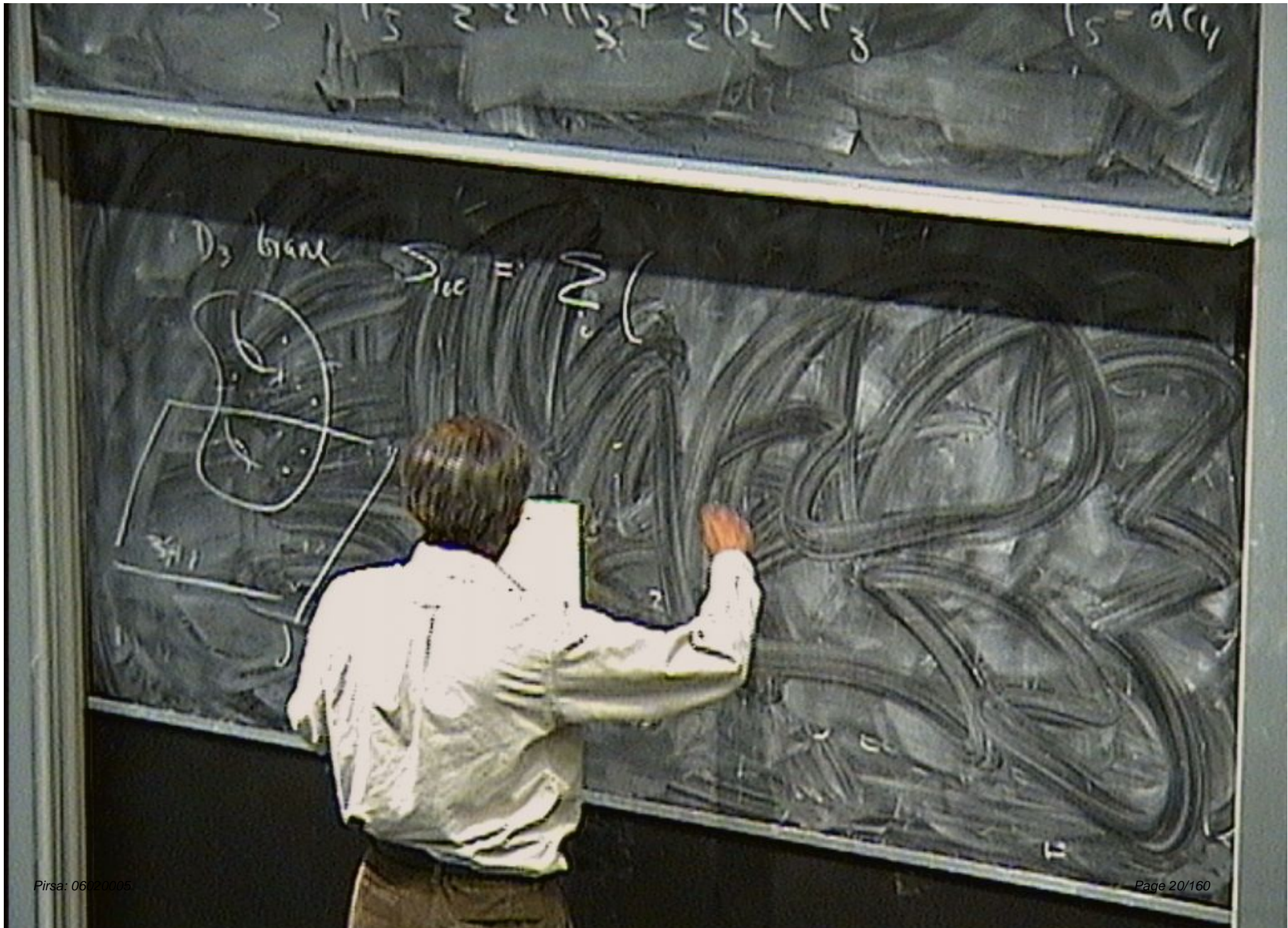
$$- \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3$$

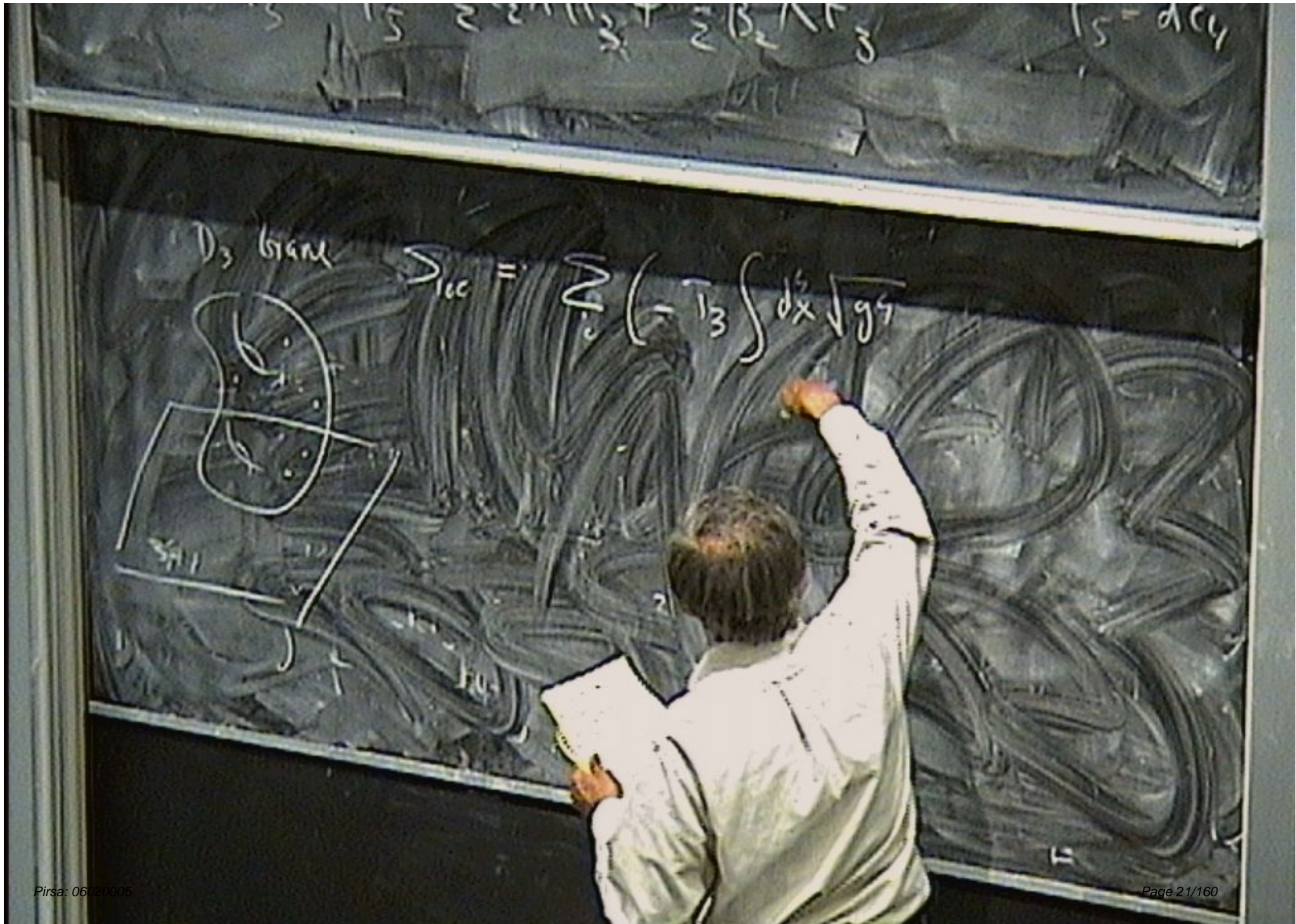
$$F_5 = dC_4$$



D3 brane









D₃ brane

$$S_{loc} =$$

$$\sum_i \left(-T_3 \int dx \sqrt{g_4} \right)$$

$$\sim M_3 \int C_4$$



D₃ brane

$$S_{loc} =$$

$$\sum_i \left(-T_3 \int dx \sqrt{g} \right)$$

$$+ M_3 \int c_4$$



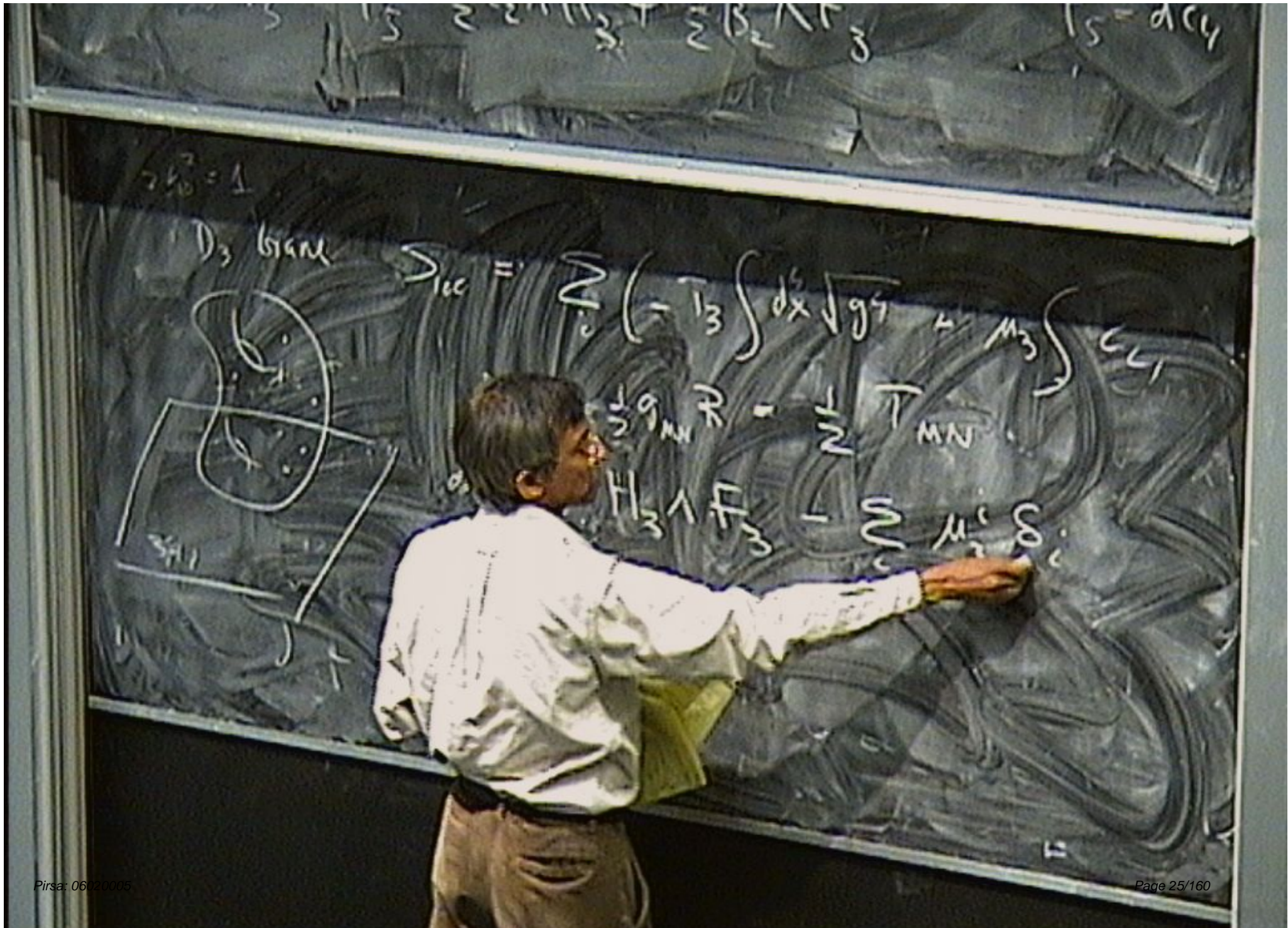
$$g_{00} = 1$$

1) static

$$S_{EH} = \int d^4x \sqrt{g} \mathcal{L} \quad \mathcal{L} = \frac{1}{16\pi G} R - \Lambda$$

$$R_{MN} = \nabla_M \Gamma_{NP} - \nabla_N \Gamma_{MP} + \Gamma_{MP} \Gamma_{NQ} - \Gamma_{MQ} \Gamma_{NP}$$





$$2\beta_0 = 1$$

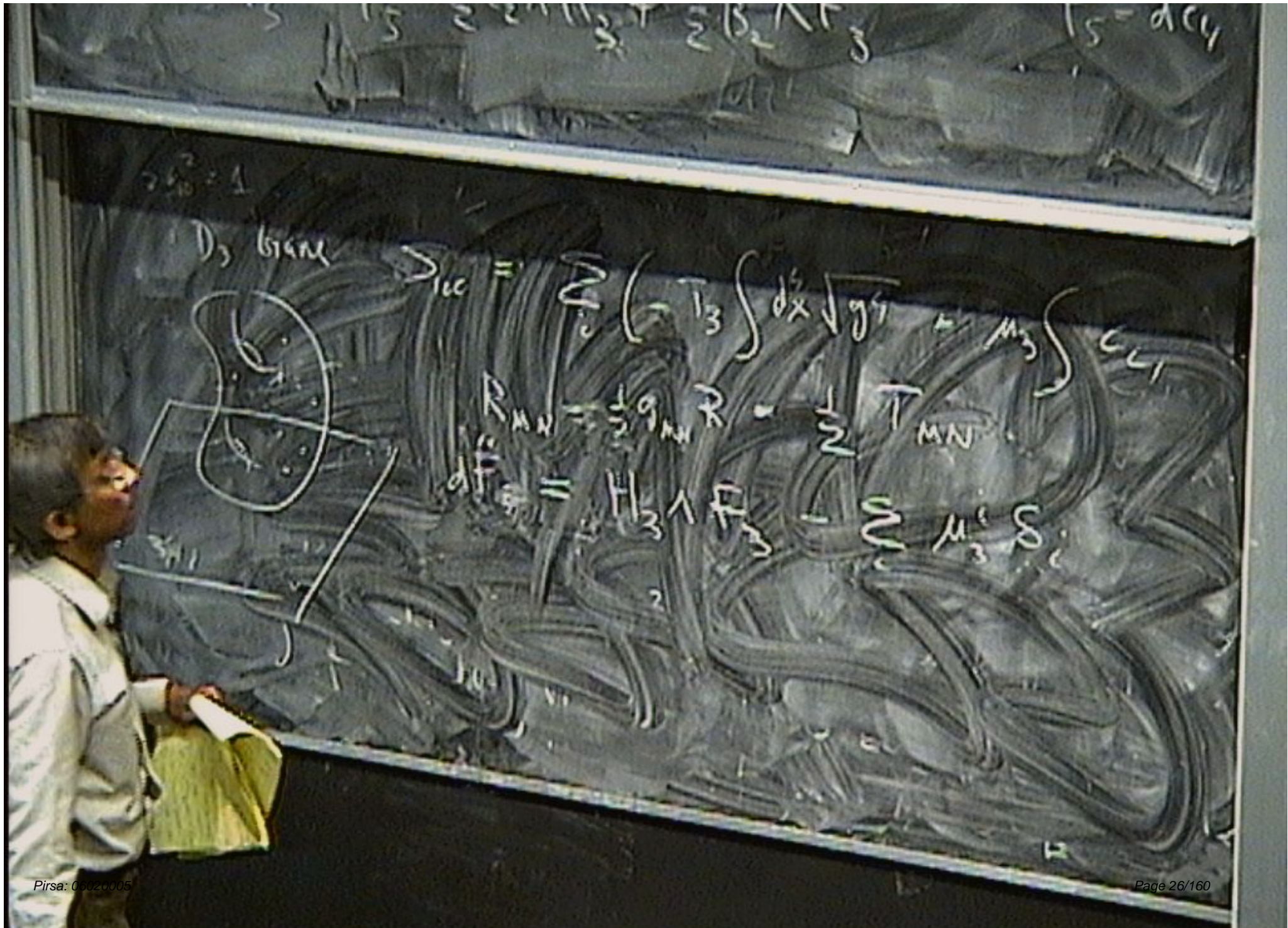
D₃ brane



$$S_{loc} = \sum_i \left(-T_3 \int dx \sqrt{g_4} \dots \right)$$

$$\frac{1}{2} g_{MN} R = -\frac{1}{2} T_{MN}$$

$$H_3 \wedge F_3 = \sum_i \mu_i^c \delta_i^c$$



D_3 brane



$$S_{loc} = \sum_i \left(-T_3 \int dx \sqrt{g_4} + \mu_3 \int C_4 \right)$$

$$R_{MN} = \frac{1}{2} g_{MN} R = \frac{1}{2} T_{MN}$$

$$dF_3 = H_3 \wedge F_3 - \sum_i \mu_3^i \delta_i$$

D_3 brane

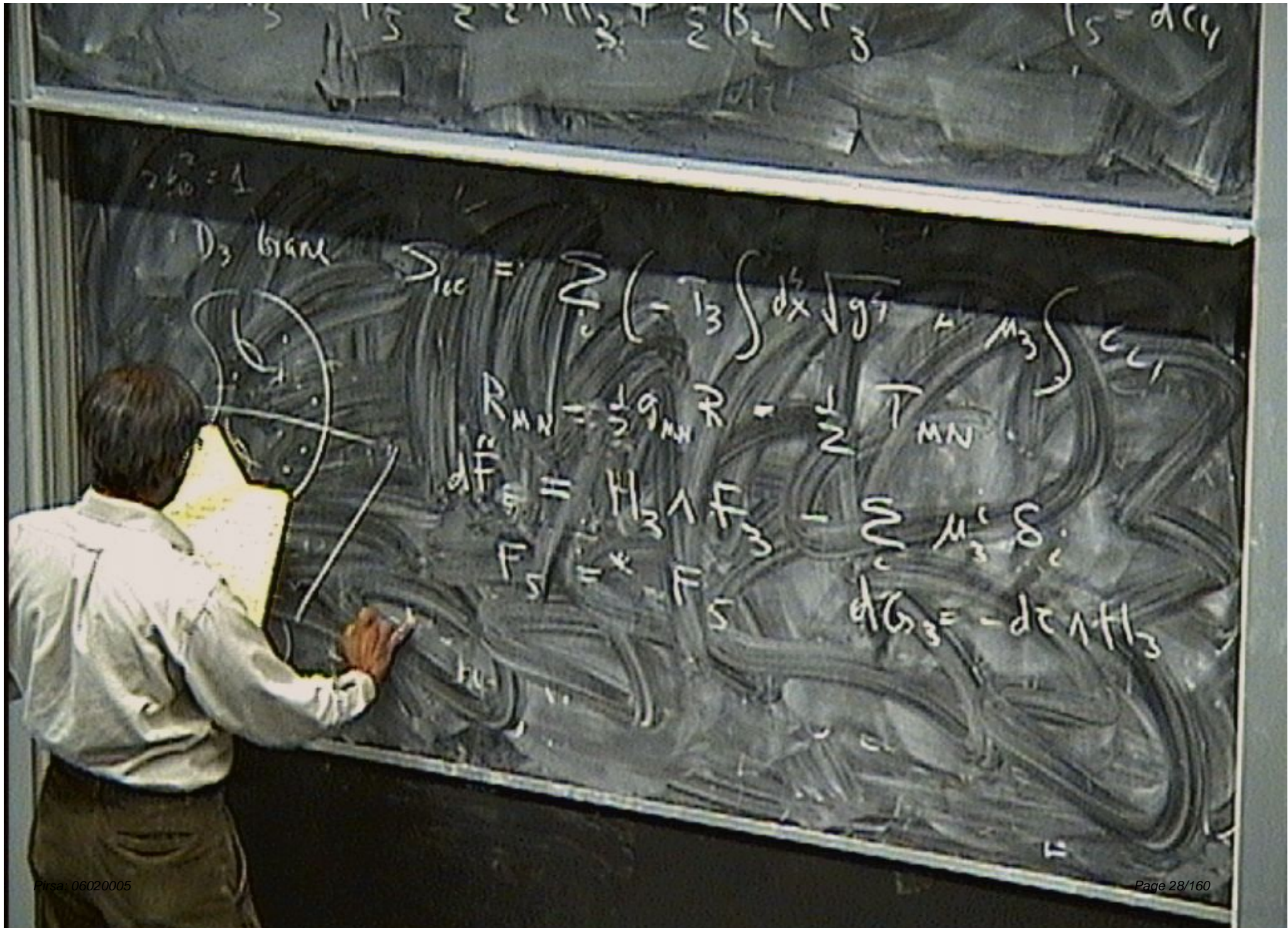


$$S_{loc} = \int d^4x \sqrt{g_4} \left(-\frac{1}{4} F_{MN}^2 + \dots \right)$$

$$F_{MN} = \partial_M A_N - \partial_N A_M$$

$$F_{MN} = \frac{1}{3} \epsilon_{MNP} F_3 \wedge F_3$$

$$= \sum_i \mu_i^c \delta_i$$



D_3 brane

$$S_{loc} = \sum_c \left(-T_3 \int dx \sqrt{g_7} + M_3 \int c_4 \right)$$

$$R_{MN} = \frac{1}{2} g_{MN} R = \sum T_{MN}$$

$$F_5 \wedge F_5 = F_3 \wedge F_3 - \sum_c \mu_c^2 \delta_c$$

$$dG_3 = -d\tau \wedge F_3$$

D_3 brane

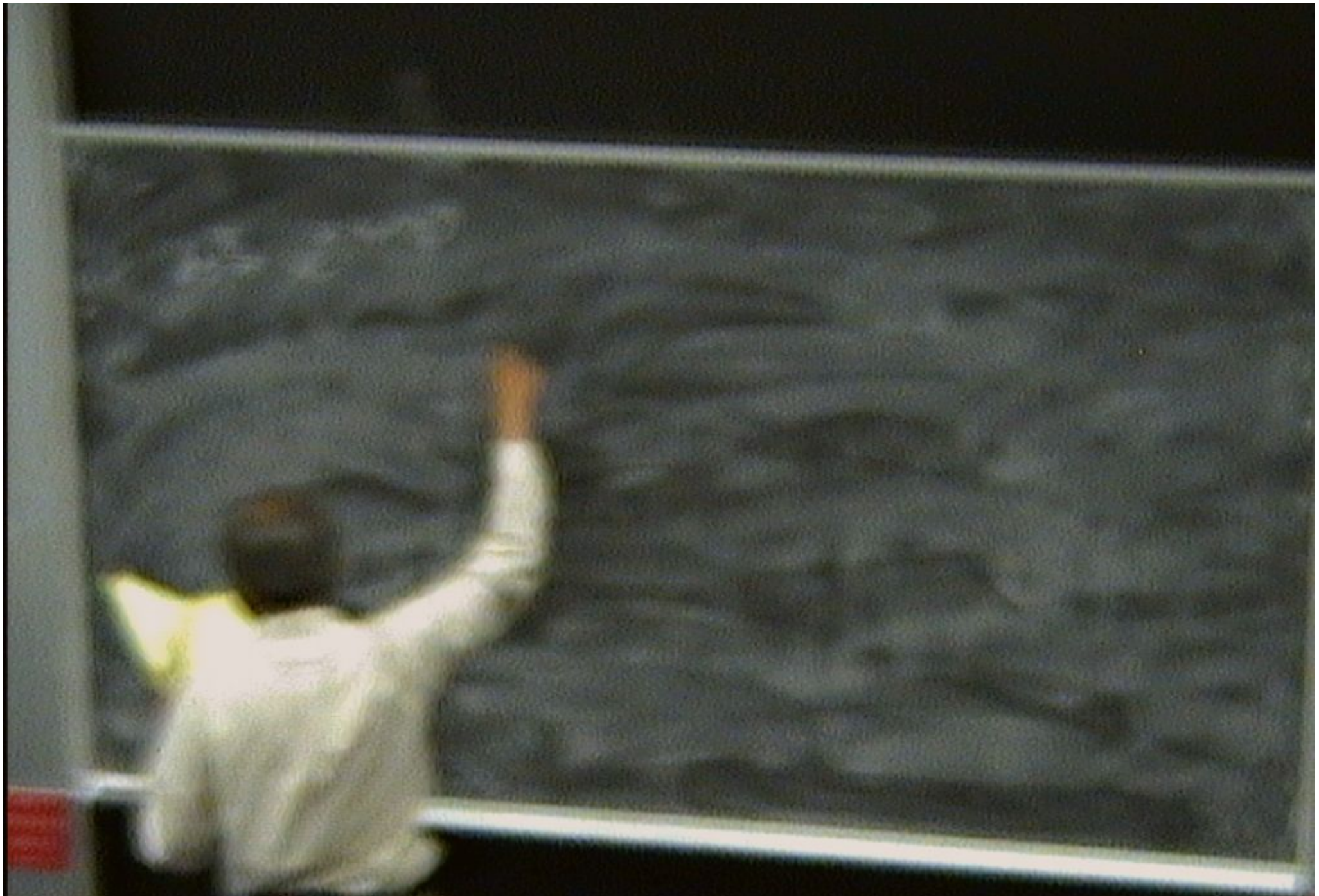


$$S_{loc} = -T_3 \int d^4x \sqrt{g_4} + \mu_3 \int C_4$$

$$dH_3 = \frac{1}{3!} g_{MN} R^3 = \frac{1}{3!} T_{MN}$$

$$F_3 \wedge F_3 = \sum_c \mu_3^c \delta_c$$

$$dG_3 = -d\tau \wedge H_3$$



$$ds^2 = e^{2\omega(\eta)}$$

$$ds^2 = e^{2\omega(y)}$$

$$x^1 = u, \quad x^2 = y, \quad x^3 = z$$

y

$$ds^2 = e^{2\omega(y)}$$

$$x^{\mu} = 0, \dots, 3.$$

$$y^m \quad m=1, \dots, 6$$

$$ds^2 = e^{2\omega(y)} \tilde{g}_{\mu\nu}(x) dx^\mu dx^\nu$$

$$x^\mu = 0, \dots, 3.$$
$$y^m, m = 1, \dots, 6$$

$$ds^2 = e^{2\omega(\eta)} \tilde{g}_{\mu\nu}(\eta) dx^\mu dx^\nu + e^{-2\omega(\eta)} g_{mn}(\eta) dy^m dy^n$$

$\eta = \{0, 1, \dots, 3\}$
 $y^m \quad m=1, \dots, 6$



$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n$$

$x^m = 0, \dots, 3$
 $y^m = 1, \dots, 6$

$$ds^2 = e^{2\omega(x)} \tilde{g}_{\mu\nu}(x) dx^\mu dx^\nu + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n$$

$\mu, \nu = 0, \dots, 3$
 $y^m, m = 1, \dots, 6$

Hunt, F. Mat

$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n$$

$x^a = (t, \dots, \dots)$
 $y^m \quad m=1, \dots, 6$

$$H_{\text{int}}, \quad F_{\text{int}}, \quad F_S = \frac{1}{4!}$$

$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^a \\ y^m \end{matrix} \quad \begin{matrix} a=0, \dots, 3 \\ m=1, \dots, 6 \end{matrix}$$

$H_{\text{int}}, F_{\text{int}}$

$$F_S = \frac{1}{4!} (1 + \star) \sqrt{\tilde{g}_6} \omega dx^1 dx^2 dx^3 dx^4$$

with fluxes

$$S = \int d^4x \left[R - \frac{1}{2\epsilon^2} \partial_\mu \phi \partial^\mu \phi \right]$$

$$- \frac{1}{4\epsilon^2} \frac{G_{MN} G^{MN}}{\tau_3} - \frac{1}{4\epsilon^2} \left(\vec{F}_{MNPQ} \vec{F}^{MNPQ} \right)$$

$$+ \frac{1}{4\epsilon^2} \int C_4 \wedge G_3 \wedge F_2$$

$$\tau = C_0 \tau_0 e^{\alpha \phi}$$

$$G_3 = F_3 - \tau H_3 \quad F_3 = dC_2, \quad H_3 = dB_2$$

$$\vec{F}_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4$$

D_3 here



$$\chi_{11c} = \sum_i \left(-T_3 \int dx \sqrt{g_3} \wedge M_3 \right) \text{CUT}$$

$$R_{MN} = \frac{1}{2} g_{MN} R = \frac{1}{2} T_{MN}$$

$$H_3 \wedge F_3 = \sum_i \mu_i^c \delta_i$$

$$dG_3 = -d\tau H_3$$

$$ds^2 = e^{2\omega(x)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(x)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^a = 0, \dots, 3 \\ y^m = 1, \dots, 6 \end{matrix}$$

$$H_{\text{int}}, \quad F_{\text{int}} \quad F_S = \frac{1}{4!} (1 + \star) \sqrt{g_0} \omega \text{d}x^1 \wedge \text{d}x^2 \wedge \text{d}x^3$$

$$ds^2 = e^{2\omega(x)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} m, n = 1, \dots, 3 \\ m, n = 1, \dots, 6 \end{matrix}$$

H_{int}, F_{int}

$$\mathbb{P}_S = \frac{1}{4!} (1 + \star) \sqrt{g_0} \text{ or } dx^1 \wedge \dots \wedge dx^4$$

$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^a = 0, \dots, 3 \\ y^m = 1, \dots, 6 \end{matrix}$$

H_{int}, F_{int}

$$\mathbb{Z}_2 = \frac{1}{4!} (1 + \star) \sqrt{\tilde{g}_0} \omega dx^1 dx^2 dx^3$$

\tilde{R}_{mn}

$$ds^2 = e^{2\omega(\rho)} \left[g_{mn}^{(x)} dx^m dx^n + e^{-2\omega(\rho)} g_{mn}^{(y)} dy^m dy^n \right] \quad \begin{matrix} x^a = 0, \dots, 3 \\ y^m = 1, \dots, 6 \end{matrix}$$

$$H_{int} = \int d^3x \sqrt{-g} \mathcal{L}_{int} \quad \mathcal{L}_S = \frac{1}{4} (1 + \kappa) \sqrt{-g} \omega \text{ dunder } dx^i dx^j dx^k$$

$$R_{mn} = e^{4\omega} \nabla_\mu \nabla^\mu g_{mn} = -g_{mn} \left[\frac{|G_3|^2}{48\pi^2} + e^{-3\omega} |\partial \alpha|^2 + \bar{T}_{1e} \right]$$



$$ds^2 = e^{2\omega(x)} \tilde{g}_{\mu\nu}(x) dx^\mu dx^\nu + e^{-2\omega(x)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} \mu, \nu = 0, \dots, 3 \\ m, n = 1, \dots, 6 \end{matrix}$$

H_{int} F_{int}


$$\mathbb{R}^3 = \frac{1}{4!} (1 + \star) \sqrt{g_0} \omega dx^1 dx^2 dx^3$$

$$R_{\mu\nu} = e^{4\omega} \tilde{\nabla}_\mu \tilde{\nabla}_\nu \omega - g_{\mu\nu} \left[\frac{|G_3|^2}{48\pi^2} + e^{-3\omega} |\partial\omega|^2 + \tilde{T}_{\mu\nu} \right]$$

$$G_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2$$

$$F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4$$

D_3 brane



$$S_{\text{loc}} = \int (-T_3) dx \sqrt{g_4} + \int M_3 C_4$$

$$R_{MN} = \frac{1}{2} g_{MN} R = -\frac{1}{2} T_{MN}$$

$$dG_3 = -dC \wedge H_3$$



$$ds^2 = e^{2\omega(y)} \underset{m,n}{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \underset{m,n}{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^a = 0, \dots, 3 \\ y^m = 1, \dots, 6 \end{matrix}$$

Hunt \bar{F}_{unt}

$$\bar{\Pi}_5 = \frac{1}{4!} (1+x) \sqrt{g_0} \omega dx^1 dx^2 dx^3 dx^4$$

$$\bar{R}_{mn} = e^{4\omega} \nabla_{[m} \omega \underset{p,q]{n]} g_{pq}(x) = -g_{mn} \left[\frac{|G_3|^2}{48\pi^2} + e^{-8\omega} |\partial \alpha|^2 + \dots \right]$$

$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^a \\ y^m \end{matrix} = 0, \dots, 3$$

$$H_{int} \quad F_{int} \quad \mathbb{F}_S = \frac{1}{4!} (1 + *) \sqrt{g_0} \omega \text{d}x^1 \text{d}x^2 \text{d}x^3$$

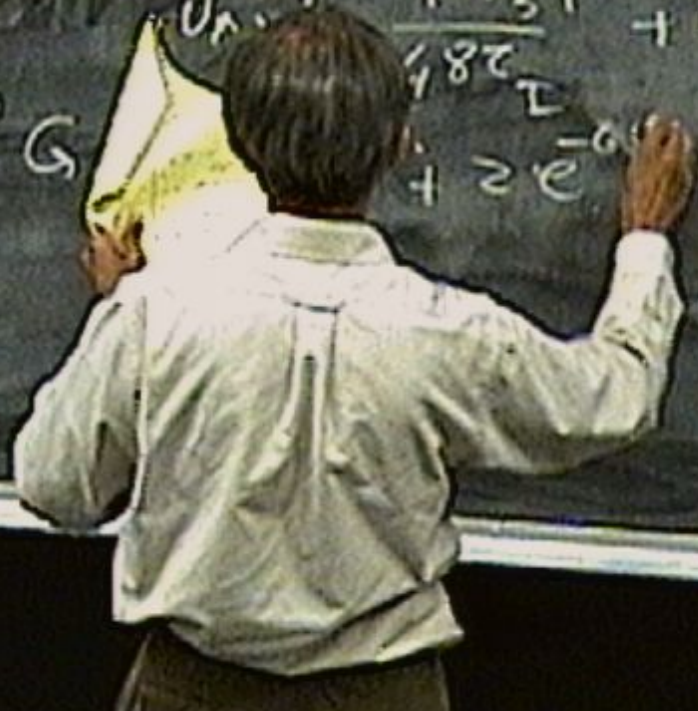
$$\bar{R}_{mn} = e^{4\omega} \nabla_\omega^2 \tilde{g}_{mn}(x) = -g_{mn} \left[\frac{|G_3|^2}{48\pi^2} + e^{-3\omega} |\partial \alpha|^2 + \bar{T}_{ie} \right]$$

$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^m = 0, \dots, 3 \\ y^m = 1, \dots, 6 \end{matrix}$$

$$H_{\text{int}} = \int_{\Sigma_3} F_{\text{int}} = \frac{1}{4!} (1 + *) \sqrt{g_0} \omega \text{d}x^1 \text{d}x^2 \text{d}x^3$$

$$\tilde{\nabla}^2 \omega \tilde{g}_{mn}(x) = -g_{mn} \left[\frac{|G_3|^2}{48\pi^2} + e^{-3\omega} (|\partial x|^2 + \tilde{T}_{1e}) \right]$$

$$\tilde{\nabla}^2 \alpha = \frac{1}{12\pi^2} e^{2\omega} G$$



$$ds^2 = e^{2\omega(y)} \bar{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \bar{g}'_{mn}(y) dy^m dy^n \quad \begin{matrix} x^a = 0, \dots, 3 \\ y^m = 1, \dots, 6 \end{matrix}$$

H_{int}

F_{mnp}

\mathcal{H}_S

$$= \frac{1}{4!} (1 + *) \sqrt{|g_u|} \omega dx^1 dx^2 dx^3 dx^4$$

$$\bar{R}_{mn} = e^{4\omega} \nabla^2 \omega \bar{g}_{mn}(x) = -g_{mn} \left[\frac{|G_3|^2}{48\tau_I} + e^{-3\omega} |\partial x|^2 + \bar{T}_{1a} \right]$$

$$\nabla^2 \alpha = \frac{1}{12\tau_I} e^{2\omega} G_{mnp} G^{mnp} + 2e^{-\omega} \partial_a \alpha \partial^a e^{4\omega} + e^{-\omega} \sum \mu_i \delta_i$$

$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^m = 0, \dots, 3 \\ y^m = 1, \dots, 6 \end{matrix}$$

$$H_{\text{int}} = \frac{1}{4} (1 + *) \sqrt{|\tilde{g}_0|} \omega \quad \text{and} \quad F_{\text{int}} = \frac{1}{24} \epsilon^{ijkl} F_{ij} F_{kl}$$

$$-\frac{1}{2} R^{(4)} - \frac{1}{2} \nabla^2 (e^{4\omega} - \alpha) = \frac{e^{2\omega}}{24\epsilon^2} |G_3 - *G_3|^2 + e^{-6\omega} \frac{1}{10} (e^{4\omega} - \alpha)$$

$$\nabla^2 \alpha = \frac{1}{12\epsilon^2} e^{2\omega} G_{mnp} G^{mnp} + e^{-6\omega} \sum \alpha \partial^4 e^4$$

$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^a \\ y^m \end{matrix} = 0, \dots, 3$$

$$H_{\text{int}} = F_{mnp} \quad \mathbb{F}_S = \frac{1}{4!} (1 + *) \sqrt{|g_0|} \omega \, dx^0 dx^1 dx^2 dx^3$$

$$-\bar{R}^{(4)} = \nabla^2 (e^{4\omega} - \alpha) = \frac{e^{2\omega}}{24\zeta_I} \left[(\mu_3 - \mu_3)^2 + e^{-6\omega} |D(e^{-4\omega})|^2 \right]$$

$$\nabla^2 \alpha = \frac{1}{12\zeta_I} e^{2\omega} G_{mnp} G^{mnp} + 2e^{-6\omega} \partial_\alpha \partial^\alpha e^{4\omega} + e^{-6\omega} \sum \mu_3 \delta_i$$

$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^m = 0, \dots, 3 \\ y^m = 1, \dots, 6 \end{matrix}$$

H_{int}

F_{int}

\mathbb{F}_S

$$= \frac{1}{4!} (1 + \star) \sqrt{|\tilde{g}_0|} \omega \, dx^1 dx^2 dx^3 dx^4$$

$$-\tilde{R}^{(4)} - \tilde{\nabla}^2 (e^{4\omega} - \alpha) = \frac{e^{2\omega}}{24\epsilon_I} \left[6G_3 - \frac{1}{2} G_3^2 + e^{-6\omega} |\partial_\alpha e^{4\omega}|^2 \right]$$

$$\tilde{\nabla}^2 \alpha = \frac{1}{12\epsilon_I} e^{2\omega} G_{mnp} G^{mnp} + 2e^{-6\omega} \partial_\alpha e^{4\omega} \partial^\alpha e^{4\omega}$$

$$-\tilde{R}^{(4)} \leq 0 + e^{-6\omega} \sum \mu_3 \delta_c$$

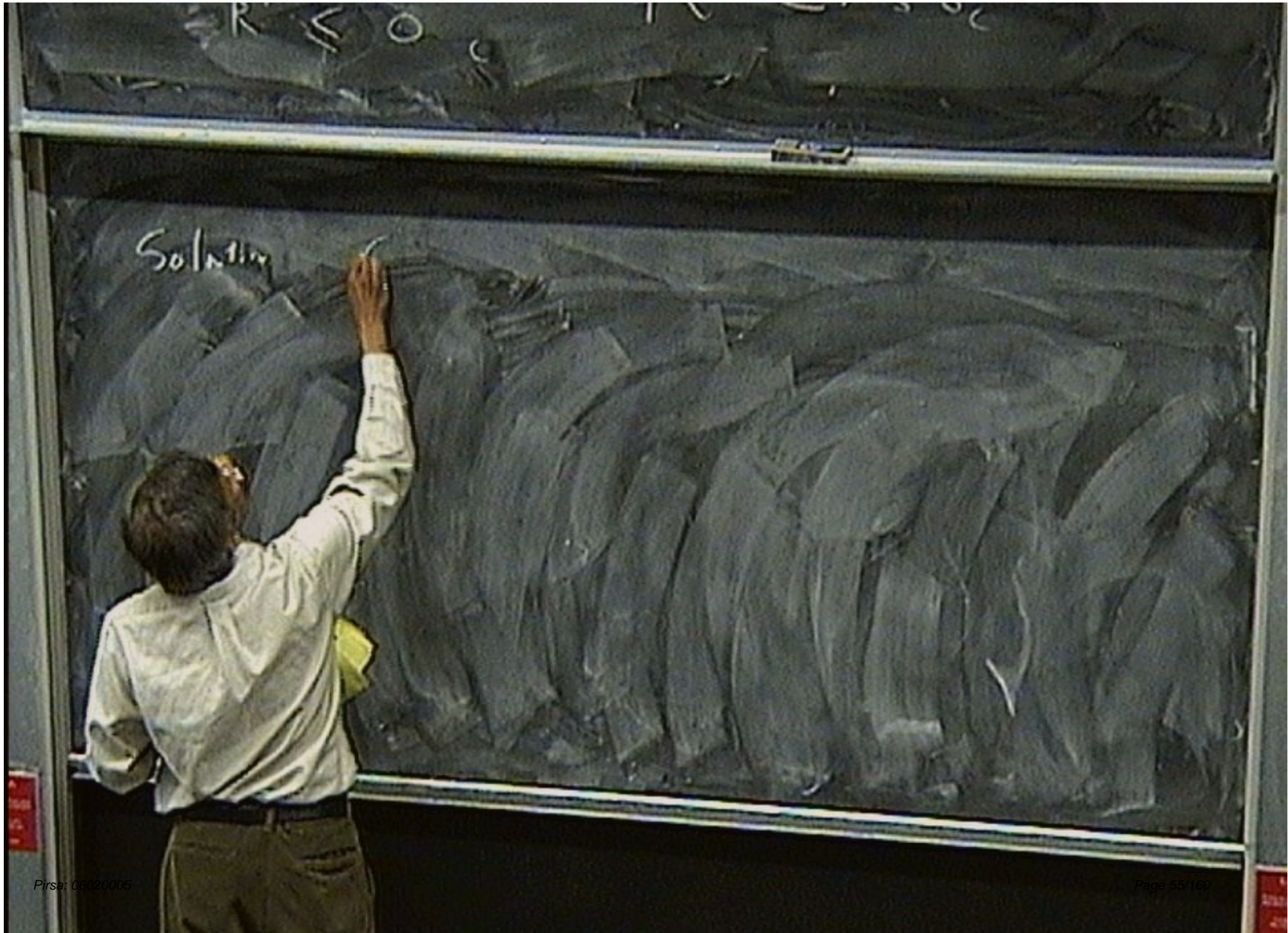
$$ds^2 = e^{2\omega(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)} \tilde{g}_{mn}(y) dy^m dy^n \quad \begin{matrix} x^a \\ y^m \end{matrix} = (0, \dots, 3)$$

$$H_{\text{int}} \quad F_{mnp} \quad \mathbb{I}_S = \frac{1}{4!} (1 + *) \sqrt{|\tilde{g}_6|} \omega \, d^4x \, dx^1 \, dx^2 \, dx^3$$

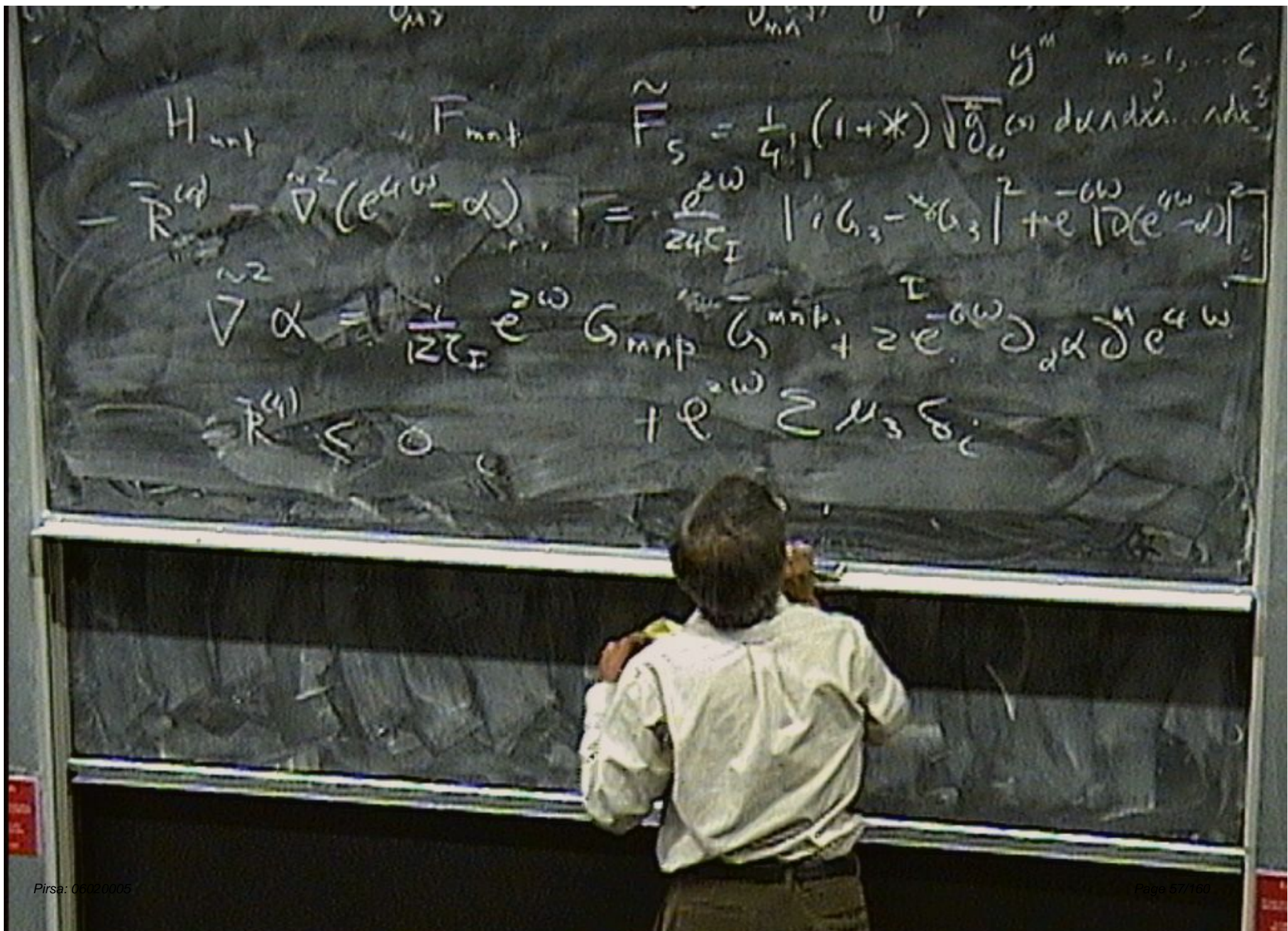
$$-\tilde{R}^{(4)} - \nabla^2 (e^{4\omega} - \alpha) = \frac{e^{2\omega}}{24\zeta_I} \left[|G_3 - *G_3|^2 + e^{-6\omega} |\partial_\alpha e^{4\omega}|^2 \right]$$

$$\nabla^2 \alpha = \frac{1}{12\zeta_I} e^{2\omega} G_{mnp} G^{mnp} + 2e^{-6\omega} \partial_\alpha \alpha \partial^\alpha e^{4\omega}$$

$$-\tilde{R}^{(4)} \leq 0 \quad + e^{-\omega} \sum \mu_i \delta_i$$



Solnⁿ "G₁₃ = *



H_{ant} F_{mat}

$$F_{S} = \frac{1}{4} (1 + *) \sqrt{\frac{\mu_0}{\epsilon_0}} \int \mathbf{v} \cdot d\mathbf{x} \cdot dx^3$$

$$-\bar{R}^{(4)} = \nabla^2 (e^{i\omega t} - \alpha) = \frac{e^{2\omega}}{24\epsilon_I} \left[|i\mu_3 - \mu_3|^2 + e^{-i\omega} \int \partial_\alpha (e^{i\omega t})^2 \right]$$

$$\nabla^2 \alpha = \frac{1}{12\epsilon_I} e^{2\omega} G_{mnp} G^{mnp} + 2e^{-i\omega} \partial_\alpha \partial^\alpha e^{i\omega t}$$

$$-\bar{R}^{(4)} \leq 0 + e^{2\omega} \sum \mu_3 \delta_i$$

$$ds^2 = e^{2\alpha(t)} g_{mn}(y) dy^m dy^n + e^{-2\alpha(t)} g_{\mu\nu}^{(4)}(y) dy^\mu dy^\nu$$

$$H_{\text{tot}} = F_{\text{tot}} \quad F_S = \frac{1}{4!} (1+\star) \sqrt{|g_4|} \omega$$

$$-\bar{R}^{(4)} - \nabla^2(e^{4\alpha} - \alpha) = \frac{e^{2\alpha}}{24\ell_P^2} |g_4|^{-1/2} (\omega^2 + e^{-6\alpha} |g_4|^{-2})$$

$$\nabla^2 \alpha = \frac{1}{12\ell_P^2} e^{2\alpha} G_{mn} G^{mn} + 2e^{-6\alpha} \partial_\mu \alpha \partial^\mu e^{4\alpha}$$

$$\Rightarrow \bar{R}^{(4)} \leq 0 \quad + e^{2\alpha} \sum \mu_i \delta_i$$

Solution: $|g_4| = \mu_i \delta_i \quad F = D \quad e^{4\alpha} = \alpha$

$$ds^2 = e^{2\alpha} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2\alpha} \tilde{g}_{mn}(y) dy^m dy^n \quad \tilde{r} = \alpha, \quad y^m \quad m=1, \dots, 6$$

$$H_{int} \quad F_{int} \quad F_S = \frac{1}{4!} (1+x) \sqrt{\tilde{g}_{ab}} \omega^a dx^b dx^c dx^d dx^e$$

$$- \tilde{R}^{(4)} - \nabla^2 (e^{4\alpha} - \alpha) = \frac{e^{2\alpha}}{24\zeta_I} \left[|G_{33} - x G_{33}|^2 + e^{-6\alpha} |\partial_\alpha (e^{4\alpha})|^2 \right]$$

$$\nabla^2 \alpha = \frac{1}{12\zeta_I} e^{2\alpha} G_{mnp} G^{mnp} + 2e^{-6\alpha} \partial_\alpha \alpha \partial^\alpha e^{4\alpha}$$

$$\tilde{R}^{(4)} \leq 0 \quad + e^{-\alpha} \sum \mu_3 \delta_i$$

Solution: $G_{33} = G_{33} - ISD, \quad e^{4\alpha} = \alpha$

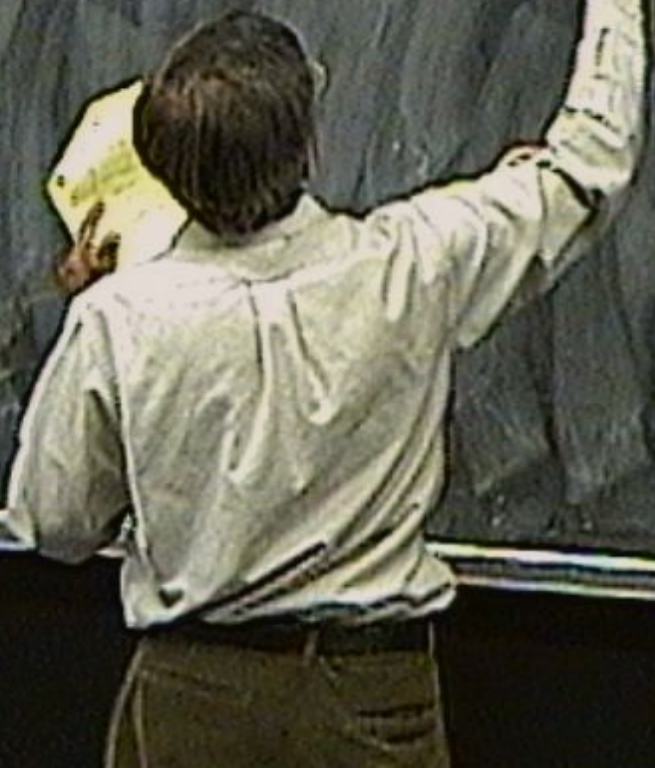
2.3.2

$$R^{(4)} \leq 0 \quad + e \quad \sum \mu_3 \delta_i$$

Solution $G_3 = G_3 - TSD, \quad e^{4\omega} = a + \text{const}$

$$d\mu = \frac{1}{2} d\omega$$

$$ds^2 = e^{-6\omega + 2\mu} dt^2 + \dots$$

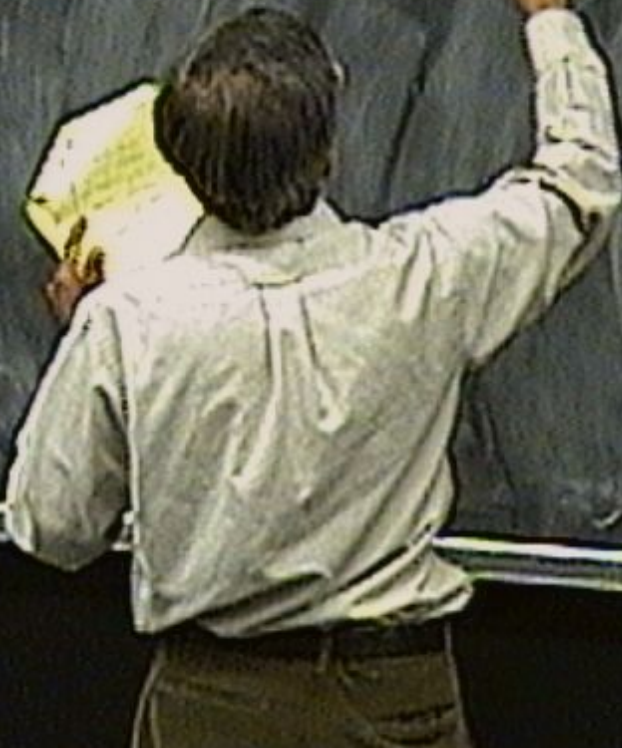


$$R^{(4)} \leq 0 \quad + \rho \sum \mu_3 \delta_i$$

Solution $G_{13} = G_{31} = -\Gamma_{13}$ $e^{4\omega} = a + \text{const}$

$\partial_{13} = \partial_{31}$

$$ds^2 = e^{-6\omega + 2\psi(x)} g_{ij}(x) dx^i dx^j$$

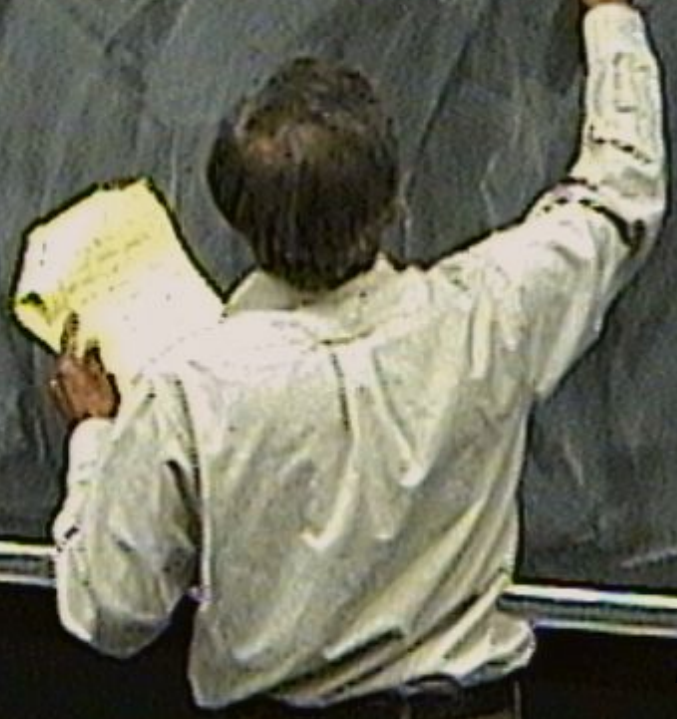


$$\vec{R}^{(4)} \leq 0 \quad + \rho \sum \mu_3 \delta_i$$

Solution $G_3 = G_3 - TSD, \quad e^{4\omega} = a + \text{const}$

$g_{ij} = g_{ij}$

$$ds^2 = e^{-6\omega + 2\psi(\eta)} \left(\frac{dx^2}{\eta^2} + e^{-2\psi(\eta)} d\eta^2 \right) + e^{-2\psi(\eta)}$$

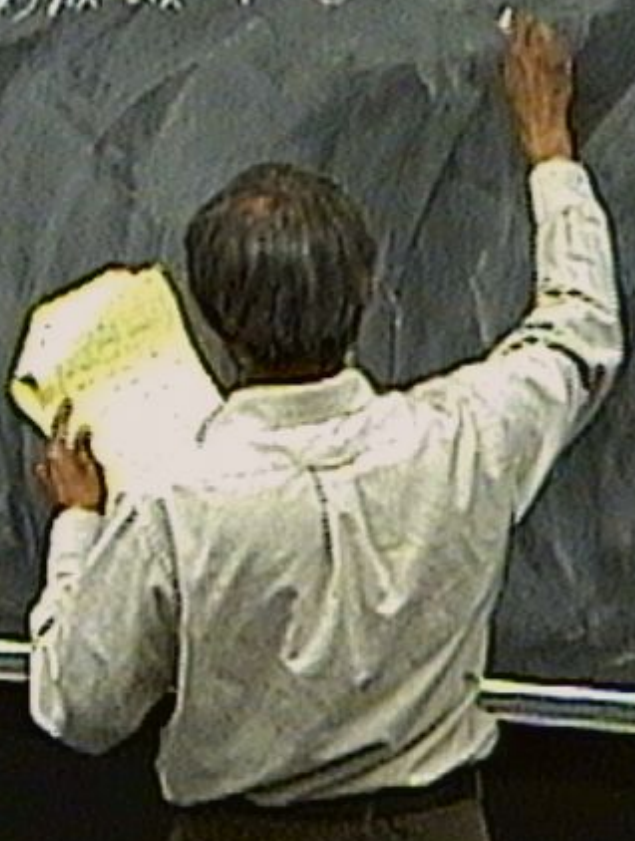


$$\bar{R}^{(4)} \leq 0 \quad + \rho \sum \mu_3 \delta_i$$

Solution $G_3 = G_3 - \Gamma \delta$ $e^{4\omega} = a + \text{const}$

$$d\omega = \frac{1}{2} \frac{dx}{x}$$

$$ds^2 = e^{-6\omega + 2\psi(x)} \left(\frac{dx}{x} \right)^2 + e^{-2\omega + 2\psi(x)}$$



$$R^{(4)} \leq 0 \quad + e \sum \mu_3 \delta_i$$

Solution $G_3 = G_3$ - ISD. $e^{4\omega} = \alpha + \beta \ln t$

$\partial_x = \frac{\partial}{\partial x}$
 $\partial_y = \frac{\partial}{\partial y}$

$$ds^2 = e^{-6u(x) + 2v(y)} g_{ij}(x) dx^i dx^j + e^{-2u(x) + 2v(y)} \tilde{g}_{mn}(x,y) dy^m dy^n$$



$$R^{(4)} \leq 0 \quad + e \sum \mu_3 \delta_i$$

Solution $G_{13} = G_{31}$ ISD. $e^{4\omega} = a + \dots$

$\partial_{\mu} g_{\nu\sigma}$

$$ds^2 = e^{-6u(x)+2v(y)} \tilde{g}_{ij}(x) dx^i dx^j + e^{-2u(x)+2v(y)} \tilde{g}_{mn}(x,y) dy^m dy^n$$

$$\partial_{\mu} \det \tilde{g} = 0$$

$$\tilde{g}_{mn}(x,y) = \tilde{g}_{mn}$$

$$-\ddot{R}^{(4)} \leq 0 \quad + e \sum \mu_3 \delta_i$$

Solution $G_{13} = G_{31} = 15D$. $e^{4\omega} = d$ constant

$\partial_{\mu} \partial_{\nu}$

$$ds^2 = e^{-2u(x) + 2v(y)} \tilde{g}_{mn}(x) dx^m dx^n + e^{-2u(x) + 2v(y)} \tilde{g}_{mn}(x,y) dy^m dy^n$$

$\partial_{\mu} \partial^{\mu} = 0$

$$\tilde{g}_{mn}(x,y) = \tilde{g}_{mn}(x) + 2v(x) \delta_{mn}(y) + \dots$$

$$R^{(4)} \leq 0 \quad + \rho \sum \mu_i \delta_i$$

Solution $G_3 = \dots G_3 \quad \text{I.S.D.} \quad e^{4\omega} = \alpha + \text{const}$

$\partial_{\mu} \tilde{g}_{\mu\nu}$

$$ds^2 = e^{-2u(x)+2v(y)} \tilde{g}_{\mu\nu}(x) dx^{\mu} dx^{\nu} + e^{-2u(x)+2v(y)} \tilde{g}_{mn}(x,y) dy^m dy^n$$

$$\partial_{\mu} \tilde{g}_{\mu\nu} = 0$$

$$\tilde{g}_{mn}(x,y) = \tilde{g}_{mn}(y) + 2v(y) \tilde{g}_{mn}(y)$$

$$\vec{R}^{(4)} = 0 \quad + e^{\int \mu_3 \cos t}$$

Solution: $C_3 = \dots$ ISD. $e^{\int \mu_3} = \dots$

$z = \dots$

$$ds^2 = e^{-2u(x) + 2v(y)} \left(\frac{dx^2}{f(x)} + \frac{dy^2}{g(y)} \right)$$

$$\partial_x \partial_x \dots = 0$$

$$\frac{1}{g(y)} = \frac{1}{g(y)} + 2v(y) \frac{1}{g(y)}$$

$$R_{xy} = \langle e^u \rangle$$

$$R^{(4)} \leq 0 \quad + \rho \sum \mu_i \delta_i$$

Solution $G_3 = {}^{2,0}G_3$ ISD. $e^{4\omega} = d \text{ constant}$

$g_{\mu\nu} = \hat{g}_{\mu\nu}$

$$ds^2 = e^{-2u(x)+2\omega(x)} \hat{g}_{\mu\nu}(x) dx^\mu dx^\nu + e^{-2\omega(x)+2u(x)} \hat{g}_{mn}(x,y) dy^m dy^n$$

$$\partial_\mu \det \hat{g} = 0$$

$$\hat{g}_{mn}(x,y) = \hat{g}_{mn}(y) + 2(x) \phi_{mn}^i(y)$$

$$R_{\mu\nu} = \langle e^u \rangle$$

If KK modes ignored

$$\partial_\mu \omega = 0 \quad \Rightarrow \quad \partial_\mu u = \partial_\mu z^i = 0$$

$$R^{(4)} \leq 0 \quad + \rho \subset \mu_3 \delta_i$$

Solution $G_{13} = \dots G_{13} \quad \text{I.S.D.} \quad e^{4\omega} = \dots$

$g_{\mu\nu} = \dots$

$$ds^2 = e^{-6\omega + 2\alpha(x)} \tilde{g}_{ij}(x) dx^i dx^j + e^{-2\alpha(x) + 2\omega(x)} \tilde{g}_{mn}(x,y) dy^m dy^n$$

$$\partial_\mu \det \tilde{g} = 0$$

$$g_{\mu\nu}(x,y) = \tilde{g}_{mn}(x) + 2\alpha(x) \tilde{g}_{mn}(x,y) + \dots$$

$R_{\mu\nu} \dots$

If KK modes ignore \dots

$$\partial_\mu \partial_\nu \omega = \partial_\mu \partial_\nu \alpha = 0$$

$$R^{(4)} \leq 0 \quad + e \quad \sum \mu_3 \delta_i$$

Solution $G_3 = \dots$ ISD. $e^{4\omega} = \dots$

$g_{\mu\nu}$

$$ds^2 = e^{-2u(x)+2\omega(y)} \hat{g}_{mn}(x) dx^m dx^n + e^{-2\omega(y)+2u(x)} \hat{g}_{mn}(x,y) dy^m dy^n$$

$$\partial_\mu \det \hat{g} = 0$$

$$\hat{g}_{mn}(x,y) = \hat{g}_{mn}(x) + 2\omega(y) \delta_{mn}^y + \dots$$

$$R_{xy} = \langle e^y \rangle$$

II KK modes
if $\partial_\mu \omega \neq 0$

$$\partial_\mu \omega \neq 0 \Rightarrow \partial_\mu u = \partial_\mu \omega = 0$$

III KK modes

$$N = \int$$

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$$V = \int \int \int \sqrt{g} \cdot e^{\frac{4\omega(x) - 12u(x)}{24\tau}}$$

$$V = \int \int \int \sqrt{g} \cdot \frac{e^{4\psi(\mathbf{r}) - 12u(\mathbf{r})}}{24\tau_I} |i G_3 - \sqrt{4\psi(\mathbf{r})}|$$



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$$W = \int \sigma_y \sqrt{g^{\alpha\beta}} \frac{e^{4\omega(\tau) - 12\psi(\tau)}}{24\tau^2} \frac{1}{|iG_3 - \sqrt{4G_3}|^2} + KK?$$



$$V = \int \int \sqrt{g} \frac{e^{4\psi(r) - 12u(r)}}{24\pi I} \left| \epsilon_{G_3} - \tilde{u}_{G_3} \right|^2 + KK ?$$

$$\int \partial \alpha -$$

$$V = \int \int \int \sqrt{g} \frac{e^{4\psi - 12u}}{24\pi^2} |iG_3 - \tilde{K}G_3|^2$$

$$= \int \int \int (2\alpha - e^{4\psi})^2 d^3x + KK?$$



$$N = \int \int \sqrt{g} \frac{e^{4\alpha(\tau) - 12\psi(\tau)}}{24\tau_I} \left| iG_3 - \sqrt{463} \right|^2$$

Can be expressed $N=1$ SUGRA form

$$V = \int \sigma_y \sqrt{g} \frac{e^{4\omega(t) - 12\psi(t)}}{24^2 \Gamma} \left| i G_3 - \sqrt{4G_3} \right|^2$$

Can be expressed $N=1$ SUGRA form

$$K = -\ln(s+3)$$

$$s = i\tau$$

$$N = \int \int \int \sqrt{g} \frac{e^{-(\alpha_1 + 12u_1)} |i \alpha_2 - \alpha_3|^2}{24 \tau^2}$$

Can be expressed $N \approx 1$ SUGRA form

$$K = -\ln(s+\bar{s}) - 3\ln(T+\bar{T})$$

$$s = i\tau \\ \text{Re } T = \frac{e^{2u}}{4}$$

$$V = \int \sigma_y \sqrt{g} \frac{e^{4\sigma_y - 12u(x)}}{24^2 I} |i G_3 - \sqrt{4G_3}|^2$$

Can be expressed $N=1$ SUGRA form

$$K = -\ln(s+3) - 3\ln(T+\bar{T}) - \ln\left(-i \int_X \Omega \wedge \bar{\Omega}\right)$$

$$s = i\tau$$

$$R, T = e^{4u}$$

$$V = \int \sigma_y \sqrt{g} \frac{e^{4\psi(\tau) - 12\psi(\tau)}}{24\tau^2} \left| i G_3 - \sqrt{-G_3} \right|^2$$

Can be expressed $N=1$ SUGRA for m

$$K = -\ln(s+\bar{s}) - 3\ln(T+\bar{T}) - \ln(-i \int_X \Omega \wedge \bar{\Omega})$$

$$S = i\tau$$

$$R_{\tau T} = e^{4\psi}$$

$$V = \int \int \sqrt{g} \frac{e^{4\psi} - 12\psi}{24\tau_I} \left| i G_{13} - \sqrt{4G_{13}} \right|^2$$

Can be expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - 3\ln(T+\bar{T}) - \ln\left(-i \int_X \Omega \wedge \bar{\Omega}\right)$$

$$W = \frac{1}{4} \int_X G_{13} \wedge \Omega$$

$$S = i\tau \\ R_{1T} = e^{4\psi}$$

$$V = \int \sqrt{g} \sqrt{f(\sigma)} \frac{e^{4\sigma - 12\psi}}{24\pi^2} |iG_3 - \tilde{X} \wedge \sigma_3|^2$$

Can be expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - 3\ln(T+\bar{T})$$

$$S = i\tau \\ R_+ T_- = e^{4\psi}$$

$$-i \int_X \Omega \wedge \bar{\Omega} \\ \int_X G_3 \wedge \Omega$$

$$V = e^K (D_\mu D_\nu W)^2 - 3|W|^2$$

$$V = \int \int \int \sqrt{g} \frac{e^{(2011) - 120(11)}}{24^2 I} |G_{13} - \sqrt{463}|^2$$

Can be expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - \frac{3 \ln(T+\bar{T})}{\int \int \Sigma \wedge \bar{\Sigma}}$$

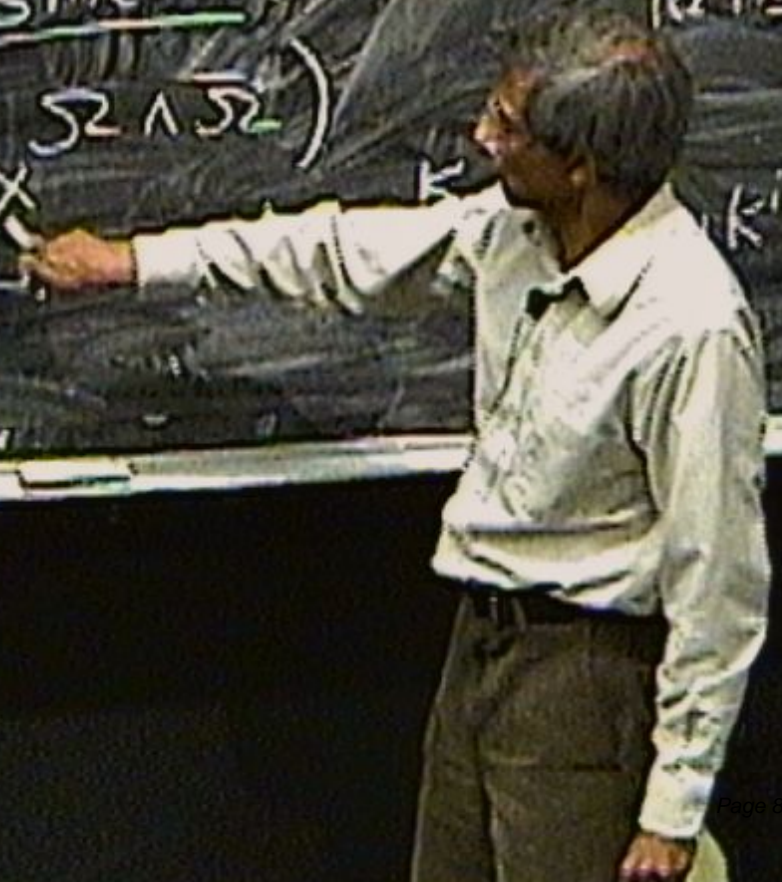
$$s = i\tau$$

$$R_{11} T_{11} = e^{4\tau}$$

$$W = \frac{1}{4} \int \int \Sigma \wedge \bar{\Sigma}$$

↑
independent of T

$$K = -3 \ln(T)$$



$$N = \int \int \sqrt{g} \sqrt{\det g} \frac{e^{\frac{1}{2}(s+\bar{s}) - 12u(v)}}{24\tau_H} |iG_3 - \sqrt{4G_3}|^2$$

Can be expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - 3\ln(T+\bar{T}) - \ln(-i \int_X \Omega \wedge \bar{\Omega})$$

$$S = i\tau \\ R_{1,1} T = e^{4u}$$

$$W = \frac{1}{4} \int_X G_3 \wedge \Omega$$

$$V = e^K (i \int_X \Omega \wedge \bar{\Omega})^{-3/4}$$

independent of T , $D_T W =$



$$N = \int \int \sqrt{g} \sqrt{f} \frac{e^{2\psi} - 12\psi}{24\pi} \left(G_{13} - \dots \right)^2$$

Can be expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - 3\ln(T+\bar{T}) - \ln(-i \int_X \Omega \wedge \bar{\Omega})$$

$$S = i\tau \\ R, T = e^{2\psi}$$

$$W = \frac{1}{4} \int_X G_{13} \wedge \Omega \quad V = e^K (D\mu D\nu K^{\mu\nu} - 3\mu^2)$$

independent of T , $D_T V = \frac{3}{2} W$

$$N = \int \int \sqrt{g} \sqrt{g^{(4)}} \frac{e^{4\phi(x) - 12\psi(x)}}{24\pi^2} |iG_{ij} - \tilde{g}_{ij}|^2$$

Can be expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - 3\ln(T+\bar{T}) - \ln(-i \int_X \Omega \wedge \bar{\Omega})$$

$$S = i\tau \\ R_{ij} T^i T^j = e^{4\psi}$$

$$W = \frac{1}{4} \int_X G_3 \wedge \Omega$$

$$V = e^K (D_\mu D_\nu W K^{\mu\nu} - 3W^2)$$

independent of T , $D_T W = \frac{3}{(T+\bar{T})} W = e^K [p_\mu W^\mu + p_\nu W^\nu]$




\vec{x}
independent of T , $D_T W = \frac{3}{(1-\gamma)} W = e^{-\gamma} \left[\frac{1}{2} W + \frac{1}{2} W \right]$

$S =$

$$C_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2$$

$$F_5 = -F_3 - \frac{1}{2}C_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 \quad F_5 = dC_4$$

D_3 brane



$$S_{loc} = \int_C (-1/3) dx \sqrt{g} \dots$$

$$R_{MN} = \frac{1}{2} g_{MN} R = \frac{1}{2} T_{MN}$$

$$T_{MN} = H_3 \wedge F_3 = \sum \mu_3^i \delta_i$$

$$dG_3 = -dC_4 \wedge H_3$$

x
independent of T , $D_T W = -\frac{\partial}{\partial T} W = e^{-\beta} \left[\frac{\partial W}{\partial T} + \beta W \right]$

$$S = -\alpha = e^{-\alpha} - i \alpha$$

$$T =$$



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independent of T , $D_T W = \frac{3}{(1-T)} W = e^{-\int \frac{3}{1-T} dt} = e^{-3 \ln(1-T)} = (1-T)^{-3}$

$$S = -\pi = e^{-4 - i t \omega}$$

$$T = (-3) = e^{4 \ln(1-T) - i \frac{b(t)}{\sqrt{2}}}$$

$$C_4 =$$

independent of T , $D_T W = \frac{3}{(1-T)} W = e^{-\int \frac{3}{1-T} dt} = e^{-3 \ln(1-T)} = (1-T)^{-3}$

$$S = -rc = e^{-4-ic_0}$$

$$T = (-s) = e^{4(1+i) \frac{b(s)}{r_0}}$$

$$C_4 = da_2 \wedge \int_{t_1}^{t_2} \dots$$



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independent of T , $D_T W = -\frac{3}{(1-T)} W = e^{-\int \frac{3}{1-T} dt} [P_2 W + P_3 W]$

$$S = -\pi = e^{-4 - i t_0}$$

$$T = (-3) - e^{\frac{4 \ln(1-T)}{1-T} - i \frac{b \ln(1-T)}{1-T}}$$

$$C_4 = \text{Vol} \wedge \sum_2 (a_i)$$

↑
Kähler 2-form in CY



independent of T , $D_T W = \frac{3}{(1-T)} W = e^{-\int \frac{3}{1-T} dt} = e^{-3 \ln|1-T|} = (1-T)^{-3}$

$$S = -\pi = e^{-4 - i c_0}$$

$$T = (-1) = e^{-4u - i \frac{b(x)}{4}}$$

$$C_4 = da_2 \wedge \sum_2^4 (x)$$

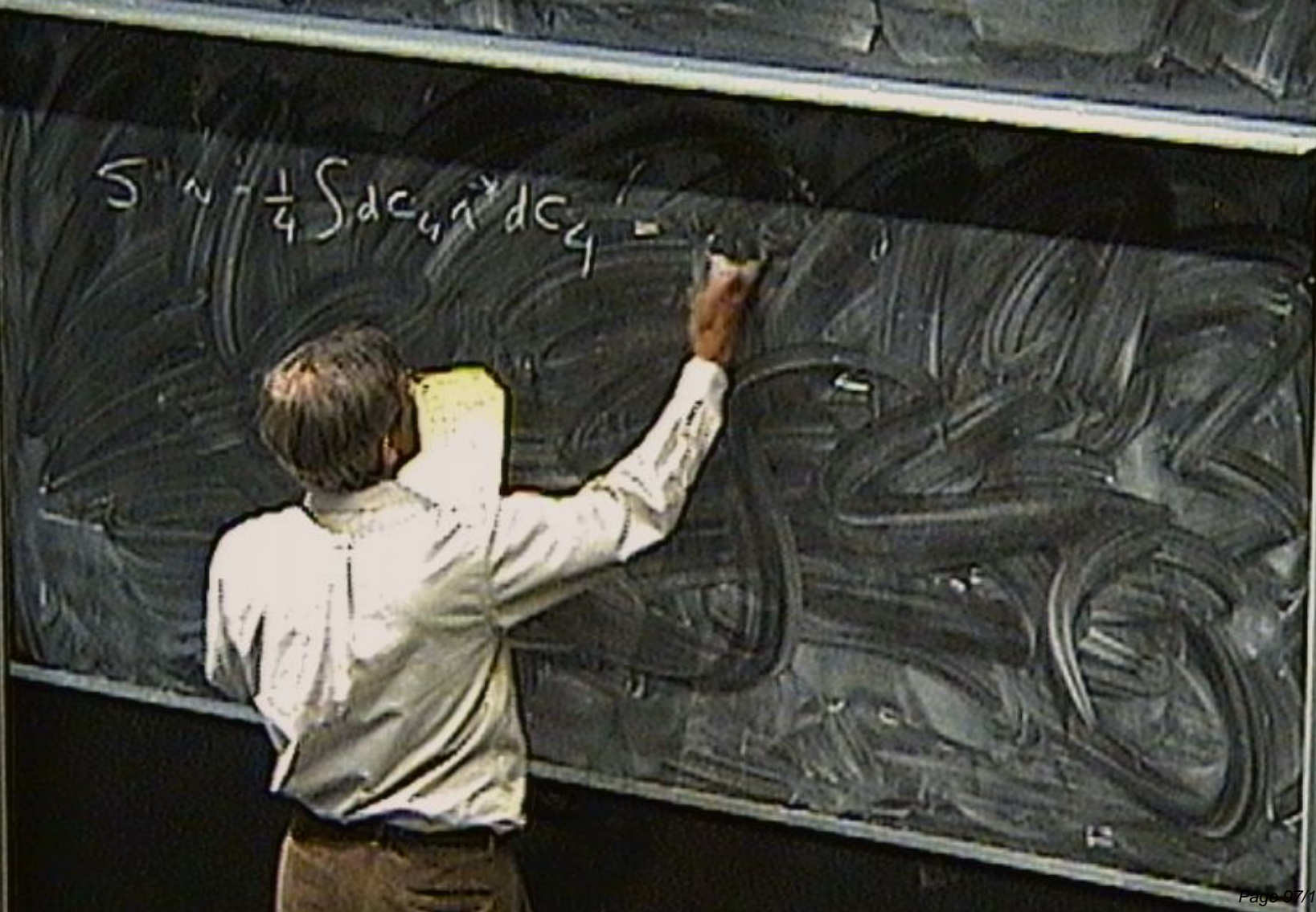
↑
Kähler 2-form in CY

$$db = e^{2u} * 4 da_2$$

$$\begin{aligned}
 & C_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = F_3 - \frac{1}{2}C_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$S \cdot \omega = \frac{1}{4} \int dC_4 \wedge dC_4$$

$$\begin{aligned}
 c_3 - F_3 - 2H_3 &= F_3 = dC_2, \quad H_3 = dB_2 \\
 F_5 = -F_5 - \frac{1}{2}c_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 &= F_5 = dC_4
 \end{aligned}$$



$$S \sim -\frac{1}{4} \int dC_4 \wedge dC_4 =$$

$$\begin{aligned}
 & \vec{G}_3 = \vec{F}_3 - \nabla H_3 & \vec{F}_3 = dC_2, & H_3 = dB_2 \\
 \Rightarrow \vec{F}_5 = & -\vec{F}_3 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 & \vec{F}_5 = dC_4
 \end{aligned}$$

$$S \sim -\frac{1}{4} \int dC_4 \wedge dC_4 = -\frac{1}{4} \int da_2 \wedge da_2 \int S_2 \wedge C_2$$



(can be expressed)

$$K = -\ln(S+\bar{S}) - \frac{3}{2} \ln(T+\bar{T}) - \ln(-i \int_X \Omega \wedge \bar{\Omega})$$

$$S = i\tau \\ R_4 T = e^{4\sigma}$$

$$W = \frac{1}{4} \int_X G_{1,3} \wedge \Omega$$

$$V = e^K (D_1 W D_2 W K^{1,2} + 3W^2)$$

independent of T, $D_T W = \frac{3}{2} W = e^K \left[\frac{3}{2} W \right]$

$$S = -\tau = e^{4\sigma - i\theta}$$

$$T = (S) = e^{4\sigma - i\theta} \frac{1}{\tau}$$

$$C_4 = da_0 \wedge \sum_{\mu} \gamma_{\mu}$$

Kähler 2-form in CY

$$db = e^{2\sigma} \tau da_2$$

ignore warp factor

$$\begin{aligned}
 & \mathcal{L}_3 = F_3 - \mathcal{L} H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 S \sim -\frac{1}{4} \int dC_4 \wedge * dC_4 &= -\frac{1}{4} \int da_2 \wedge * da_2 \int \tilde{F}_2 \wedge * \tilde{F}_2 \\
 &= -\frac{3}{4} \int \tilde{F}_2 \wedge * \tilde{F}_2
 \end{aligned}$$

$$R^{(4)} \leq 0 \quad + \rho \sum \mu_i \delta_i$$

Solution $G_3 = G_3$ ISD. $e^{4\omega} = a + \dots$

$\partial_{\mu} \partial^{\mu} \hat{g} = 0$

$$ds^2 = e^{-6u} dx^{\mu} dx^{\nu} + e^{2u(x)} \hat{g}_{mn}(y) dy^m dy^n$$

$$\partial_{\mu} \partial^{\mu} \hat{g} = 0$$

$$\hat{g}_{mn}(x, y) = \hat{g}_{mn}(y) + z(x) \hat{g}_{mn}(y) + \dots$$

$$R_{xy} = \langle e^u \rangle$$

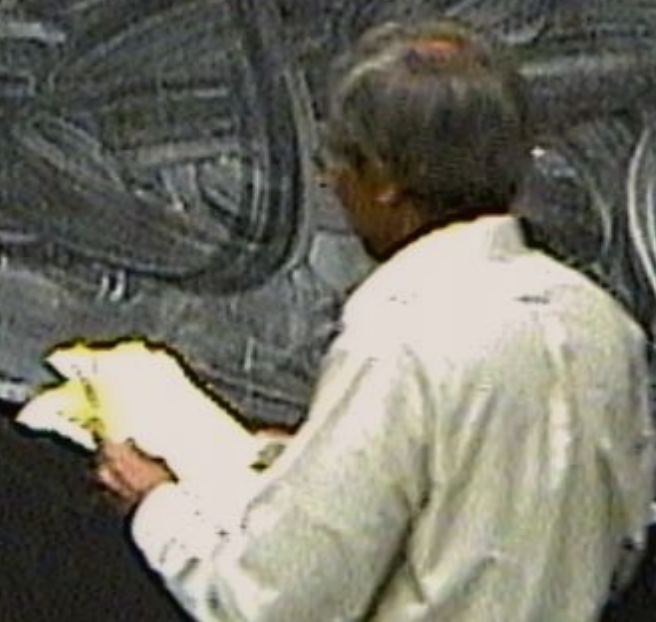
If KK modes ignored

$$\partial_{\mu} \omega \neq 0 \Rightarrow \partial_{\mu} u = \partial_{\mu} z = 0$$

III KK modes

$$\begin{aligned}
 & \omega_3 = F_3 - 2H_3 & F_3 = dC_2, & H_3 = dB_2 \\
 & F_5 = -F_5 - \frac{1}{2}C_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 & F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 S & \sim -\frac{1}{4} \int dC_4 \wedge *dC_4 = -\frac{1}{4} \int da_2 \wedge *da_2 \int \tilde{S}_2 \wedge *C_2 \\
 & \sim -\frac{3}{4} \frac{2\pi}{V_6} e^{2u} \int_{M_4} da_2 \wedge *da_2 \\
 da_2 & = e^{-2u} *db
 \end{aligned}$$



$$\begin{aligned}
 & \mathcal{L}_3 = F_3 - \mathcal{L} H_3 & F_3 = dC_2, & H_3 = dB_2 \\
 & F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 & F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 S & \sim -\frac{1}{4} \int dC_4 \wedge * dC_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int S_2 \wedge * J_2 \\
 & \sim -\frac{3}{4} V_6 e^{2\alpha\phi} \\
 da_2 & = e^{-\alpha\phi} \wedge * da_2 = \frac{3}{4} V_6 \int_M e^{-\alpha\phi} dB \wedge * dB
 \end{aligned}$$

$$\begin{aligned}
 & \psi_3 = F_3 - 2H_3 \quad F_3 = dc_2, \quad H_3 = dB_2 \\
 & F_5 = -F_5 - \frac{1}{2}c_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 \quad F_5 = dc_4
 \end{aligned}$$

$$\begin{aligned}
 S & \sim -\frac{1}{4} \int dc_4 \wedge * dc_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int \tilde{S}_2 \wedge * \tilde{J}_2 \\
 & \sim -\frac{3}{4} \frac{\tilde{V}_6}{V_6} e^{2u} \int_{M_4} da_2 \wedge * da_2 = \frac{3}{4} \frac{\tilde{V}_6}{V_6} \int_M e^{-8u} db \wedge * db \\
 & da_2 = e^{-8u} * db
 \end{aligned}$$

$$\begin{aligned}
 & \omega_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = -F_3 - \frac{1}{2}C_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 S & \sim -\frac{1}{4} \int dC_4 \wedge * dC_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int \tilde{F}_2 \wedge * \tilde{F}_2 \\
 & \sim -\frac{3}{4} \int_{M_4} d^4x \sqrt{|g|} e^{2u} \int da_2 \wedge * da_2 = \frac{3}{4} \int_{M_4} d^4x \sqrt{|g|} e^{-8u} db \wedge * db \\
 & \quad da_2 = e^{-8u} * db \\
 & = \frac{3}{4} \int_{M_4} d^4x \sqrt{|g|} e^{-8u} (\partial_{\mu} b)^2
 \end{aligned}$$

$$\vec{R}^{(4)} \leq 0 \quad + \rho \subset \mu_3 \delta_i$$

Solution $G_3 = G_3$ TSD. $e^{4\omega} = d + \text{const}$

$$\partial_{\mu} \partial^{\mu} \omega$$

$$ds^2 = e^{-6u(x)} \hat{g}_{\mu\nu}(x) dx^{\mu} dx^{\nu} + e^{2u(x)} \hat{g}_{mn}(y) dy^m dy^n$$

$$\partial_{\mu} \det \hat{g} = 0$$

$$\hat{g}_{mn}(xy) = \hat{g}_{mn}(y) + 2u(x) \hat{g}_{mn}(y) + \dots$$

$$R_{xy} = \langle e^u \rangle$$

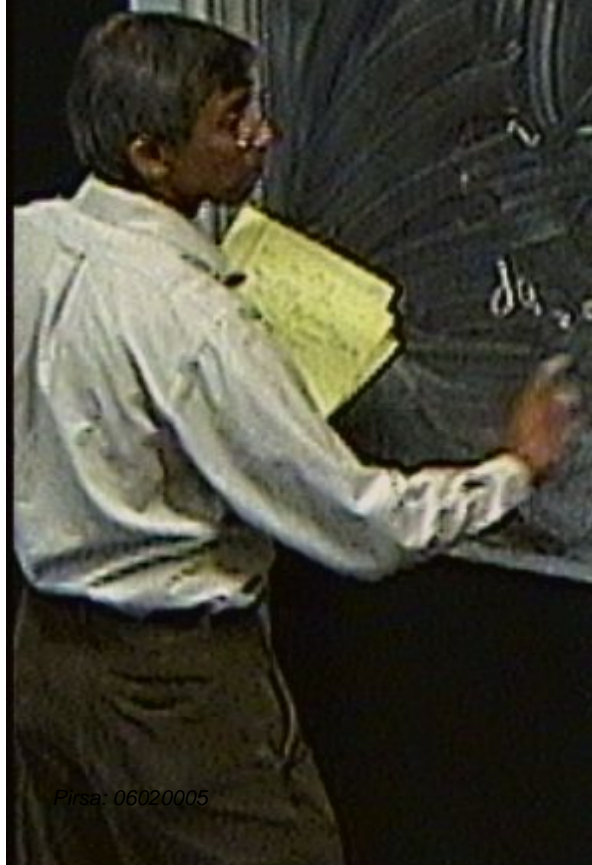
II KK modes
if $\partial_{\mu} \omega \neq 0$

$$\partial_{\mu} \omega \neq 0 \Rightarrow \partial_{\mu} u = 0$$

III KK modes

$$\begin{aligned}
 &U_3 = F_3 - 2H_3 & F_3 = Jc_2, & H_3 = dB_2 \\
 &F_5 = -F_5 - \frac{1}{2}c_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 & F_5 = dc_4
 \end{aligned}$$

$$\begin{aligned}
 S &\sim -\frac{1}{4} \int da_4 \wedge * da_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int \sum_{\pm} \wedge^2 c_2 \\
 &= -\frac{3}{4} \frac{1}{V_6} e^{2u} \int_{M_4} da_2 \wedge * da_2 = \frac{1}{4} \frac{1}{V_6} \int e^{-8u} db \wedge * db \\
 &= \frac{3}{4} \frac{1}{V_6} \int_{M_4} \left(\frac{1}{2} \right)^2 e^{8u} \left(\frac{1}{2} \right)^2
 \end{aligned}$$



$$\begin{aligned}
 & \omega_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 S & \sim -\frac{1}{4} \int dC_4 \wedge * dC_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int S_2 \wedge * J_2 \\
 & \sim -\frac{3}{4} \frac{\hat{V}_6}{V_6} e^{2u} \int_{M_4} da_2 \wedge * da_2 = \frac{3}{4} \frac{\hat{V}_6}{V_6} \int_M e^{-8u} db \wedge * db \\
 & \frac{3}{4} e^{-8u} \int_M (db)^2 + 24 \int_M (du)^2 = \frac{3}{4} \frac{\hat{V}_6}{V_6} \int_M e^{-8u} (db)^2 \\
 & \frac{3}{4} \frac{\hat{V}_6}{V_6} \int_M e^{-8u} (db)^2
 \end{aligned}$$



$$\begin{aligned}
 & \psi_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 S & \sim -\frac{1}{4} \int dC_4 \wedge * dC_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int S_2 \wedge * C_2 \\
 & - \frac{3}{4} \int V_6 e^{2u} \int_{M_4} da_2 \wedge * da_2 = \frac{3}{4} \int V_6 \int e^{-8u} db \wedge * db \\
 & \int_{M_4} e^{-8u} (da_2)^2 + 24 \int_{M_4} (du)^2 = 6 \int_{M_4} \frac{3}{4} V_6 \int e^{-8u} (db)^2 \\
 & \frac{1}{16} \int_{M_4} e^{-8u} (db)^2
 \end{aligned}$$

independent of T , $D_T W = \frac{3}{(1-T)} W = e^{-\int \frac{3}{1-T} dt} = e^{-3 \ln(1-T)} = (1-T)^{-3}$

$$S = -it = e^{-4 - i\omega}$$

$$T = (-b) = \frac{e^{4u - i\frac{b(t)}{f_0}}}{f_0}$$

$$C_4 = da_2 \wedge \int_2^2 (u)$$

2-form in cy

$$db = e^{2u - 4} da_2$$

more warp factor



$$\begin{aligned}
 & c_3 = F_3 - 2H_3 & F_3 = dc_2, & H_3 = dB_2 \\
 & F_5 = -F_5 - \frac{1}{2}c_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 & F_5 = dc_4
 \end{aligned}$$

$$\begin{aligned}
 S &= -\frac{1}{4} \int dc_4 \wedge * dc_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int \tilde{S}_2 \wedge * \tilde{J}_2 \\
 &= -\frac{3}{4} \frac{V_6}{V_6} e^{2u} \int_{M_4} da_2 \wedge * da_2 = \frac{3}{4} \frac{V_6}{V_6} \int e^{-8u} db \wedge * db \\
 &= \frac{3}{4} \frac{V_6}{V_6} \int_{M_4} e^{-8u} (db)^2 + 24 \frac{V_6}{V_6} (du)^2 = 6 \frac{V_6}{V_6} \int_{M_4} e^{-8u} (db)^2 \\
 &= 6 \frac{V_6}{V_6} \int_{M_4} e^{-8u} (db)^2
 \end{aligned}$$

$$\begin{aligned}
 & \psi_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = F_3 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 S &= -\frac{1}{4} \int dC_4 \wedge dC_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int \Sigma_2 \wedge * J_2 \\
 &= -\frac{3}{4} \frac{\hbar}{V_6} e^{2u} \int_{M_4} da_2 \wedge * da_2 = \frac{3}{4} \frac{\hbar}{V_6} \int_M e^{-8u} db \wedge * db \\
 &= \frac{3}{4} \frac{\hbar}{V_6} \int_M e^{-8u} (db)^2 + 24 \frac{\hbar}{V_6} \int_M e^{-8u} (du)^2 \\
 &= \frac{3}{4} \frac{\hbar}{V_6} \int_M e^{-8u} (db)^2 + \frac{24 \hbar}{V_6} \int_M e^{-8u} (du)^2
 \end{aligned}$$

$$S = \int d^4x \left[R - \frac{1}{2\epsilon_I} \partial_\mu \tau \partial^\mu \tau \right. \\
\left. - \frac{1}{2\epsilon_I} \frac{G_{MN} G^{MN}}{\tau_I} - \frac{1}{4\epsilon_I} F_{MNPQ} F^{MNPQ} \right] \\
+ \frac{1}{4\epsilon_I} \int C_4 \wedge G_3 \wedge F_2 \\
\tau = C_0 \tau_0 \tau^\dagger \quad G_3 = F_3 - \tau H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
F_5 = -F_3 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4$$

$$S \sim -\frac{1}{4} \int dC_4 \wedge * dC_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int \tau_2 \wedge * \tau_2 \\
= -\frac{3}{4} \int_V e^{2u} \int_{M_4} da_2 \wedge * da_2 = \frac{3}{4} \int_V e^{-8u} \int_M db \wedge * db$$

$$c_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2$$

$$F_5 = F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4$$

$$S \sim -\frac{1}{4} \int dC_4 \wedge * dC_4 = -\frac{1}{4} \int da_2 \wedge * da_2 \int \Sigma_2 \wedge * \Sigma_2$$

$$= -\frac{3}{4} \frac{\hbar}{V_6} e^{2u} \int_{M_4} da_2 \wedge * da_2 = \frac{\hbar}{4} \frac{V_6}{V_6} \int e^{-8u} db \wedge * db$$

$$= \frac{3}{4} \frac{\hbar}{V_6} \int_{M_4} e^{-8u} (db)^2$$

$$\frac{3}{4} e^{-8u} (db)^2 + 24 (e^{-2u})^2 = 6 \frac{\hbar}{V_6} \frac{1}{(T+T)^2} = \frac{\hbar}{T^2} \frac{1}{(T+T)^2}$$

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$$K_{i\bar{j}} \partial \Phi^i \partial \bar{\Phi}^{\bar{j}} = K_{s\bar{s}} \partial_s s \partial_{\bar{s}} \bar{s}$$

$$K = -\ln(s + \bar{s})$$

$$K_{TS} \frac{\partial \Phi}{\partial S} = K_{SS} \frac{\partial \Phi}{\partial S} + K_{TT} \frac{\partial \Phi}{\partial T}$$

$$K = -\ln(S + \bar{S}) - 3 \ln(T + \bar{T})$$

$$K_{i\bar{j}} \partial \Phi^i \partial \bar{\Phi}^{\bar{j}} = K_{s\bar{s}} \partial_s \partial^{\bar{s}} \bar{s} + K_{T\bar{T}} \partial_T \partial^{\bar{T}} \bar{T}$$

$$K = -\frac{1}{\pi} \ln(s + \bar{s}) - 3 \ln(T + \bar{T})$$

X
 harmonic forms
 one (3,0) Ω

$$K_{i\bar{j}} \partial \Phi^i \partial \bar{\Phi}^{\bar{j}} = K_{S\bar{S}} \partial S \partial \bar{S} + K_{T\bar{T}} \partial T \partial \bar{T}$$

$$K = -\ln(S + \bar{S}) - 3 \ln(T + \bar{T})$$

on X harmonic forms

- 1. $dm(3,0) \quad \Omega$
- 2. $h_{2,1} \quad \text{primitive}(2,1)$

$$k_{ij} \partial \Phi^i \partial \Phi^{\bar{j}} = k_{s\bar{s}} \partial_s \partial^{\bar{s}} \bar{s} + k_{TT} \partial T \partial \bar{T}$$

$$K = -\ln(s + \bar{s}) - 3 \ln(T + i\bar{T})$$

on X ... forms

1. h_{11}
2. h_{21}
3. h_{12}

$$\left(\partial^i \bar{\partial}^{\bar{j}} \chi_{i\bar{j}} = 0 \right)$$

$$K_{i\bar{j}} \partial \Phi^i \partial \bar{\Phi}^{\bar{j}} = K_{s\bar{s}} \partial_s \partial^{\bar{s}} \bar{s} + K_{T\bar{T}} \partial_T \partial^{\bar{T}} \bar{T}$$

$$K = -\frac{1}{T} \ln(s + \bar{s}) - 3 \ln(T + \bar{T})$$

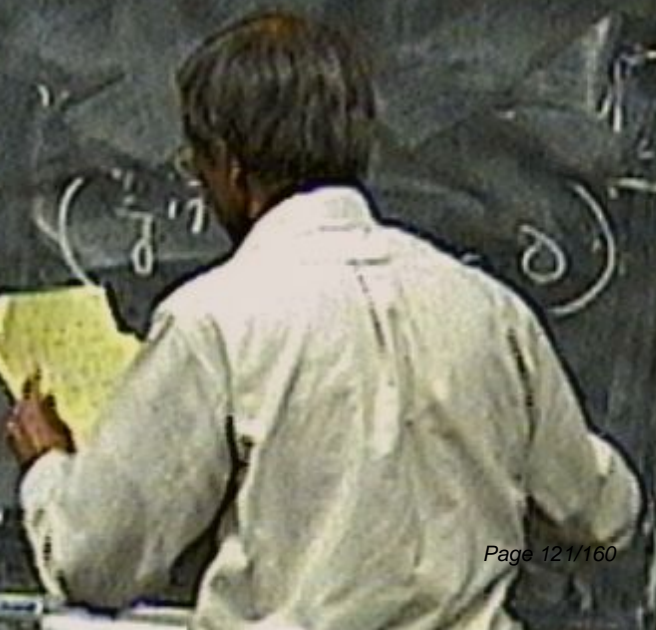
on X harmonic forms

1. $dm(3,0) \quad \Omega$

2. $h_{1,1}$ primitive $(2,1)$

3. $h_{1,2} = h_{2,1} \quad (1,2)$

4. $(0,3) \quad \bar{\Omega}$



$$K_{i\bar{j}} \partial \Phi^i \partial \bar{\Phi}^{\bar{j}} = K_{s\bar{s}} \partial_s \partial^{\bar{s}} \bar{s} + K_{T\bar{T}} \partial_T \partial^{\bar{T}} \bar{T}$$

$$K = -\ln(s + \bar{s}) - 3 \ln(T + i\bar{T})$$

on X harmonic forms

1. $h_{0,0} = (3,0) \quad \Omega$

2. $h_{1,1} = \text{primitive}(2,1) \quad \chi_{2,1}$

3. $h_{1,2} = h_{2,1} \quad (1,2) \quad \bar{\chi}_{1,2}$

4. $(0,3) \quad \bar{\Omega}$

$$\left(\delta^{i\bar{j}} \chi_{i,j} = 0 \right)$$

$$\chi_{0,3} \Omega = -i \Omega$$

$$\chi_{1,2} = \chi_{2,1}$$

$$\begin{aligned}
 &3 \quad h_{12} = h_{21} \quad (1,2) \rightarrow \tau_1 \\
 &4 \quad (0,0) \quad \bar{\Sigma} \quad \psi \Sigma = -i \Sigma \\
 & \quad \quad \quad \quad \quad \quad \quad \quad \psi \Sigma = i \Sigma
 \end{aligned}$$

$$K(\alpha) = -\ln \left[-i \int_X \Sigma \wedge \bar{\Sigma} \right]$$

$$\begin{aligned}
 &3 \quad h_{12} = h_{21} \quad (1,2) \rightarrow \gamma_1 \\
 &4 \quad (0,0) \quad \bar{\Sigma} \quad \psi_0 \Sigma = -i \Sigma \\
 & \quad \quad \quad \quad \quad \quad \quad \quad \psi_1 = i \Sigma
 \end{aligned}$$

$$K(\Sigma) = -\ln \left[-i \int_X \Sigma \wedge \bar{\Sigma} \right]$$

$$\frac{\delta K}{\delta \Sigma} = k_{\alpha}(\Sigma, \bar{\Sigma}) \Sigma + \lambda_{\alpha}$$

All $K \ll$



$3 \quad h_{12} = h_{21}$
 $4 \quad (0, 0)$
 $(1, 2)$
 $\bar{\Sigma}$
 $\Sigma = -1 \Sigma$
 $\lambda_1 = i\lambda_2$

$$K(\alpha) = -\ln \left[\int_{\Sigma} e^{-\alpha \Sigma} \right]$$

$$\frac{\partial K}{\partial \alpha} = \langle \Sigma \rangle + \lambda_{\alpha}$$

$$\frac{\partial K}{\partial \lambda} = -\lambda \frac{\partial K}{\partial \lambda}$$

$$\begin{aligned}
 & \text{3 } h_{12} = h_{21} \quad (1,2) = \bar{z} \\
 & \text{4 } (0,0) \quad \bar{z} \\
 & \text{46 } \int \Sigma = -i \Sigma \\
 & \text{46 } \lambda_1 = i \lambda_2
 \end{aligned}$$

$$K(z) = -\ln \left[-i \int_X \Sigma \wedge \bar{\Sigma} \right]$$

$$\frac{\partial \Sigma}{\partial z^x} = k_x(z, \bar{z}) \Sigma + \lambda_x$$

$$\partial_x k = -k_x \quad \partial_x \partial_{\bar{x}} K(z, \bar{z}) = \lambda_x$$

III K K



$$\begin{aligned}
 & \text{III } h_{12} = h_{21} \quad (1,2) = \bar{1} \bar{2} \\
 & \text{IV } (0,0) = \bar{0} \bar{0} \\
 & \text{V } \int \Sigma = -i \Sigma \\
 & \text{VI } \lambda_1 = i \lambda_2
 \end{aligned}$$

$$K(z) = -\ln \left[-i \int_X \Sigma \wedge \bar{\Sigma} \right]$$

$$\frac{\partial K}{\partial z^i} = k_i(z, \bar{z}) \Sigma + \lambda_i$$

$$\partial_{\alpha} K = -k_{\alpha} \quad \partial_{\alpha} \partial_{\bar{\beta}} K(z, \bar{z}) = G_{\alpha\bar{\beta}} = \frac{\int \lambda_{\alpha} \wedge \lambda_{\bar{\beta}}}{\int \Sigma \wedge \bar{\Sigma}}$$

III K K

$$V = \int \frac{1}{g} \sqrt{\frac{g}{g}} \frac{e^{\frac{1}{2}(s_1) - 12 u(t)}}{24 \tau_I} \left(i G_{13} - \sqrt{G_{13}} \right)^2$$

can be expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - \frac{3}{2} \ln(T+\bar{T}) - \ln(-i \int_X \Omega \wedge \bar{\Omega})$$

$$S = i\tau$$

$$Re T = e^{4u}$$

$$W = \frac{1}{4} \int_X G_{13} \wedge \Omega$$

$$V = e^K (D_\mu W D_\nu \bar{W} K^{\mu\nu} - 3|W|^2)$$

independent of T , $D_T W = \frac{3}{2(T+\bar{T})} W = e^K \left(\frac{3}{2} W \right)$

$W_1 = \frac{4}{3} \times 10^3 \text{ N}$
independent of T , $D_T W = -\frac{3}{(1-T)} W = e^k [p_1 W + p_2 W]$

Expand



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$$W = 4 \int \chi G_3 \wedge \Omega$$

independent of T, $D_T W = \frac{3}{(1-T)} W = e^K \left(\frac{1}{2} W + \frac{1}{2} W \right)$

Expanded

$$d^k G_3 = 0 \quad dG_3 = 0 \quad z = \text{const}$$

$$G_3 = a \Omega + b \chi \wedge \Omega + \tilde{a} \tilde{\Omega} + \tilde{b} \tilde{\chi} \wedge \tilde{\Omega}$$



$$W = 4 \int \chi G_3 \wedge \Omega$$

independent of T

$$D_T W = \frac{1}{(T+\bar{T})} W$$

$$= e^K \left(\frac{1}{2} W + \frac{1}{2} \bar{W} \right)$$

Expand

$$d^4 x G_3 = 0 \quad dG_3 = 0$$

$$G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$$

$W = \dots$
 $\uparrow x$
 independent of T , $D_T W = \dots W = \dots$

$dG_3 = 0$

Expand
 $G_3 = a \Omega + b \chi + \dots$

$a = \frac{\int G_3 \wedge \Omega}{\int \Omega \wedge \Omega}$

$b = \frac{\int G_3 \wedge \chi}{\int \Omega \wedge \chi}$



$$W_i = 4 \int \dots G_3 \dots$$

independent of T, $D_T W = -\frac{3}{(T-1)} W = e^{\int \dots} [p_2 W + p_3 W]$

Expend $d^* G_3 = 0$ $d G_3 = 0$

$$G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$$

$$a = \frac{\int \dots \Omega}{\int \dots \Omega}$$

$$b = \frac{\int \dots \chi}{\int \dots \Omega}$$

*6



$$24T_E$$

is expressed $N=1$ SUGRA form

$$K = -\ln(S+\bar{S}) - 3\ln(T+\bar{T}) - \ln(-i \int \Omega \wedge \bar{\Omega})$$

$$S = \frac{c}{R} \\ R, T = e^{4\phi}$$

$$W = \frac{1}{4} \int \chi G_3 \wedge \Omega$$

$$V = e^K (D_\mu W D_\nu \bar{W} K^{\mu\nu} - 3|W|^2)$$

independent of T , $\frac{D_\mu W}{D_\mu T} = \frac{3}{(T+\bar{T})} W = e^K [D_\mu W] \bar{W}$

Expand

$$G_3 = a \Omega + b \chi + \hat{a} \bar{\Omega} + \hat{b} \bar{\chi}$$

$$a = \frac{\int G_3 \wedge \bar{\Omega}}{\int \bar{\Omega} \wedge \bar{\Omega}}$$

$$\hat{b} = \frac{\int G_3 \wedge \bar{\chi}}{\int \bar{\chi} \wedge \bar{\chi}}$$

$$\chi \wedge G_3 = -ia \bar{\Omega} + ib \chi + i\hat{a} \bar{\Omega} - i\hat{b} \bar{\chi}$$

$$24 \tau_{II}$$

is expressed $N=1$ SUSY form

$$K = -\ln(S+\bar{S}) - 3 \ln(T+\bar{T}) - \ln(-i \int \Omega \wedge \bar{\Omega})$$

$$S = i\tau \\ R_4 T = e^{4\sigma}$$

$$W = \frac{1}{4} \int_X G_3 \wedge \Omega$$

$$V = e^K (D_\mu W)^2$$

independent of T , $D_T W = \frac{\partial W}{\partial T} = e^K [D_\mu W]^2$

Expand

$$G_3 = a \Omega + b \chi + \tilde{a} \bar{\Omega} + \tilde{b} \bar{\chi}$$

$$a = \int G_3 \wedge \bar{\Omega} / \int \bar{\Omega} \wedge \bar{\Omega}$$

$$\tilde{b} = \frac{G_3 \wedge \bar{\chi}}{\int \bar{\chi} \wedge \bar{\chi}}$$

$$*G_3 = -i a \Omega + i b \chi + i \tilde{a} \bar{\Omega} - i \tilde{b} \bar{\chi}$$

$$G_2 = \frac{1}{2} (G_3 + *G_3) = a \Omega + \tilde{b} \bar{\chi}$$

24°C

is expressed $N=1$ SUGRA form

$$K = -\ln(S+\bar{S}) - 3\ln(T+\bar{T}) - \ln(-i \int \Omega \wedge \bar{\Omega})$$

$$S = i\tau \\ R_{1,1} = e^{4\sigma}$$

$$W = \frac{1}{4} \int_X G_3 \wedge \Omega$$

independent of T

$$V = e^K (D_{\mu} W)^2 + \dots$$

$$\frac{D_{\mu} W}{W} = \dots$$

Expand

$$G_3 = a \Omega + b \chi_1 + \tilde{a} \tilde{\Omega} + \tilde{b} \tilde{\chi}_1$$

$$a = \frac{\int G_3 \wedge \bar{\Omega}}{\int \Omega \wedge \bar{\Omega}}$$

$$\tilde{b} = \frac{\int G_3 \wedge \tilde{\Omega}}{\int \tilde{\Omega} \wedge \tilde{\bar{\Omega}}}$$

$$\ast G_3 = -i a \Omega + i b \chi_1 + i \tilde{a} \tilde{\Omega} - i \tilde{b} \tilde{\chi}_1$$

$$\frac{1}{2} (G_2 + \ast G_3) = a \Omega + b \chi_1 + \tilde{a} \tilde{\Omega} + \tilde{b} \tilde{\chi}_1$$

$$F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3$$

$$F_3 = dC_2, H_3 = dB_2$$

$$F_5 = dC_4$$

$$\sum_X G_3^+ \wedge G_3^+ = \text{Sgn} \int \text{Sgn} \int$$

$$F_5 = -F_3 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = d\psi_4$$

$$\sum_X G_3^+ \wedge G_3^+ = \sum_X G_3^+ \wedge G_3^+ + \sum_X G_3^+ \wedge G_3^+ + \dots$$

$$F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4$$

$$\sum_X G_3^+ \wedge G_3^+ = \dots \quad \sum G_3^+ \wedge G_3^+ + \dots = \sum G_3^+ \wedge G_3^+$$



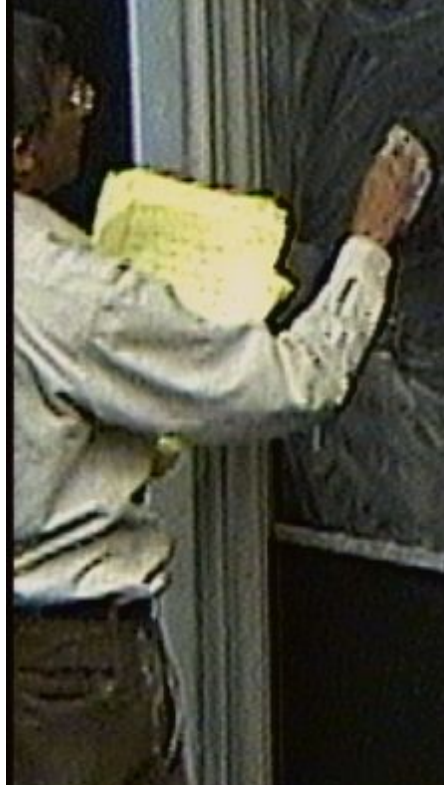
$W = \int \dots$
 independent of T , $D_T W = \frac{3}{(T+1)} W = e^k \left[\frac{1}{T} W + \frac{1}{T^2} W \right]$

$d^k G_3 = 0$ $dG_3 = 0$
 Expand $G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$
 $a = \frac{\int G_3 \Omega}{\int \Omega \Omega}$ $b = \frac{\int G_3 \chi}{\int \chi \chi}$
 $* G_3 = -i a \Omega + i b \chi + i \bar{a} \bar{\Omega} - i \bar{b} \bar{\chi}$
 $G_2 = \frac{1}{2} (G_2 + \chi G_3) = a \Omega + b \chi$
 $G_2 = \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$

CAUTION
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 AREA

$$\begin{aligned}
 & \omega_3 - F_3 - \epsilon H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = -F_3 - \frac{1}{2} \epsilon_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 \int_X G_3^+ \wedge G_3^+ &= \int_{S^4} G_3^+ \wedge G_3^+ + \int_{S^4} G_3^+ \wedge G_3^+ \\
 &= \int_{S^4} G_3^+ \wedge G_3^+
 \end{aligned}$$



$$V = \int \sqrt{g} \sqrt{g^{(0)}} \frac{e^{-\int G_3}}{24^2 \Gamma} |i G_3 - \bar{G}_3|$$

is re expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - \frac{3}{2} \ln(T+\bar{T})$$

$$s = i\tau \\ \text{Re } T = e^{4\sigma}$$

$$W = \frac{1}{4} \int_X G_3 \wedge \Omega$$

$$V = e^K (D_\mu W)^2 (K^{-1})^{\mu\nu} (D_\nu W)^2$$

independent of T , $D_T W = -\frac{3}{2(T+\bar{T})} W = e^K \left[\frac{3}{2(T+\bar{T})} W \right]$

Expand $d^4 x G_3 = 0$

$$G_3 = a \Omega + b^{\mu\nu} \chi_{\mu\nu} + \bar{b}^{\mu\nu} \bar{\chi}_{\mu\nu} + \bar{c}^{\mu\nu} \bar{\chi}_{\mu\nu}$$

$$a = \frac{\int G_3 \wedge \bar{\Omega}}{\int \Omega \wedge \bar{\Omega}}$$

$$b^{\mu\nu} = \frac{\int G_3 \wedge \chi_{\mu\nu}}{\int \Omega \wedge \bar{\Omega}}$$

$$\bar{b}^{\mu\nu} = \frac{\int G_3 \wedge \bar{\chi}_{\mu\nu}}{\int \Omega \wedge \bar{\Omega}}$$

$$\bar{c}^{\mu\nu} = \frac{\int G_3 \wedge \bar{\chi}_{\mu\nu}}{\int \Omega \wedge \bar{\Omega}}$$

$$F_5 = -F_5 - \frac{1}{2} C_2 \Lambda H_3 + \frac{1}{2} B_2 \Lambda F_3 \quad F_5 = d\phi_4$$

$$\sum_X G_3^+ \Lambda G_3^+ = \dots \quad \sum G_3^+ \Lambda G_3^+ + \dots = \sum G_3^+ \Lambda G_3^+$$

$$D_\alpha W = \partial_\alpha W + \partial_\alpha K W = \dots$$

$$\begin{aligned}
 & \text{3 } h_{12} = h_{21} \quad (1,2) \rightarrow \chi \\
 & \text{4 } (0,0) \quad \bar{\Sigma} \quad \chi_{11} = -i \Sigma \\
 & \quad \quad \quad \quad \quad \quad \quad \quad \chi_{12} = i \chi_{21}
 \end{aligned}$$

$$K(\alpha) = -\ln \left[-i \int_X \Sigma \wedge \bar{\Sigma} \right]$$

$$\frac{\partial \Sigma}{\partial x^{\mu}} = k_{\mu}(\alpha, \bar{\alpha}) \Sigma + \chi_{\mu}$$

$$\frac{\partial^2 K}{\partial \alpha^{\mu} \partial \bar{\alpha}^{\nu}} = G_{\mu\nu} = \frac{\int \chi_{\mu} \wedge \chi_{\nu}}{\int \Sigma \wedge \bar{\Sigma}}$$

III K K

$$C_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2$$

$$F_5 = -F_3 - \frac{1}{2}C_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 \quad F_5 = dC_4$$

$$\sum_X G_3^+ \wedge \chi_6 G_3^+ = -i \sum G_3 \wedge G_3 + \dots$$

$$D_\alpha W = \dots \quad \partial_\alpha KW = \frac{1}{4} \sum_X G_3^+ \wedge \chi_\alpha$$



$$\begin{aligned}
 & C_3 - F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = -F_3 - \frac{1}{2}C_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 & \sum_X G_3^+ \wedge \chi_6 G_3^+ = \dots \int \text{tr} G_3^+ \wedge G_3^+ + \dots \\
 & D_4 W = \partial_4 W + \partial_4 K W = \frac{1}{4} \int_X G_3^+ \wedge \chi_4
 \end{aligned}$$



$$\begin{aligned}
 & \alpha_3 - F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = -F_3 - \frac{1}{2}C_2 \wedge H_3 + \frac{1}{2}B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 & \int_X G_3 \wedge \chi_6 G_3 = \dots \int G_3 \wedge \chi_6 + \dots \\
 & D_\alpha W = \partial_\alpha W + \partial_\alpha KW = \frac{1}{4} \int_X G_3 \wedge \chi_\alpha \\
 & D_S W = \partial_S W + \partial_S KW = \frac{1}{4} \frac{1}{ST^3} \int G_3 \wedge \chi_S
 \end{aligned}$$

$$V = \int \sqrt{g} \sqrt{\bar{g}} \frac{e^{4\phi - 12\psi}}{24\tau_I} |iG_3 - \sqrt{2}G_3|^2$$

is expressed in $N=1$ SUGRA form

$$K = -\ln(S+\bar{S}) - 3\ln(T+\bar{T}) - \ln(-i \int_X \Omega \wedge \bar{\Omega})$$

$$S = i\tau \\ \text{Re } T = e^{4\phi}$$

$$W = \frac{1}{4} \int_X G_3 \wedge \Omega$$

$$V = e^K (D_\mu D_\nu W)^2 - 3|W|^2$$

independent of T , $D_T W = -\frac{3}{(T+\bar{T})} W = e^K [p_1 W + p_2 \bar{W}]$

Expand $d^6 G_3 = 0$, $dG_3 = 0$

$$G_3 = a\Omega + b^i \chi_i + \hat{a} \bar{\Omega} + \hat{b}^i \bar{\chi}_i$$

$$a = \frac{\int G_3 \wedge \bar{\Omega}}{\int \bar{\Omega} \wedge \bar{\Omega}} \quad \hat{b}^i = \frac{\int G_3 \wedge \bar{\chi}_i}{\int \bar{\Omega} \wedge \bar{\chi}_i}$$

$$F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = d\alpha_4$$

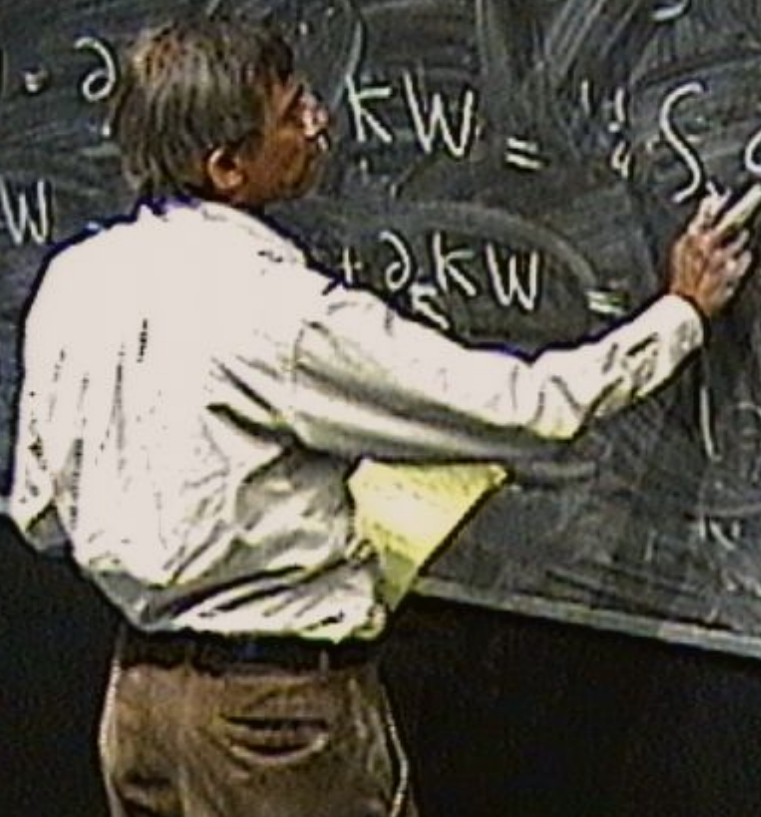
$$\sum_X G_3^+ \wedge G_3^+ = \dots \int G_3 \wedge \alpha$$

$$D_\alpha W = \partial \dots$$

$$D_\beta W = \partial \dots$$

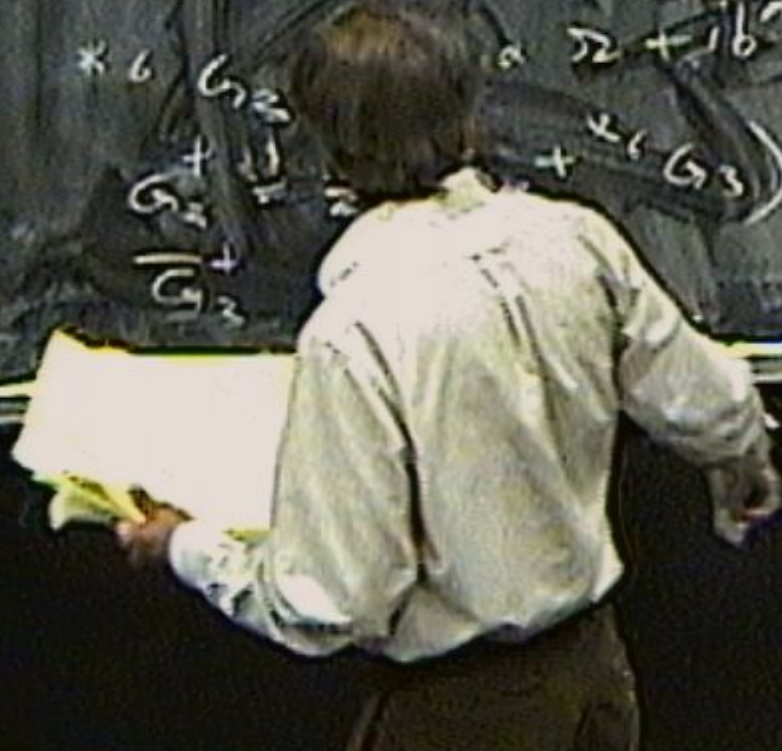
$$KW = \frac{1}{4} \int G_3 \wedge \alpha$$

$$\partial KW = \frac{1}{8\pi^2} \int G_3 \wedge \alpha$$



$W = \dots$
 independent of T , $D_T W = \frac{\sum W}{(T+1)} = e^k \left(\frac{1}{2} W + \frac{1}{2} W \right)$

$d^k G_3 = 0$ $d G_3 = 0$
 Expand
 $G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$
 $a = \frac{\int G_3 \Omega}{\int \Omega \bar{\Omega}}$ $b = \frac{\int G_3 \chi}{\int \chi \bar{\chi}}$
 $* G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$
 $(G_3 + \bar{G}_3) = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$

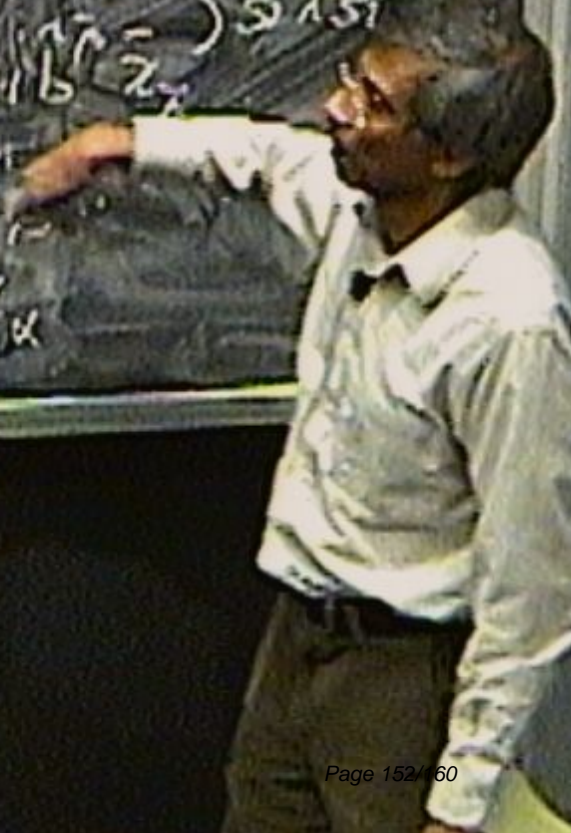


$$\begin{aligned}
 & C_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 & \int_X G_3^+ \wedge \chi_6 G_3^+ = \int G_3 \wedge \chi_6 + \int G_3 \wedge \chi_6 + \int G_3 \wedge \chi_6 \\
 & D_\alpha W = \partial_\alpha W + \partial_\alpha KW = \frac{1}{4} \int_X G_3 \wedge \chi_\alpha \\
 & D_S W = \partial_S W + \partial_S KW = \frac{1}{4} \frac{1}{\text{Vol}(S)} \int G_3 \wedge \chi_S
 \end{aligned}$$

$W = \int \dots$
 independent of T , $D_T W = \frac{3}{(1-T)} W = e^k \left(\frac{1}{2} W + \dots \right)$

$d^k G_3 = 0$ $dG_3 = 0$
 $G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$
 $a = \frac{\int G_3 \wedge \bar{\Omega}}{\int \Omega \wedge \bar{\Omega}}$ $b = \frac{\int G_3 \wedge \bar{\chi}}{\int \Omega \wedge \bar{\chi}}$
 $* dG_3 = -i a \Omega + i b \chi + i \bar{a} \bar{\Omega} - i \bar{b} \bar{\chi}$
 $\frac{1}{2} (G_3 + \chi \wedge G_3) = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$



$$C_3 - F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2$$

$$F_5 = -F_5 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4$$

$$\sum_X G_3^+ \wedge \chi_6 G_3^+ = \dots \quad \sum G_3 \wedge \chi_4 + \dots$$

$$D_W = \partial_\mu W + \partial_\nu KW = \frac{1}{4} \sum_X G_3^+ \wedge \chi_4$$

$$D_W = \partial_\mu W + \partial_\nu KW = \frac{1}{4} \frac{1}{ST^3} \int G_3^+ \wedge \chi_4$$

$$\begin{aligned}
 & \hat{F}_3 = -F_3 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \\
 & F_3 = dC_2, \quad H_3 = dB_2 \\
 & F_5 = dC_4
 \end{aligned}$$

$$\begin{aligned}
 & \sum_X G_3^+ \wedge \alpha G_3^+ = \dots \\
 & D_\alpha W = \partial_\alpha W + \partial_\alpha KW = \dots \\
 & D_S W = \partial_S W + \partial_S KW = \dots \\
 & D_T W = \partial_T W + \partial_T KW = \dots
 \end{aligned}$$

$W = \dots$
 \uparrow
 x
 \uparrow
 $\text{independent of } T$, $D_T W = \frac{3}{(1-T)} W = e^k \left[\frac{p}{1-p} W + \dots \right]$

$d^* G_3 = 0$ $d G_3 = 0$
 $G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$
 $a = \frac{\int G_3 \Omega}{\int \Omega \Omega}$ $\bar{b} = \frac{\int G_3 \bar{\chi}}{\int \bar{\chi} \bar{\chi}}$
 $* G_3 = -i a \Omega + i b \chi + \bar{a} \bar{\Omega} - i \bar{b} \bar{\chi}$
 $G_2 + \frac{1}{2} (G_2 + 2 G_3)$ $+ \bar{b} \chi + \bar{b} \chi$
 $G_2 + \frac{1}{2} (G_2 + 2 G_3)$



$$V = \int \int \int \sqrt{g} \frac{e^{4\sigma - 12u}}{24\tau_H} |iG_{ij} - \gamma_{ij}|^2$$

is expressed $N=1$ SUGRA form

$$K = -\ln(s+\bar{s}) - 3 \ln(T+\bar{T}) - \ln(-i \int_X \Omega \wedge \bar{\Omega})$$

$$S = i\tau$$

$$Re T = \frac{e^{\sigma}}{4}$$

$$W = \frac{1}{4} \int_X G_3 \wedge \Omega$$

$$V = e^K (D_\mu W)^2 + \dots$$

independent of T , $D_T W = \frac{3}{(T+\bar{T})} W = e^K (p_1 W + p_2 \bar{W})$

Expand

$$d^k G_{ij} = 0$$

$$dG_3 = 0$$

$$G_3 = a\Omega + b\bar{\chi}_2 + \bar{a}\bar{\Omega} + b\bar{\chi}_2$$

$$F_3 = -F_3 - \frac{1}{2} C_2 \Lambda H_3 + \frac{1}{2} B_2 \Lambda F_3$$

$$F_3 = d\alpha_2, H_3 = d\alpha_2$$

$$F_3 = d\alpha_4$$

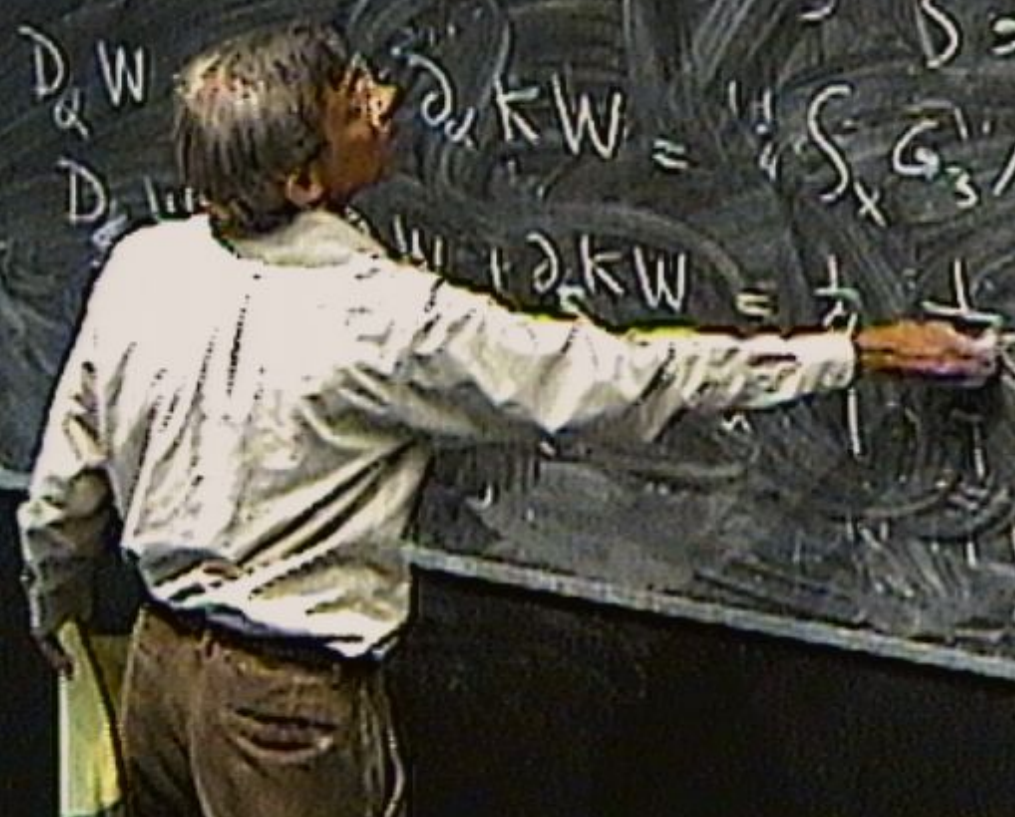
$$\sum_X G_3^+ \Lambda G_3^+ = \dots$$

$$\frac{\partial KW}{\partial \alpha} = \dots$$

$$\frac{\partial KW}{\partial \beta} = \dots$$

$$\int G_3 \Lambda \alpha$$

$$\int G_3 \Lambda \alpha$$



$$K = -\ln(-i \int \Omega \wedge \bar{\Omega})$$

$$W = \frac{1}{4} \int_X G_3 \wedge \Omega$$

↑
independent of T

$$V = e^K (D_i W D_{\bar{j}} W K^{i\bar{j}})$$

$$D_T W = \frac{3}{(T-iT)} W = e^K \left[\frac{3}{2} W \right]$$

Expand $d^k G_3 = 0$ $dG_3 = 0$

$$G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$$

$$a = \frac{\int G_3 \wedge \bar{\Omega}}{\int \Omega \wedge \bar{\Omega}}$$

$$b = \frac{\int G_3 \wedge \bar{\chi}}{\int \Omega \wedge \bar{\Omega}}$$

*6 $G_3 = a \Omega + b \chi + \bar{a} \bar{\Omega} + \bar{b} \bar{\chi}$

$$C_3 = F_3 - 2H_3 \quad F_3 = dC_2, \quad H_3 = dB_2$$

$$F_3 = -F_3 - \frac{1}{2} C_2 \wedge H_3 + \frac{1}{2} B_2 \wedge F_3 \quad F_5 = dC_4$$

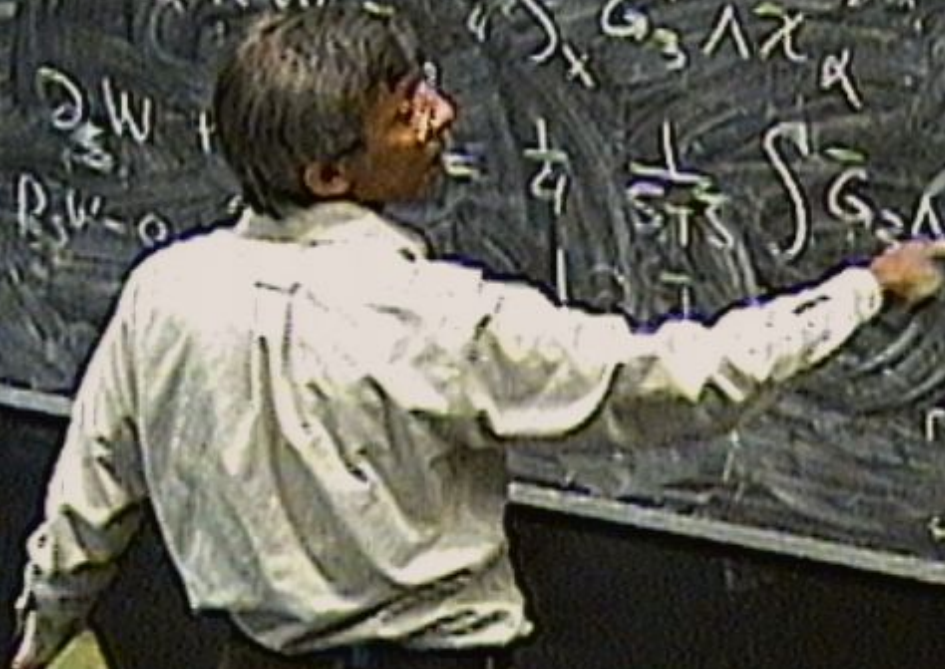
$$\int_X G_3 \wedge \chi_6 G_3 + \dots = \int_{S^2} G_3 \wedge \chi_6 + \int_{S^2} G_3 \wedge \chi_6 + \dots$$

$$D_\alpha W = \partial_\alpha W + \partial_\alpha K W$$

$$D_\beta W = \partial_\beta W + \dots$$

$$D_\gamma W = \partial_\gamma W - \dots$$

$$\int_X G_3 \wedge \chi_6 + \dots = \frac{1}{4} \int_{S^2} G_3 \wedge \chi_6$$



$$\begin{aligned}
 & \text{3 } |h_{12} - h_{21}| \quad (1,2) = \chi_A \\
 & \text{4 } (0,0) = \bar{\Sigma} \quad \chi_A \Sigma = -i \Sigma \\
 & \quad \quad \quad \quad \quad \quad \quad \quad \chi_A = i \chi_A
 \end{aligned}$$

$$K(\alpha) = -\ln \left[-i \int_X \Sigma \wedge \bar{\Sigma} \right]$$

$$\frac{\partial \Sigma}{\partial \alpha^k} = k_k(\alpha_0, \bar{\alpha}) \Sigma + \chi_k$$

$$\frac{\partial K}{\partial \alpha^k} = -k_k \quad \frac{\partial^2 K}{\partial \alpha^k \partial \alpha^l} = G_{kl} = \frac{\int \chi_k \wedge \chi_l}{\int \Sigma \wedge \bar{\Sigma}}$$

III K k