

Title: Ekpyrotic/Cyclic Cosmology - Lecture 4

Date: Jun 29, 2009 11:30 AM

URL: <http://pirsa.org/09060081>

Abstract: TBA

IV Higher-Dimensional Point of View

IV Higher-Dimensional Point of View

Approach to by much / 5th Milne

after ek phase V turns off
kinetic phase $a = a_0(-t)^{1/3}$

Approach to by much / 5th Milne

after ek phase V turn off

linear phase $a = a_0 (-t)^{1/3}$

gravity is 5d

$$S_5 = \frac{1}{2} \int \sqrt{g} R_5$$

Approach to by much / 5th Milne

after ek phase V turn off

linear phase $a = a_0(-t)^{1/3}$

scaly in 5d

$$S_5 = \frac{1}{2} \int \sqrt{g} R_5$$

scaly on

S'

orbifold fixed
pts



compactify on $S^1/\mathbb{Z}_2$ orbifold fixed pts



$$ds_5^2 = e^{-\sqrt{5}\phi} ds_4^2 + e^{2\sqrt{5}\phi} dy^2$$

compatibility on $S'/\mathbb{Z}_2$... orbifold fixed pts



$$ds_r^2 = e^{-\sqrt{\frac{2}{3}}\phi} ds_3^2 + e^{2\sqrt{\frac{2}{3}}\phi} dy^2$$

$$\rightarrow S_3 = \frac{1}{2} \int \sqrt{-g} [R - (\partial\phi)^2]$$

$$ds_4^2 = -dt^2 + \frac{a^2(t)}{(1-t)^8} ds^2$$

$$ds_r^2 = (1-t)^{-1/4} [-dt^2 + (1-t)^{1/4} ds^2] + (1-t)^{1/4} dy^2$$



$$T' \propto (-\tilde{t})^{2/3}$$

$$dr_s' = -dT' + T'dj^2 + ds^2$$



Melvin

↳ scale factor is finite!

$$T \propto (-\tilde{t})^{2/3}$$

$$ds_5^2 = -dT^2 + T^2 dy^2 + ds^2$$



Melne

↳ scale factor is finite!

$$\begin{cases} u = T \cosh y \\ v = T \sinh y \end{cases}$$

$$\Rightarrow ds_5^2 = -du^2 + dv^2 + ds^2$$

Minkowski

$$T \propto (-\tilde{t})^{2/3}$$

$$ds_5^2 = -dT^2 + T^2 dy^2 + ds^2$$



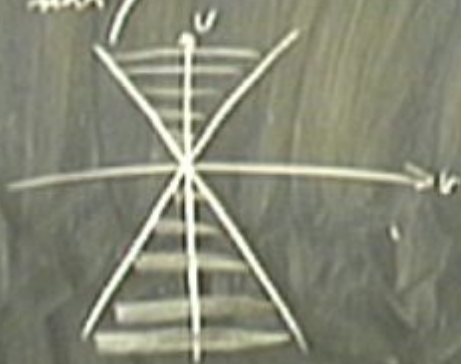
Milne

↳ scale factor is finite!

$$\begin{cases} u = T \cosh y \\ v = T \sinh y \end{cases}$$

$$\Rightarrow ds_5^2 = -du^2 + dv^2 + ds^2$$

Minkowski



Hörner, Witten

IIA SUGRA $\rightarrow E_8 \times E_8$ heterotic string

Horava-Witten

11d SUGRA $\longleftrightarrow$ $E_8 \times E_8$ heterotic string

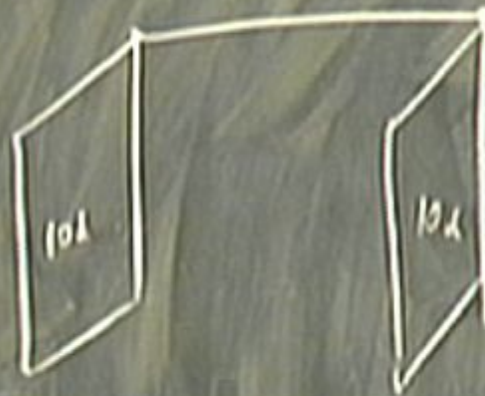
$G_{10} \times S^1/Z_2$



Horava-Witten

11d SUGRA $\longleftrightarrow E_8 \times E_8$ heterotic string

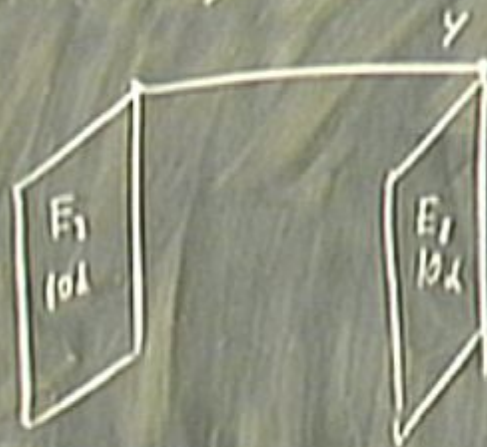
$G_{210} \times S^1/Z_2$



Horava; Witten

IIA SUGRA $\leftrightarrow E_8 \times E_8$ heterotic string

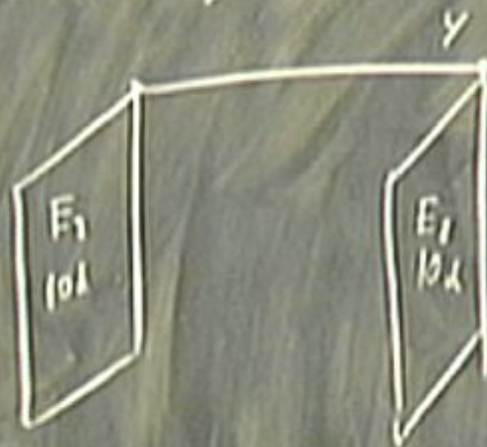
$G_{M_{10}} \sim S^1/\mathbb{Z}_2$



Hörner, Witten

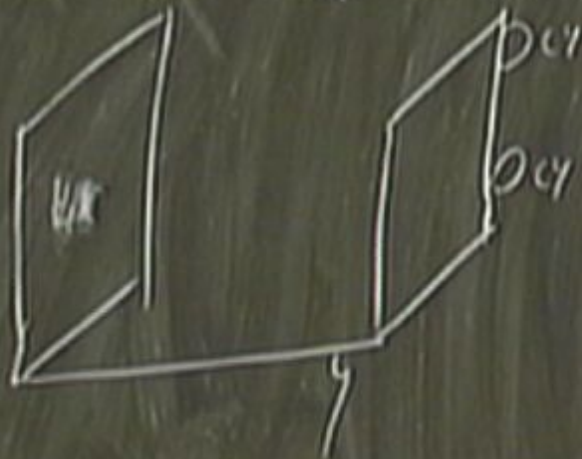
IIA SUGRA $\leftrightarrow E_8 \times E_8$ heterotic string

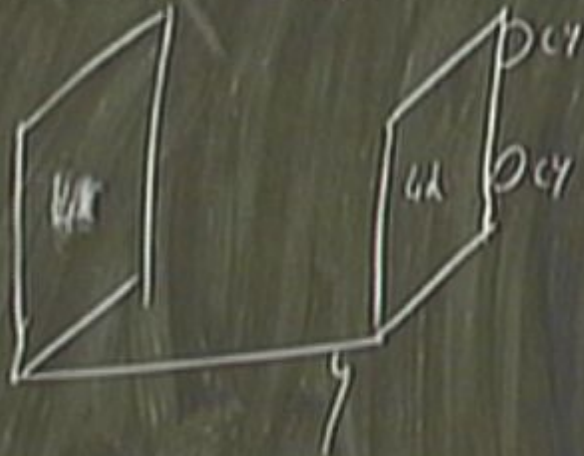
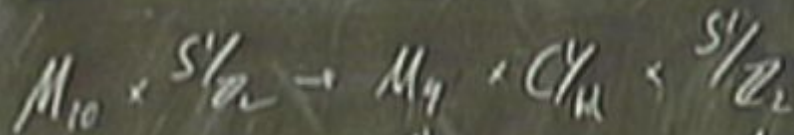
$M_{10} \times S^1/\mathbb{Z}_2$



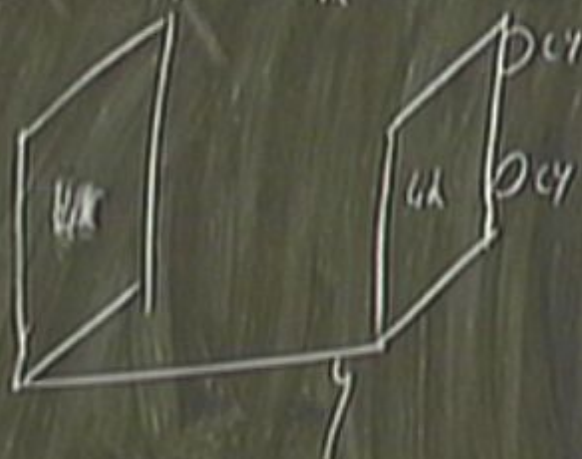
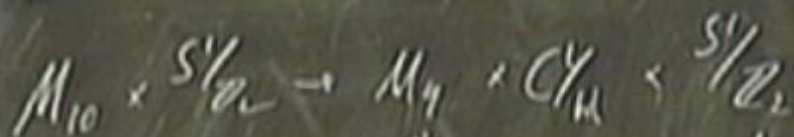
$$A_{11} = g \frac{26}{24}$$

$$M_{10} \times S^1/\mathbb{Z}_2 \rightarrow M_4 \times CY_4 \times S^1/\mathbb{Z}_2$$



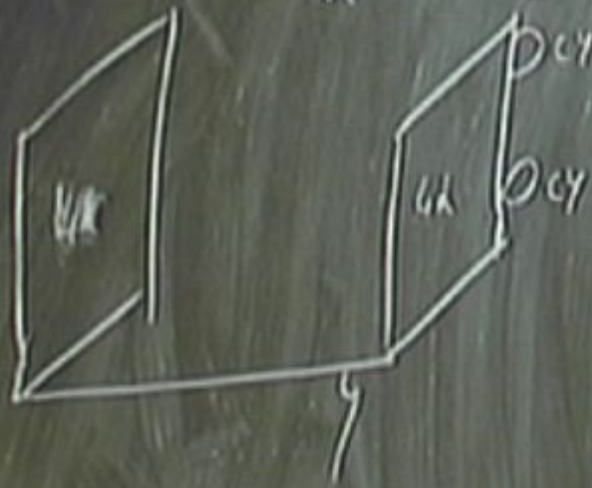


$d_{11} \sim 30$ Plancksc



$d_{11} \sim 30$ multiplicity

$4d \rightarrow 5d \rightarrow 11d$



$d_{||} \sim 30 \text{ fm}$

$$4d \rightarrow (5d) \rightarrow 11d$$

$t \rightarrow 0$ branes collide



$$ds_{11}^2 = V_{CY}^{-2/3} ds_5^2 + V_{CY}^{1/3} ds_{CY}^2$$

in 4d. get 2 scalars: volume of CY
radius (distance between orbifolds)

Interacting M-theory

$$S_5 = \int \left(R - \frac{1}{2} \frac{(\partial V_{\mu\nu})^2}{V_{\mu\nu}^2} - \frac{6\alpha'}{V_{\mu\nu}^2} \right)$$



Intenti M-theory

$$S_r = \int \left(R - \frac{10 V_{cr}^2}{V_{cr}^2} - \frac{6 \alpha'}{V_{cr}^2} \right)$$

↳ potential

$$ds^2 = h^{2/5} (y) [A^2 (dt^2 + ds^2) + B^2 dy^2]$$

$$V_{cr} = B h^{6/5}$$

$$h = 5xy + C$$

Intenti M-theory

$$S_r = \int \left(R - \frac{10 V_{cr}^2}{V_{cr}^2} - \frac{6 \alpha^2}{V_{cr}^2} \right)$$

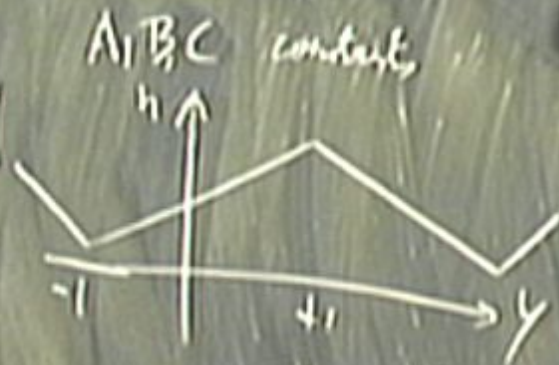
↳ potential

Sol

$$ds^2 = h^{2/5} (y) [A^2 (dz^2 + dy^2) + B^2 dy^2]$$

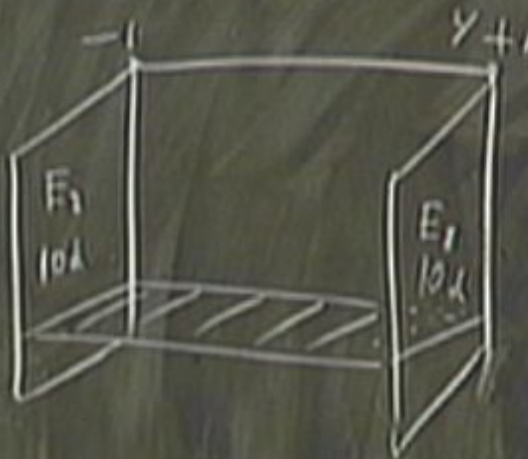
$$V_{cr} = B h^{6/5}$$

$$h = 5xy + C$$



primate A, B, C - lots of T

11d SIGRA $\leftrightarrow E_8 \times E_8$ heterotic string
 $M_{10} \times S^1/Z_2$



$$A_{11} = g_s^{2/3}$$

promote $A, B, C \rightarrow$ sets of T

$$I_n \equiv \int_{-1}^1 h^n dy$$

$$\alpha^2 = A^2 B I_{2/5}$$

$$e^{q/\alpha} = B (I_{2/5})^{3/4}$$

$$\phi_2 = -\frac{q}{2\alpha} \int dC \frac{1}{I_{2/5}} \sqrt{9(I_{2/5})^2 + 16 I_{2/5} I_{4/5}}$$

promote $A, B, C \rightarrow$ fcts of τ

$$I_n \equiv \int_{-1}^1 h^n dy$$

$$\begin{cases} a^2 = A^2 B I_{2/5} \\ e^{\phi/\sqrt{2}} = B (I_{2/5})^{3/4} \end{cases}$$

$$\phi_2 = -\frac{\sqrt{2}}{20} \int d\tau \frac{1}{I_{2/5}} \sqrt{9(I_{2/5})^2 + 16 I_{2/5} I_{4/5}}$$

$$\Rightarrow \boxed{S_n = \int -6a'' + a^2 (\phi_1'^2 + \phi_2'^2)}$$

promote $A, B, C \rightarrow$ fcts of τ

$$I_n \equiv \int_{-1}^{+1} h^n dy$$

$$\begin{cases} \alpha^2 = A^2 B I_{2/5} \\ e^{q/\alpha} = B (I_{2/5})^{3/4} \end{cases}$$

$$\phi_2 = -\frac{\alpha}{20} \int d\tau \frac{1}{I_{2/5}} \sqrt{9(I_{2/5})^2 + 16 I_{2/5} I_{4/5}}$$

$$\Rightarrow \boxed{S_n = \int -6\alpha'' + \alpha^2 (\phi_1'^2 + \phi_2'^2)}$$

Hörner, Witten

at $y = -1$ $V_{\text{eff}} = e^{\frac{\phi_0}{f_1}} (-\sinh \beta \phi_0)^{\frac{3}{2}}$

Horava-Witten

at $y = -1$ $V_{CY} = e^{\frac{\phi_2}{f}} (-\sinh \beta \phi_2)^{\frac{1}{2}}$

$\phi_2 = 0 \Rightarrow V_{CY} = 0$

$\phi_2 > 0$ unphysical



promote $A, B, C \rightarrow$ fcts of T

$$I_n \equiv \int_{-1}^1 h^n dy$$

$$\begin{cases} a^2 = A^2 B I_{2/5} \\ e^{a/2} = B (I_{2/5})^{3/2} \end{cases}$$

$$\phi_2 = -\frac{16}{20} \int dC \frac{1}{I_{2/5}} \sqrt{9(I_{2/5})^2 + 16 I_{2/5} I_{4/5}}$$

$$\Rightarrow \boxed{S_n = \int -6a'^2 + a^2(\phi_1'^2 + \phi_2'^2)}$$

moduli space approximation

at $y=-1$ $V_{eff} = e^{\mu}$ (from $V(\phi_1)$)

$$\phi_1 = 0 \Rightarrow V_{eff} = 0$$

$\phi_1 > 0$ unphysical

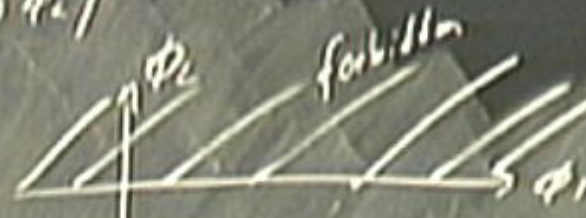


to MSA: $\alpha = |2\epsilon|^{1/2}$ $e^{\phi_1} = |2\epsilon|^{3/2\sqrt{2}}$ $e^{\phi_1} = |4\alpha\epsilon|^{3/\sqrt{2}}$

at $y=-1$ $V_{eff} = e^{\mu}$ (from 0 to ∞)

$$\phi_2 = 0 \Rightarrow V_{eff} = 0$$

$\phi_2 > 0$ unphysical



sol to MSA: $a = |2\epsilon|^{1/2}$ $e^{\phi_1} = |2\epsilon|^{3/2}$ $e^{\phi_2} = |4\epsilon|^{1/2}$

$d \sim 2\epsilon$

write
variety of matter on -ve tension

with
variety of matter on -ve tension

$$\rho_{\text{matter}} \sim T_{\text{matter}}^{1/4}$$

write
velocity of matter on -ve tension

$$\ddot{\phi} \sim T_{\text{matter}}'' +$$



wide
variety of matter on -ve tension

$$\rho_{\text{eff}} \sim T_{\text{matter}}^{\mu\nu} + \text{1-Loop corrections}$$

with
velocity of matter on -ve tension

$$\ddot{\phi} \sim T_{\text{matter}}'' + \text{Vey. dep. corrections}$$

> 0

-ve tension have bounces!

