

Title: Part 2: An introduction to the pure-spinor formalism for the superstring

Date: May 12, 2011 11:00 AM

URL: <http://pirsa.org/11050060>

Abstract: Higher loop amplitudes and non-minimal formalism

$$A_\alpha(x, 0)$$

$$\partial^\alpha A_\alpha = 0$$

BRST

$$Q = \lambda^\alpha D_\alpha$$

$$\gamma_{m_1 \dots m_p} F_{\alpha\beta} = 0$$

$$A_\alpha = (\partial\gamma^\mu)_\alpha A_\mu + (\partial\gamma^\mu\xi)(\partial\gamma_\mu)_\alpha + \dots \partial\lambda, \partial\xi$$

$$\xi = W^\alpha|_{\alpha=0}$$

$$W^\alpha = (\gamma_\mu \gamma^\mu) (\partial_\mu A_\alpha - \partial_\alpha A_\mu)$$

$$Q^2 = \lambda \gamma^\mu \lambda \partial_\mu \Rightarrow \lambda \gamma^\mu \lambda = 0$$

$$\{Q, \lambda^\alpha A_\alpha\} = 0$$

WS fields x, θ, p, λ, w

$S =$

WS fields x, θ, p, λ, w

$$S = \int \theta \dot{x} + p \dot{\theta} + \beta \dot{\bar{\theta}} + w \dot{\lambda} + \bar{w} \dot{\bar{\lambda}}$$

WS fields x, θ, p, λ, w

$$S = \int \theta \dot{x} + p_1 \dot{\theta} + \beta_1 \dot{\bar{\theta}} + \underline{w \dot{\lambda} + \dot{w} \bar{\lambda}}$$

WS fields x, θ, p, λ, w

$$S = \int \theta x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + \underbrace{w \partial \lambda + \bar{w}_\alpha \partial \bar{\lambda}^\alpha}_{b \partial c}$$

$c \rightarrow -2$

WS fields x, θ, p, λ, w

$$S = \int \theta \dot{x} + p_\alpha \dot{\theta}^\alpha + \beta_\alpha \dot{\bar{\theta}}^\alpha + \underline{w \dot{\lambda} + \dot{w}_\alpha \lambda^\alpha}$$

$b \partial c$

$$c = -2$$

$$+ 2$$

$$c_\alpha = 10$$

$$c = -32$$

$$c = 22$$

$$c_{\text{tot}} = 0$$

$$\rightarrow \mathcal{S} = \int \dot{x}_n P + [P^*(\theta \Pi^{-1} \theta) + eP] = \int \dot{x} P + S \dot{S} + eP$$

$$\langle \lambda \delta^m \theta \quad \lambda \gamma^m \theta \quad \lambda \gamma^p \theta \quad \theta \delta_{m+1} \theta \rangle = 1$$

$$\rightarrow \dot{S} = \int \dot{x}_m P^m + P^0 (\dot{\theta} \Pi^0 - \theta) + e P^1 = \int \dot{x}_m P^m + S \dot{S} + e P^1$$

$$\langle \lambda \delta^m \theta \quad \lambda \gamma^0 \theta \quad \lambda \gamma^p \theta \quad \theta \delta_{m+1} \theta \rangle = 1 \quad \text{unique gamma of } H^1(Q)$$

$$\rightarrow \dot{S} = \int \dot{x}_n P^n + P^*(\dot{\theta} \Pi - \theta) + e P^* = \int \dot{x} P + S \dot{S} + e P^*$$

$$A_n(x, \theta) \quad Y_{n+1}^{n,p} E_n = \theta$$

$$\langle \lambda \gamma^m \theta \quad \lambda \gamma^n \theta \quad \lambda \gamma^p \theta \quad \theta \gamma_{n+1} \theta \rangle = \text{eigen values of } H^p(Q)$$

$$U = \lambda^* A_n$$

~~4.2.11~~

$$\rightarrow S = \int \dot{x}_n P^n + P^n (\dot{\theta} \Pi^n - \theta) + e P^n = \int \dot{x} P + S \dot{S} + e P$$

$$A_x(x, \theta) \quad Y_{n+1}^* P^n - E_{n+1} = 0$$

$$\langle \lambda \gamma^n \theta \quad \lambda \gamma^n \theta \quad \lambda \gamma^n \theta \quad \theta \gamma_{n+1} \theta \rangle = 1$$

unique ground state of H^n

$$U = \lambda^* A_n$$

~~...~~ $\lambda_1 + \text{cycle permutations}$

$\partial \Lambda \quad \Lambda \quad A$



$$\rightarrow \dot{S} = \int \dot{x}_m P^m + P^* (\dot{\theta} \Gamma^{-1} \theta) + e P^* = \int \dot{x}_m P^m + S \dot{S} + e P^*$$

$\Lambda(\theta) \quad \gamma^{\alpha\beta} =$

$$\langle \lambda \gamma^m \theta \quad \lambda \gamma^n \theta \quad \lambda \gamma^p \theta \quad \theta \gamma_{m+n} \theta \rangle = 1 \quad \text{unique gamma of } H^1(Q)$$

$$U = \lambda^T A$$

~~$\lambda \gamma^m \theta$~~ $\lambda_3 + \text{cycle conditions}$

$\partial A \quad A \quad A$



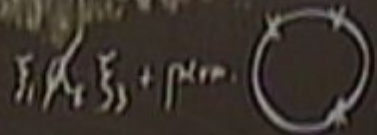
$$\rightarrow \dot{S} = \int \dot{\chi}_m P^m + P^*(\dot{\theta} \Pi^* - \dot{\theta}) + e P^* = \int \dot{\chi}_m P^m + S \dot{S} + e P^*$$

$$\langle \lambda \gamma^m \theta \lambda \gamma^n \theta \lambda \gamma^p \theta \theta \gamma_{m+n} \theta \rangle = 1 \quad \text{unique gamma of } H^3(Q)$$

$$U = \lambda^T A_e$$

~~...~~ $\lambda_3 + \text{cycle condition}$

$\partial A \ A \ A$



$$\rightarrow \dot{S} = \left(\dot{X}_m P^* + P^* (\theta \Pi^{-1} \theta) + e P^* \right) = \left(\dot{X}_m P^* + S \dot{S} + e P^* \right)$$

$$\langle \lambda \gamma^* \theta \quad \lambda \gamma^* \theta \quad \lambda \gamma^* \theta \quad \theta \gamma_{m+1} \theta \rangle = 1 \quad \text{unique gamma of } H^1(Q)$$

$$U = \lambda^* A_e$$

~~$\lambda^* A_e$~~ $\lambda^* A_e$ + cycle conditions
 $\lambda^* A_e \xi_j + \rho_{j,m}$

$\partial A \quad A A$

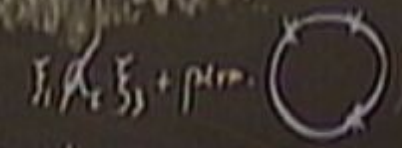


ΕΛΛΗΝ
 ΠΑΝΕΠΙΣΤΗΜΙΟΝ ΑΘΗΝΩΝ
 ΠΑΙΔΑΓΩΓΙΚΗ ΣΧΟΛΗ
 ΤΜΗΜΑ ΠΕΔΑ

$$\rightarrow \mathcal{S} = \int \dot{x}_\mu P^\mu + P^\mu (\partial_\mu \pi - \theta) + e P^\mu = \int \dot{x}_\mu P^\mu + S \dot{S} + e P^\mu$$

$$\langle \lambda \gamma^{\mu\nu} \theta \lambda \gamma^{\rho\sigma} \theta \lambda \gamma^{\rho\sigma} \theta \theta \gamma_{\mu\nu} \theta \rangle = 1 \quad \text{unique ground state of } H^1(\mathbb{R})$$

$$U = \lambda A_e \quad \text{with } \lambda_1 + \text{cycle conditions} \quad \partial A \quad A A$$



$$\int d^4 \theta \quad D_x U \dots$$

$$\rightarrow \dot{S} = \int \dot{x}_n P^n + P^n (\theta \pi^n - \theta) + e P^n = \int \dot{x} P + S \dot{S} + e P^n$$

$$A_n(x, \theta)$$

$$Y_{m_1, \dots, m_r}^{n, p}, F_{np} = 0$$

$$P^n$$

$$A_n = (\theta \gamma^n)_{\nu} A_{\nu} + (\theta \gamma^n \xi) (\theta \gamma^n)_{\nu} + \dots \partial \lambda, \partial \xi$$

$$\xi^n = W^n |_{x=0}$$

$$W^n = (\gamma_n \gamma^n)^{-1} (\Phi_p A_n - \partial_n A_p)$$

$$\text{BRST } Q = \lambda^n D_n$$

$$Q^2 = \lambda \gamma^n \lambda \partial_n \Rightarrow \lambda \gamma^n \lambda = 0$$

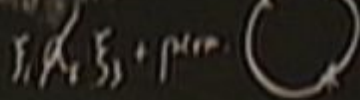
$$\{0, \lambda^n A_n\} = 0$$

$$\lambda \gamma^n \theta \theta \gamma_{m_1, \dots, m_r} \theta = 1$$

unique gauge if $H^0(Q)$

$\lambda, \lambda, \lambda, \lambda$ + cyclic permutations

$$\partial A A A$$



$$D_n V \dots$$

WS fields x, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_{\alpha} \bar{\partial} \theta^{\alpha} + \bar{p}_{\alpha} \partial \bar{\theta}^{\alpha} + \underline{w \bar{\partial} \lambda + \bar{w} \partial \lambda}$$

$b \partial c$

$$c = -2$$
$$+ ?$$

$$Q_2 = 10$$

$$C = -32$$

$$C = 22$$

$$C_{tot} = 0$$

W.S fields x, θ, p, λ, w

$$S = \int \theta \dot{x} + p_x \dot{\theta} + \beta_x \dot{\bar{\theta}} + w \dot{\lambda} + \bar{w}_x \dot{\lambda}$$

$b \partial c$

$$c = -2$$
$$+ 2$$

$$Q_x = 10$$

$$C = -32$$

$$C = 22$$

$$C_{tot} = 0$$



WS fields $x, \theta, \rho, \lambda, \omega$

$$S = \int \theta \dot{x} + p_\alpha \dot{\theta}^\alpha + \bar{p}_\alpha \dot{\bar{\theta}}^\alpha + \omega \dot{\lambda} + \bar{\omega}_\alpha \dot{\lambda}^\alpha$$

$b \partial c$

$$c = -2$$

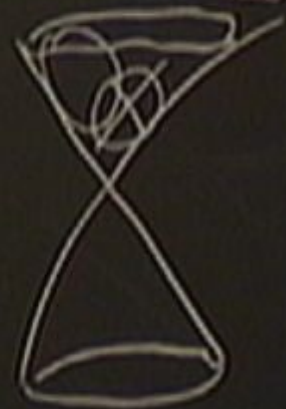
$$+2$$

$$Q_\alpha = 10$$

$$C = -32$$

$$C = 22$$

$$C_{tot} = 0$$



$$P^{\mu} = U_{\mu} \tilde{U}$$

$$w, \lambda$$

$$\tilde{\lambda}$$

WS fields x, θ, p, λ, w

$$S = \int dx d\theta \left(p_{\alpha} \dot{\theta}^{\alpha} + \tilde{p}_{\alpha} \dot{\bar{\theta}}^{\alpha} + w \dot{\lambda} + \tilde{w}_{\alpha} \dot{\tilde{\lambda}}^{\alpha} \right)$$

$b\partial c$

$$c = -2$$

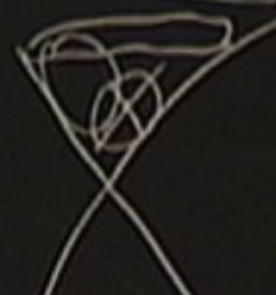
$$+2$$

$$C_1 = 10$$

$$C_2 = -32$$

$$C_3 = 22$$

$$C_{tot} = 0$$



$$P^d$$

$$w, \lambda$$

$$\tilde{\lambda} = \frac{1}{\lambda}$$

$$T = w \partial \lambda$$

$$\tilde{w} = \frac{\partial \lambda}{\partial x} w = -\lambda^2 w$$

W.S. fields x, θ, p, λ, w

$$S = \int \partial x \partial x + p_\alpha \partial \theta^\alpha + \beta$$

$$b \partial c$$

$$c = -2$$

$$c_\alpha = 10$$

$$c = -32$$

$$c = 22$$

$$c_{tot} = 0$$

$$\frac{\partial \tilde{\lambda} + \tilde{w} \partial \tilde{\lambda}^2}{\lambda^2 + \tilde{w} \partial \tilde{\lambda}^2}$$



P^1
 U, \tilde{U}

w, λ

$$\tilde{\lambda} = \frac{1}{\lambda}$$

$$\tilde{w} = \frac{\partial \lambda}{\partial x} w = -\lambda^2 w + \partial \lambda \quad \Bigg| \quad \tilde{T} = \tilde{w} \partial \tilde{\lambda}$$

$$T = w \partial \lambda$$

$$w(x)\lambda(y) = \frac{1}{x-y}$$

$$\lambda \lambda = 0$$
$$w w = 0$$

$$\tilde{w} \neq 0$$

WS fields x, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_+ \bar{\partial} \theta^+ + \bar{p}_+ \partial \bar{\theta}^+ + w \bar{\partial} \lambda + \dots$$

$b \partial c$

$$c = -2$$
$$+ 2$$

$$C_1 = 10$$
$$C_2 = -32$$
$$C_3 = 22$$
$$C_{tot} = 0$$

\mathbb{P}^1
 U, \tilde{U}

w, λ

$$\tilde{\lambda} = \frac{1}{\lambda}$$

$$T = w \partial \lambda$$

$$w(x)\lambda(y) \sim \frac{1}{x-y}$$

$$\lambda \lambda = 0$$

$$\tilde{w} w = 0$$

$$\tilde{w} = \frac{\partial \lambda}{\partial x} w = -\lambda^2 w + \partial \lambda \quad \tilde{T} = \tilde{w} \partial \tilde{\lambda}$$

$$\tilde{w} w \neq 0$$

$$\tilde{w}^i = \frac{\partial \lambda^i}{\partial x} w_j + B_j^i \partial \lambda^j$$

WS fields x, θ, p, λ, w

$$S = \int \partial x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + \underbrace{w \partial \lambda + \tilde{w}_\alpha \partial \tilde{\lambda}^\alpha}_{\text{fermions}}$$

$b \partial c$

$$c = -2$$

$$+2$$

$$c_\alpha = 10$$

$$c = -32$$

$$c = 22$$

$$c_{tot} = 0$$



\mathbb{P}^1
 U, \tilde{U}

w, λ

$$\tilde{\lambda} = \frac{1}{\lambda}$$

$$T = w \partial \lambda$$

$$w(x)\lambda(y) \sim \frac{1}{x-y}$$

$$\lambda \lambda = 0$$

$$\tilde{w} w = 0$$

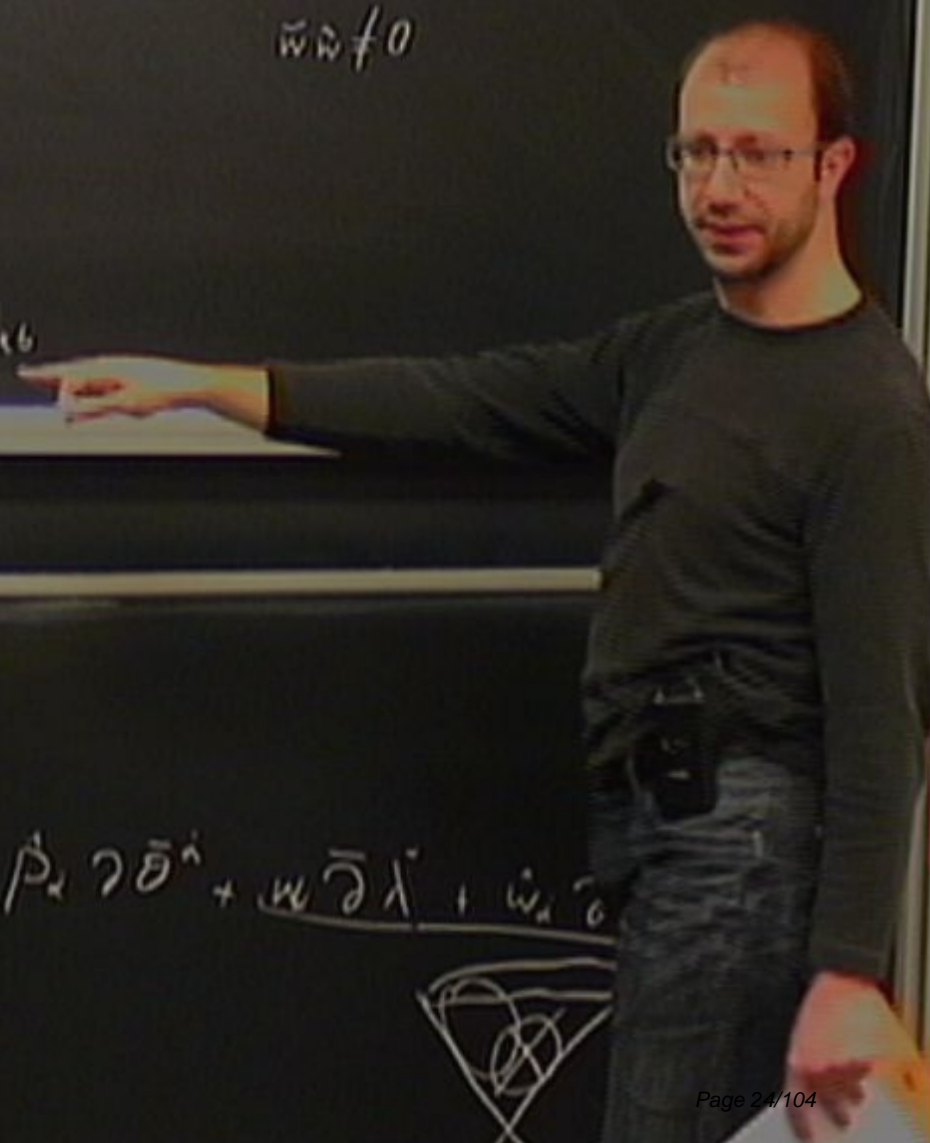
$$\tilde{w} = \frac{\partial \lambda}{\partial \tilde{\lambda}} w = -\lambda^2 w + \partial \lambda \quad \left| \quad \tilde{T} = \tilde{w} \partial \tilde{\lambda} \right.$$

$$\tilde{w} w \neq 0$$

$$\tilde{w}^i = \frac{\partial \lambda^i}{\partial \tilde{\lambda}^i} w_j + B_j^i \partial \lambda^j$$

$$g_j^i = \frac{\partial \lambda^i}{\partial \tilde{\lambda}^j}$$

$$B_{\alpha\beta} = \partial_i \tilde{\lambda}^i \partial_j \tilde{\lambda}^j \mathbb{H}_{\alpha\beta}$$



WS fields x, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \dot{p}_\alpha \partial \bar{\theta}^\alpha + w \bar{\partial} \lambda + \dot{w}_\alpha \bar{\theta}^\alpha$$

$b \partial c$

$$c = -2$$

$$+ 2$$

$$C_2 = 10$$

$$C_1 = -32$$

$$C_0 = 22$$

$$C_{tot} = 0$$



P^1
 U, \tilde{U}

w, λ

$$\tilde{\lambda} = \frac{1}{\lambda}$$

$$T = w \partial \lambda$$

$$w(x)\lambda(y) \sim \frac{1}{x-y}$$

$$\lambda \lambda = 0$$

$$\tilde{w} w = 0$$

$$\tilde{w} = \frac{\partial \lambda}{\partial x} w = -\lambda^2 w + \partial \lambda \quad \left| \quad \tilde{T} = \tilde{w} \partial \tilde{\lambda} \right.$$

$$\tilde{w} w \neq 0$$

$$\tilde{w}^i = \frac{\partial \lambda^i}{\partial x} w + B^i_j \partial \lambda^j$$

$$g^i_j = \frac{\partial \lambda^i}{\partial x^j}$$

$$B_{ab} = \partial_i \lambda^i \partial_j \lambda^j \mu_{ab}$$

$$\mu = \mu_{ab} \partial \lambda^a \partial \lambda^b$$

W.S. fields x, θ, p, λ, w

$$S = \int \partial x \partial x + p_a \partial \theta^a + \tilde{p}_a \partial \bar{\theta}^a + \underbrace{w \partial \lambda + \tilde{w} \partial \tilde{\lambda}}_{\text{fermion}}$$

$b \partial c$

$$c = -2$$

$$c = 10$$

$$c = -32$$

$$c = 22$$

$$c_{tot} = 0$$



U, \tilde{U}

w, λ

$$\tilde{\lambda} = \frac{1}{\lambda}$$

$$\tilde{T} = w \partial \lambda$$

$$w(x)\lambda(y) = \frac{1}{x-y}$$

$$\lambda \tilde{\lambda} = 0$$

$$w \tilde{w} = 0$$

$$\tilde{w} = \frac{\partial \lambda}{\partial \tilde{\lambda}} w = -\lambda^2 w + \partial \lambda \quad \left| \quad \tilde{T} = \tilde{w} \partial \tilde{\lambda} \right.$$

$$\tilde{w} \tilde{w} \neq 0$$

$$\tilde{w}^i = \frac{\partial \lambda^i}{\partial \tilde{\lambda}^i} w_j + B^i_j \partial \lambda^j$$

$$g^i_j = \frac{\partial \lambda^i}{\partial \tilde{\lambda}^j}$$

$$B_{\alpha\beta} = \partial_i \tilde{\lambda}^\alpha \partial_j \tilde{\lambda}^\beta \mathbb{F}_{ij} \mu_{\alpha\beta}$$

$$\mu = \mu_{\alpha\beta} d\tilde{\lambda}^\alpha d\tilde{\lambda}^\beta$$

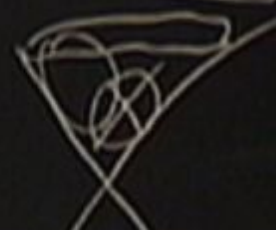
$$d\mu = \text{tr}(\tilde{g}^{-1} d\tilde{g})^2$$

W.S. fields x, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \bar{p}_\alpha \partial \bar{\theta}^\alpha + \frac{w \bar{\partial} \lambda + \tilde{w} \partial \tilde{\lambda}^2}{2}$$

$b \partial c$

- $c = -2$
- $+2$
- $c_1 = 10$
- $c_2 = -32$
- $c_3 = 2$
- $c_{tot} =$



U, \tilde{U}

ω, λ

$$\tilde{\lambda} = \frac{1}{\lambda}$$

$$T = w \partial \lambda$$

$$w(x)\lambda(y) = \frac{1}{x-y}$$

$$\frac{\lambda \lambda}{w w} = 0$$

$$\tilde{w} = \frac{\partial \lambda}{\partial \tilde{\lambda}} w = -\lambda^2 w + \partial \lambda \quad \left| \quad \tilde{T} = \tilde{w} \partial \tilde{\lambda} \right.$$

$$\tilde{w} \tilde{w} \neq 0$$

$$\tilde{w}^i = \frac{\partial \lambda^i}{\partial \tilde{\lambda}^i} w_i + B^i_j \partial \lambda^j$$
$$g^i_j = \frac{\partial \lambda^i}{\partial \tilde{\lambda}^j}$$
$$B_{ab} = \partial_i \tilde{\lambda}^i \partial_j \tilde{\lambda}^j \mu_{ab}$$

$$\mu = \mu_{ab} d\tilde{\lambda}^a d\tilde{\lambda}^b$$
$$d\mu = \text{tr}(g^{-1} d g)^2$$

WS fields x, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_a \bar{\partial} \theta^a + \beta_a \partial \bar{\theta}^a + \underbrace{w \bar{\partial} \lambda + \tilde{w}_a \partial \tilde{\lambda}^a}_{\text{Klein-Gordon}}$$

$b \partial c$

$$c = -2$$
$$+ 2$$

$$C_2 = 10$$
$$C_1 = -32$$
$$C_0 = 22$$
$$C_{tot} = 0$$



U, \tilde{U}

ω, λ

$$\tilde{\lambda} = \frac{1}{\lambda}$$

$$T = w \partial \lambda$$

$$w(x)\lambda(y) = \frac{1}{x-y}$$

$$\frac{\lambda \lambda}{w w} = 0$$

$$\tilde{w} = \frac{\partial \lambda}{\partial x} w = \lambda^2 w + \partial \lambda \quad \tilde{T} = \tilde{w} \partial \tilde{\lambda}$$

$$\tilde{w} \tilde{w} \neq 0$$

$$\tilde{w}^i = \frac{\partial \lambda^j}{\partial x^i} w_j + B^i_j \partial \lambda^j$$

$$g^i_j = \frac{\partial \lambda^i}{\partial x^j} \quad B_{\alpha\beta} = \partial_j \gamma^i \partial_i \gamma^j \mu_{\alpha\beta}$$

$$\mu = \mu_{\alpha\beta} d\gamma^\alpha d\gamma^\beta$$

$$d\mu = \text{tr}(\gamma^{-1} d\gamma)^2$$

W.S. fields x, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \bar{p}_\alpha \partial \bar{\theta}^\alpha + w \bar{\partial} \lambda + \tilde{w} \partial \tilde{\lambda}$$

$b \partial c$

$$c = -2$$

$$+ 2$$

$$c_2 = 10$$

$$c_1 = -32$$

$$c_0 = 22$$

$$c_{tot} = 0$$



$$|g| = \frac{\partial x^i}{\partial \tilde{x}^i}$$

$$B_{\alpha\beta} = 2, \delta, 2, \delta, \mu, \mu, \mu, \mu$$

$$\mu = \mu_{\alpha\beta} \delta^{\alpha\beta}$$

$$d\mu = \text{tr}(g^{-1} d g)$$

$$U_{\alpha\beta} U_{\gamma\delta} = \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta}$$

W.S. fields x, θ, p, λ, w

$$S = \int dx \partial x + p_{\alpha} \partial \theta^{\alpha} + \beta_{\alpha} \partial \bar{\theta}^{\alpha} + \underbrace{w \partial \lambda + \dot{w}_{\alpha} \partial \lambda^{\alpha}}_{}$$

$b \partial c$

$$c = -2$$

$$+ ?$$

$$c_1 = 10$$

$$c_2 = -32$$

$$c_3 = 27$$

$$c_{tot}$$



$$|g_i = \frac{\partial x^i}{\partial \tilde{x}^i}$$

$$B_{ab} = 2, g_i, 2, g_i, \mu_{ab}$$

$$\mu = \mu_{ab} d\tilde{x}^a d\tilde{x}^b$$

$$d\mu = \text{tr}(g^{-1} d\tilde{g})$$

$$U_{\alpha\beta\gamma} = \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \text{tr}\left(\frac{1}{\partial_\alpha} \wedge d\tilde{g}_{\beta\gamma} \wedge d\tilde{g}_{\gamma\alpha}\right)$$

WS fields x, θ, p, λ, w

$$S = \int \partial x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + \underbrace{w \partial \lambda + \bar{w}_\alpha \partial \lambda^\alpha}_{\text{b.c.}}$$

b.c.

$$c = -2$$

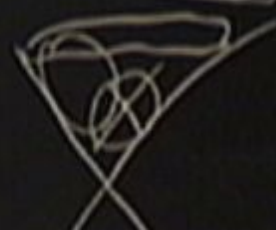
$$+ 2$$

$$c_1 = 10$$

$$c_2 = -32$$

$$c_3 = 22$$

$$c_{\text{tot}} = 0$$



$$|g_i| = \frac{\partial x^i}{\partial \bar{x}^i}$$

$$B_{\alpha\beta} = \partial_\alpha \bar{x}^\beta \partial_\beta \bar{x}^\alpha$$

$$\mu = \mu_{\alpha\beta} d\bar{x}^\alpha d\bar{x}^\beta$$

$$d\mu = \text{tr}(g^{-1} d g)$$

$$U_{\alpha\beta} U_{\gamma\delta} = \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \text{tr}(g_{\alpha\beta} \wedge d g_{\beta\gamma} \wedge d g_{\gamma\alpha}) \in H^2(X)$$

$$\Psi_1 = p_1(x) = c_2(1)$$

W.S. fields x, θ, p, λ, w

$$S = \int \theta x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \beta_\alpha \bar{\partial} \bar{\theta}^\alpha + w \bar{\partial} \lambda + \bar{w}_\alpha$$

$b \partial c$

$$c = -2$$

$$+ 2$$

$$c_1 = 10$$

$$c_2 = -32$$

$$c_3 = 2$$

$$c_4 = 2$$

$$|g_i| = \frac{\partial x^i}{\partial \bar{x}^i}$$

$$B_{\alpha\beta} = \partial_\alpha g_i \partial_\beta g^i \mu_{\alpha\beta}$$

$$\mu = \mu_{\alpha\beta} dx^\alpha dx^\beta$$

$$d\mu = \text{tr}(g^{-1} dg)$$

$$U_{\alpha\beta} U_{\gamma\delta} \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \text{tr}(g_{\alpha\beta} \wedge dg_{\beta\gamma} \wedge dg_{\gamma\alpha}) \in H^2(X, \Omega^2)$$

$$\Psi_1 = p_1(X) = c_2(TX)$$

WS fields x, θ, p, λ, w

$$S = \int \theta x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + w \partial \lambda + \bar{w}_\alpha \partial \bar{\lambda}^\alpha$$

$b\partial c$

$$c = -2$$

$$+2$$

$$c_2 = 10$$

$$c = -32$$

$$c =$$



$$|g_i = \frac{\partial x^i}{\partial \bar{x}^i}$$

$$B_{\alpha\beta} = \partial_\alpha \bar{x}^i \partial_\beta \bar{x}^j \mu_{ik}$$

$$\mu = \mu_{\alpha\beta} d\bar{x}^\alpha d\bar{x}^\beta$$

$$d\mu = \text{tr}(g^{-1} d g)$$

$$U_{\alpha\beta} U_{\gamma\delta} = \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \text{tr}(g_{\alpha\beta} \wedge d g_{\beta\gamma} \wedge d g_{\gamma\alpha}) \in H^2(X, \Omega^2)$$

$$\Psi_1 = p_1(X) = c_2(TX)$$

W.S. fields x, θ, p, λ, w

$$S = \int \theta x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + \underbrace{w \partial \lambda + \bar{w} \partial \bar{\lambda}}_{\text{triangle diagram}}$$

$b \partial c$

$$c = -2$$

$$+2$$

$$c_2 = 10$$

$$c = -32$$

$$c =$$

$$c =$$



$$|g_i| = \frac{\partial \lambda^i}{\partial x^i}$$

$$B_{\alpha\beta} = \partial_\alpha g_i \partial_\beta g^i \mu_{\alpha\beta}$$

$$\mu = \mu_{\alpha\beta} dx^\alpha dx^\beta$$

$$d\mu = \text{tr}(g^{-1} dg)$$

$$U_{\alpha\beta} U_{\gamma\delta} \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \text{tr}(g_{\alpha\beta} \wedge dg_{\beta\gamma} \wedge dg_{\gamma\alpha}) \in H^2(X, \Omega^2)$$

$$\Psi_1 = p_1(X) = c_2(TX)$$

$$T_{(n)} = w_{\alpha\beta} \partial \lambda^{(\alpha)} + \partial^2 \log \Omega(\lambda)$$

$$\Omega = \Omega(\lambda) d\lambda^1 \wedge \dots \wedge d\lambda^n$$

WS fields x, θ, p, λ, w

$$S = \int \theta x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + \frac{w \partial \lambda^i + \bar{w}_i \partial \bar{\lambda}^i}{2}$$

$b \partial c$

$$c = -2$$

$$+ 2$$

$$c = 10$$

$$c = -32$$

$$c = 27$$



$$|g_i = \frac{\partial \lambda^i}{\partial x^j}$$

$$B_{\alpha\beta} = \partial_i g_i \partial_j g_j \mu_{\alpha\beta}$$

$$\mu = \mu_{\alpha\beta} d\lambda^\alpha d\lambda^\beta$$

$$d\mu = \text{tr}(g^{-1} dg)$$

$U \cap U_{\text{pol}}$

$$\gamma = \mu_{\lambda\rho} + \mu_{\rho\lambda} + \mu_{\lambda\mu} - \text{tr}\left(\frac{\partial \mu}{\partial \lambda} \wedge d\lambda \wedge d\lambda\right) \in H^2(X, \Omega^2)$$

$$\psi_1 = p_1(X) = c_2(TX)$$

$$w_{\lambda} \partial \lambda^{(1)} + \partial^2 \log \mu(\lambda)$$

$$\Omega = \Omega(\lambda) d\lambda_1 \wedge \dots \wedge d\lambda_n$$

$x, \theta, \rho, \lambda, w$

$$\zeta = \int \partial x \partial x + \rho_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + \underbrace{w \partial \lambda^i + \bar{w}_i \partial \bar{\lambda}^i}_{\text{triangle diagram}}$$

$$c = -2$$

$$+ 2$$

$$c_2 = 10$$

$$c = -32$$



$$|g_i| = \frac{\partial \lambda^i}{\partial x^i}$$

$$B_{\alpha\beta} = \partial_\alpha \gamma_i \partial_\beta \gamma^i \mu_{\alpha\beta}$$

$$\mu = \mu_{\alpha\beta} d\gamma^\alpha d\gamma^\beta$$

$$d\mu = \text{tr}(g^{-1} d g)$$

$$U_\alpha \cap U_\beta \cap U_\gamma = \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \text{tr}(g_{\beta\gamma} \wedge d g_{\beta\gamma} \wedge d g_{\gamma\alpha}) \in H^2(X, \Omega^2)$$

$$\Psi_\alpha = p_1(x) = c_2(TX)$$

$$T_{(i)} = w_{i1} \partial \lambda^{(i)} + \partial^2 \log \mathcal{R}(\lambda)$$

$$\Omega = \Omega(\lambda) d\lambda_1 \wedge \dots \wedge d\lambda_n$$

$$c_1(X) = 0$$

$$T_{(i)} - T_{(j)} = 0$$

WS fields x, θ, p, λ, w

$$S = \int \theta x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + \underbrace{w \partial \lambda + \bar{w}_\alpha \partial \bar{\lambda}^\alpha}_{\text{tr}(g^{-1} d g)}$$

$b \partial c$

$$c = -2$$

$$+ 2$$

$$c_2 = 10$$

$$c_1 = -32$$



$$|g^i_j| = \frac{\partial x^i}{\partial x^j}$$

$$B_{\alpha\beta} = \partial_\alpha g^i_j \partial_\beta x^i \mu_{jk}$$

$$\mu = \mu_{\alpha\beta} dx^\alpha dx^\beta$$

$$d\mu = \text{tr}(g^{-1} dg)$$

$$U_{\alpha\beta} U_{\gamma\delta} \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \text{tr}(g_{\alpha\beta} \wedge dg_{\beta\gamma} \wedge dg_{\gamma\alpha}) \in H^2(X, \Omega^2)$$

$$\Psi_1 = p_1(X) = c_2(TX)$$

$$T_{(n)} = w_{\alpha\beta} \partial \lambda^{\alpha\beta} + \partial^2 \log \Omega(\lambda)$$

$$\Omega = \Omega(\lambda) d\lambda^1 \wedge \dots \wedge d\lambda^n$$

$$T_{(n)} - T_{(n)} = 0$$

$$c_1(X) = 0$$

W.S. fields x, θ, p, λ, w

$$S = \int \alpha x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + w \partial \lambda + \bar{w}_\alpha \partial \bar{\lambda}^\alpha$$

$b \partial c$

$$c = -2$$

$$+ 2$$

$$c_2 = 10$$

$$c = -32$$



$$|g_i = \frac{\partial \lambda^i}{\partial x^i}$$

$$B_{\alpha\beta} = \partial_\alpha \partial_\beta \lambda^i \mu_{ik}$$

$$\mu = \mu_{ik} dx^i dx^k$$

$$d\mu = \text{tr}(g^{-1} d g)$$

$$U_{\alpha\beta\gamma} = \Psi_{\alpha\beta\gamma} = \mu_{\alpha\beta} + \mu_{\beta\gamma} + \mu_{\gamma\alpha} - \text{tr}(g_{\beta\gamma} \wedge d g_{\alpha\beta} \wedge d g_{\gamma\alpha}) \in H^2(X, \Omega^2)$$

$$\Psi_1 = p_1(X) = c_2(TX)$$

$$T_{(n)} = w_{(n)} \partial \lambda^{(n)} + \partial^2 \log \Omega(\lambda)$$

$$\Omega = \Omega(\lambda) d\lambda_1 \wedge \dots \wedge d\lambda_n$$

$$c_1(X) = 0$$

$$T_{(n)} - T_{(n)} = 0$$

WS fields x, θ, p, λ, w

$$S = \int \alpha x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + w \partial \lambda^i + \bar{w}_i \partial \bar{\lambda}^i$$

$b \partial c$

$$c = -2$$

$$+2$$

$$c_2 = 10$$

$$c_1 = -32$$

$$c_0 =$$



$$\rightarrow \mathcal{L} = \int \dot{x}_\mu P^\mu + P^\mu (\theta \Gamma^{-1} \theta) + e P^\mu = \int \dot{x} P + S \dot{S} + e P$$

$$U(5) \hookrightarrow 1 + 5 + 10 \quad (\lambda, \lambda_c, \lambda_{\mu\nu})$$

$$\rightarrow S = \int \dot{x}_\mu P^\mu + P^\mu (\dot{\theta} \Gamma^{-1} \theta) + e P' = \int \dot{x} P + S \dot{S} + e P'$$

$$U(5) \hookrightarrow 1 + 5 + 10 \quad (\lambda, \lambda_c, \lambda_{R(5)})$$

$$\lambda_{11111}$$

$$\lambda_{11110}$$

$$\lambda_{11100}$$

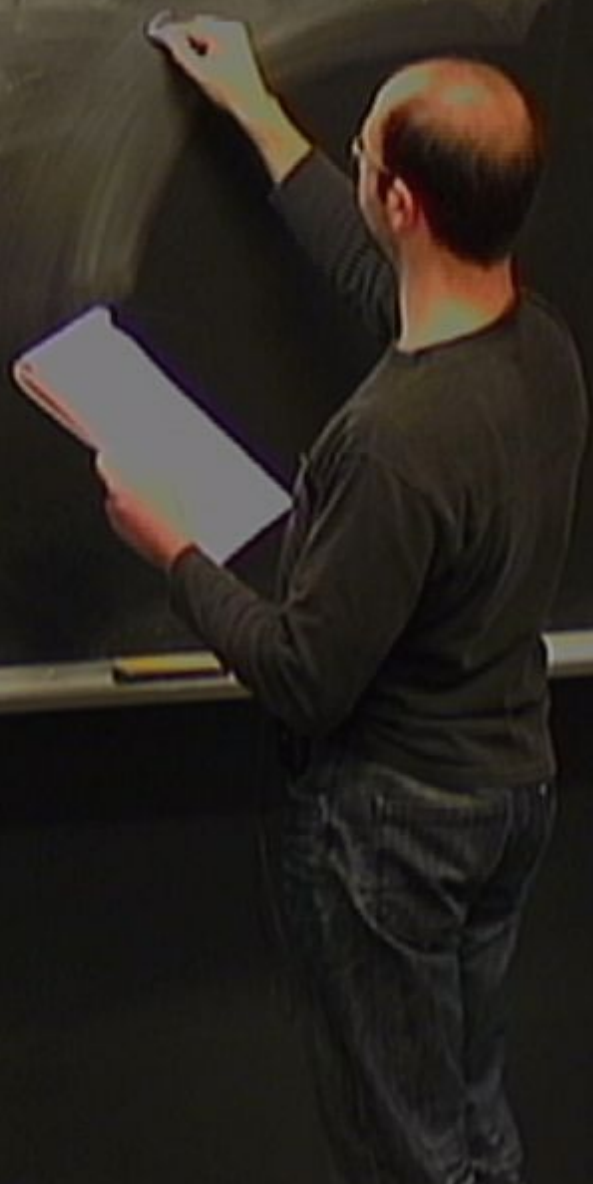
$$\lambda_{11000}$$

$$\rightarrow \mathcal{L} = \int \dot{x}_\mu P^\mu + P^\mu (\theta \Gamma^{-1} \theta) + e P' = \int \dot{x} P + S \dot{S} + e P'$$

$$U(5) \rightarrow 1 + 5 + 10 \quad (\lambda_i, \lambda_a, \lambda_{ab})$$

$$\sum_{\text{symmetrisch}} (\lambda \lambda_{abcd} + \lambda_{ab} \lambda_{cd}) = 0$$

$$\lambda_{1111}, \lambda_{1112}, \lambda_{1122}, \lambda_{1222}$$



$$\rightarrow \mathcal{L} = \left(\dot{x}_\mu P^\mu + P^\nu (\theta \Gamma^{-1} \theta) + e P^\nu \right) = \left(\dot{x} P + S \dot{S} + e P \right)$$

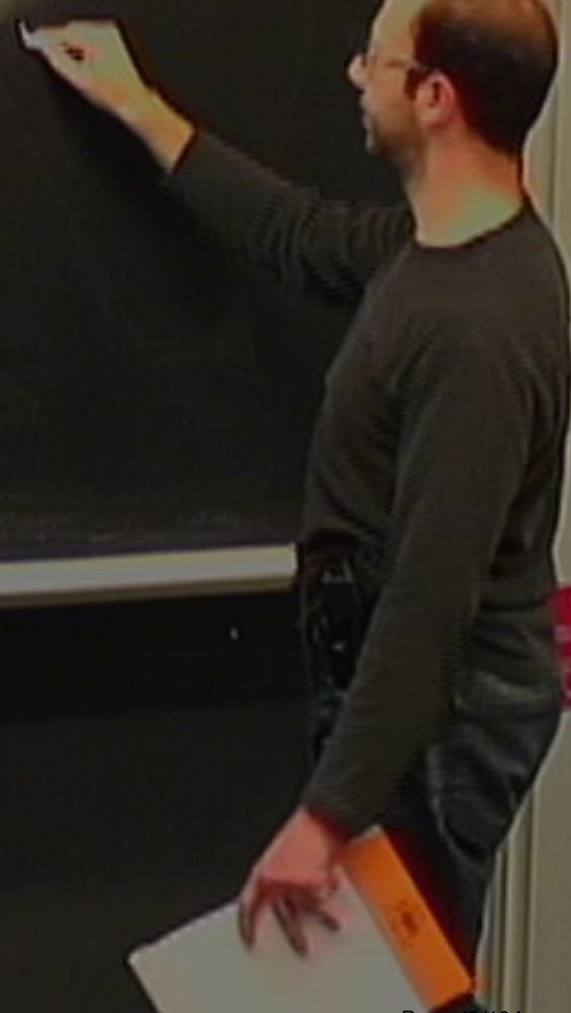
$$U(5) \rightarrow 1 + 5 + 10 \quad (\lambda_{ij}, \lambda_{\alpha\beta}, \lambda_{\mu\nu})$$

$$\begin{aligned} \lambda_{1111} & \quad \lambda_{1112} \\ \lambda_{1122} & \quad \lambda_{1123} \\ \lambda_{1222} & \end{aligned}$$

$$\sum^{antisym} (\lambda_{\alpha\beta\gamma\delta} + \lambda_{\delta\epsilon\zeta\eta}) = 0$$

$$\sum^{antisym} (\lambda_{\alpha\beta\gamma\delta} \lambda_{\epsilon\zeta\eta}) = 0$$

λ_{1011}



$$\rightarrow \dot{S} = \left(\dot{x}_m P^m + P^{\mu} (\theta \Pi^{\mu} - \theta) + e P^{\nu} \right) = \dot{x}_m P^m + S \dot{S} + e P^{\nu}$$

$$U(5) \rightarrow 1 + 5 + 10 \quad (\lambda_{\mu\nu}, \lambda_{\mu\nu}, \lambda_{\mu\nu})$$

$$\lambda_{1111}, \lambda_{1112}, \lambda_{1122}, \lambda_{1222}$$

$$\sum^{sym} (\lambda_{\mu\nu\alpha\beta} + \lambda_{\mu\alpha\beta\nu}) = 0$$

$$\sum^{antisym} (\lambda_{\mu\nu\alpha\beta} - \lambda_{\mu\alpha\beta\nu}) = 0$$

$$\lambda_{1201} = -\frac{1}{\lambda} (\lambda_{1111} - \lambda_{1112}) \sum^{antisym}$$

$$C = (\nu P + P^*(A^T - A) + \epsilon P) = (\lambda P + S S^T + \epsilon P)$$

$$U(5) \rightarrow 1+5+10 \quad (\lambda_1, \lambda_2, \lambda_{30})$$

$$\lambda_{1111}, \lambda_{1112}, \lambda_{1121}, \lambda_{1122}, \lambda_{1211}, \lambda_{1212}, \lambda_{1221}, \lambda_{1222}$$

$$\lambda = e^{i\theta}$$

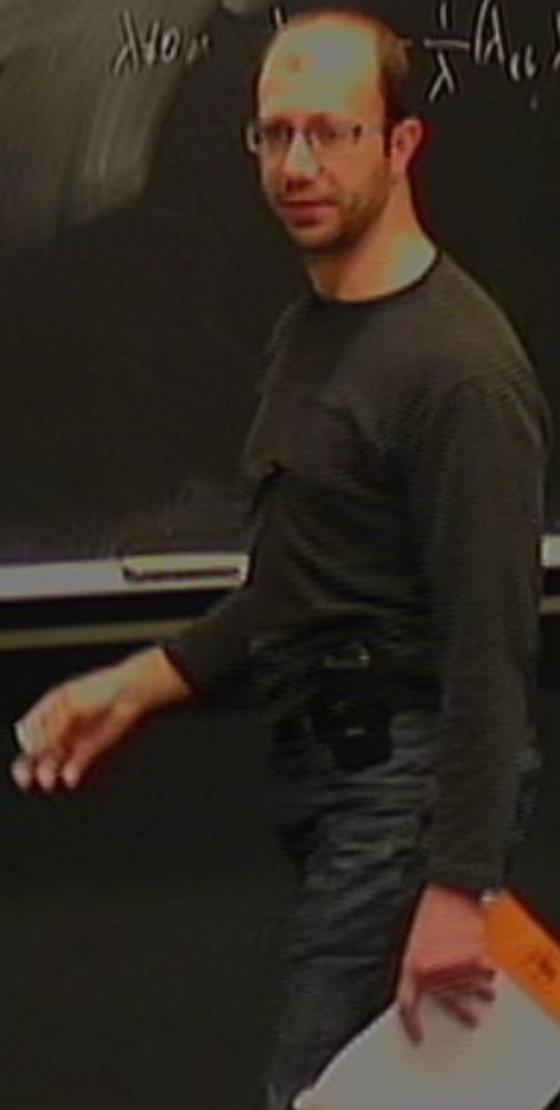
$$\lambda_{ei} = \lambda u_{ei}$$

$$\lambda_e = d(u_{21} u_{12} - u_{22} u_{11} + u_{23} u_{14})$$

$$\sum^{e \text{ balle}} (\lambda \lambda_{e1} + \lambda_{e2} \lambda_{e3}) = 0$$

$$\sum^{e \text{ balle}} (\lambda_{e1} \lambda_{e2} \lambda_{e3}) = 0$$

$$\lambda_{30} = \frac{1}{\lambda} (\lambda_{11} \lambda_{12}) \sum^{e \text{ balle}}$$



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$$U(5) \rightarrow 1+5+10 \quad (\lambda, \lambda_2, \lambda_{10})$$

$$\lambda_{11111} \quad \lambda_{11112}$$

$$\lambda_{11113}$$

$$\lambda_{11114}$$

$$\lambda = e^{\varphi/\hbar}$$

$$\lambda_{111} = \lambda u_{111}$$

$$\lambda_2 = \lambda (u_{112} u_{113} - u_{111} u_{114} + u_{113} u_{114})$$

$$\lambda_3$$

$$\sum^{abcd} (\lambda \lambda_{abc} + \lambda_{abc} \lambda_{cd}) = 0$$

$$\sum^{abcd} (\lambda_{abc} \lambda_{cd}) = 0$$

$$\lambda_{111} \lambda_{111} = -\frac{1}{\lambda} (\lambda_{111} \lambda_{111}) \epsilon^{1111}$$

$$++++ \rightarrow +++--$$

$$\tilde{u}_{111} = \frac{u_{111}}{u_{111}}, \quad \tilde{u}_{112} = \frac{u_{112}}{u_{111}} \quad \tilde{u}_{113}, \dots, \tilde{u}_{114}$$

$$\tilde{u}_{114} = \frac{u_{114}}{u_{111}} \quad \tilde{\varphi} = \varphi + \log u_{111}$$



$$\lambda = e^{\frac{\psi}{\lambda}}$$

$$\lambda_{11} = \lambda u_{11}$$

$$\lambda_2 = \lambda (u_{11} u_{22} - u_{21} u_{12} + u_{21} u_{12})$$

$$\lambda_2$$

$U_1 U_{11} U_{22}$

$$\lambda_{10} = \lambda_{11} = -\frac{1}{\lambda} (\lambda_{11} \lambda_{22}) \epsilon^{cbde}$$

++++ → +++ --

$$\tilde{u}_{12} = \frac{u_{12}}{u_{11}}, \quad \tilde{u}_{13} = \frac{u_{13}}{u_{11}}, \quad \tilde{u}_{23} = \frac{u_{23}}{u_{11}}$$

$$\tilde{u}_{21} = \frac{u_{21}}{u_{11}}, \quad \tilde{\varphi} = \varphi + \log u_{11}$$

$$\Psi = d \log u_{11} + d \log u_{22}$$

BRST $\alpha = \lambda u_{11}$

$\{0, \lambda A, \beta = 0\}$



$$\lambda_{e1} = \lambda u_{e1}$$

$$\lambda_{e2} = \lambda (u_{e1} u_{e2} - u_{e21} u_{e11} + u_{e22} u_{e14})$$

$$\lambda_3$$

$$U \cap U_{e1} \cap U_{e2}$$

$$\tilde{u}_{e1} = \frac{u_{e1}}{u_{e1}}, \quad \tilde{u}_{e2} = \frac{u_{e2}}{u_{e1}}$$

$$\tilde{u}_{e3} = \frac{u_{e3}}{u_{e1}}, \quad \tilde{\varphi} = \varphi + \log u_{e1}$$

$$\Psi = d \log u_{e1} \wedge d \log u_{e2} = \Psi_{e1} + \Psi_{e2}$$

BRST

$$Q = \lambda^* D_A$$

$$Q^2 = \lambda \gamma^* \lambda \mathcal{Z}_0 \Rightarrow \lambda \gamma^* \lambda = 0$$

$$\{Q, \lambda^* A_\mu\} = 0$$

$$\lambda = e$$

$$\lambda_{11} = \lambda u_{11}$$

$$\lambda_2 = \lambda (u_{11} u_{12} - u_{21} u_{22} + u_{23} u_{33})$$

$$\lambda_3$$

$$U_{11} U_{22} U_{33}$$

++++ -> +++ - -

$$\tilde{u}_{12} = \frac{u_{12}}{u_{11}}, \tilde{u}_{23} = \frac{u_{23}}{u_{11}}, \tilde{u}_{33} = \frac{u_{33}}{u_{11}}$$

$$\tilde{u}_{45} = \frac{u_{45}}{u_{11}}, \tilde{\varphi} = \varphi + \log u_{45}$$

$$\Psi = d \log u_{45} \wedge d \log u_{33} = \frac{1}{u_{11}} (u_{45} + u_{33})$$

b_n

$$\xi = W|_{0,0}$$

$$W = (\gamma_n)^n (D_{11} - 2_{11})$$

BRST

$$Q = \lambda^* D_{11}$$

$$Q^2 = \lambda \gamma^* \lambda \gamma \Rightarrow \lambda \gamma^* \lambda = 0$$

$$\{Q, \lambda^* A\} =$$

$$\lambda = e^{\psi/\hbar}$$

$$\lambda_{e1} = \lambda u_{e1}$$

$$\lambda_e = \lambda (u_{e1} u_{e3} - u_{e2} u_{e4} + u_{e3} u_{e4})$$

λ_e

$$U \cap U_{e1} \cap U_{e3}$$

+++++ → +++ - -

$$\tilde{u}_{e1} = \frac{u_{e1}}{u_{e4}}, \quad \tilde{u}_{e3} = \frac{u_{e3}}{u_{e4}}, \quad \tilde{u}_{e4} = \frac{u_{e4}}{u_{e4}}$$

$$\tilde{u}_{e4} = \frac{1}{u_{e4}}, \quad \tilde{\varphi} = \varphi + \log u_{e4}$$

$$\Psi = d \log u_{e1} \wedge d \log u_{e3} = \tilde{\varphi}_1 \wedge \tilde{\varphi}_3 + \tilde{\varphi}_4$$

$$b_n = d\tilde{\varphi} \wedge d \log \tilde{u}_{e1} = d\varphi \wedge d \log u_{e1}$$

BRST

$$Q = \lambda^\dagger D_\lambda$$

$$Q^2 = \lambda \gamma^\dagger \lambda \gamma \Rightarrow \lambda \gamma^\dagger \lambda = 0$$

$$\{0, \lambda^\dagger A, \lambda\} = 0$$

$$\lambda = e^{\psi}$$

$$\lambda_{c1} = \lambda u_{c1}$$

$$\lambda_c = \lambda (u_{c1} u_{c2} - u_{c2} u_{c1} + u_{c2} u_{c3})$$

λ_c

U_1, U_{c1}, U_{c2}

$$\lambda_{c1} = -\frac{1}{\lambda} (\lambda_{c1} \lambda_{c2}) \epsilon^{c1c2}$$

++++ \rightarrow +++--

$$\tilde{u}_{c1} = \frac{u_{c1}}{u_{c2}}, \quad \tilde{u}_{c2} = \frac{u_{c2}}{u_{c3}}, \quad \tilde{u}_{c3} = \frac{u_{c3}}{u_{c4}}$$

$$\tilde{u}_{c3} = \frac{u_{c3}}{u_{c4}}, \quad \tilde{\varphi} = \varphi + \log u_{c4}$$

$$\Psi = d \log u_{c1} \wedge d \log u_{c2} - \frac{1}{2} \log u_{c1} \cdot \log u_{c2}$$

$$b_{c1} = d\tilde{\varphi} \wedge d \log \tilde{u}_{c1} - d\varphi \wedge d \log u_{c1}$$

$$\lambda = e^{\varphi/2}$$

$$\lambda_{e1} = \lambda u_{e1}$$

$$\lambda_{e2} = \lambda (u_{e1} u_{e2} - u_{e2} u_{e1} + u_{e2} u_{e2})$$

λ_2

$$U_1 U_{e1} U_{e2}$$

$$\lambda_{e1} = -\frac{1}{\lambda} (\lambda_{e1} \lambda_{e2}) \epsilon^{abde}$$

++++ → +++--

$$\tilde{u}_{e1} = \frac{u_{e1}}{u_{e1}}, \quad \tilde{u}_{e2} = \frac{u_{e2}}{u_{e2}}, \quad \tilde{u}_{e3} = \dots$$

$$\tilde{u}_{e4} = \frac{u_{e4}}{u_{e4}}, \quad \tilde{\varphi} = \varphi + \log u_{e4}$$

$$\Psi = d \log u_{e4} \wedge d \log u_{e5} = \dots$$

$$b_n = d\tilde{\varphi} \wedge d \log \tilde{u}_{e1} = d\varphi \wedge d \log u_{e1}$$

$\int U, \lambda_{e1} = 0$



$$\lambda = e^{\varphi}$$

$$\lambda_{11} = \lambda u_{11}$$

$$\lambda_{12} = \lambda (u_{11} u_{22} - u_{21} u_{12} + u_{21} u_{12})$$

λ_2

$$U_1 U_{22} U_{33}$$

$$\lambda_{11} = -\frac{1}{\lambda} (\lambda_{11} \lambda_{22}) \epsilon^{ab cd}$$

++++ → +++--

$$\tilde{u}_{12} = \frac{u_{12}}{u_{22}}, \quad \tilde{u}_{13} = \frac{u_{13}}{u_{33}}, \quad \tilde{u}_{23} = \frac{u_{23}}{u_{33}}$$

$$\tilde{u}_{45} = \frac{u_{45}}{u_{55}}, \quad \tilde{\varphi} = \varphi + \log u_{45}$$

$$\Psi = d \log u_{45} \wedge d \log u_{55} = b_n \wedge (b_1 + b_2)$$

$$b_n = d \tilde{\varphi} \wedge d \log \tilde{u}_{11} = d \varphi \wedge d \log u_{11}$$

$\{0, \lambda H_2, 5 = 0$



$$N^{\mu\nu} = \omega \gamma^{\mu\nu} \lambda$$

$$\mathcal{J} = \omega \lambda$$



$$N^{mn} = \omega \gamma^{mn} \lambda$$

$$\mathcal{J} = \omega \lambda$$

$$N^{mn} = \omega \gamma^{mn} \lambda$$

$$\mathcal{J} = \omega \lambda$$

φ, \mathcal{P}

u_{ab}, v^{ab}

N^{ab}

N_{ab}

N_a^b



$$N^{mn} = \omega \gamma^{mn} \lambda$$

$$\mathcal{J} = \omega \lambda$$

φ, P

u_{ab}, v^{ab}

$$N^{ab} = v^{ab}$$

$$N_{ab} = u_{ac} v^{cb} + \delta_{ab} \left(2\varphi - \frac{1}{2} P \right)$$

$$N_a^b$$

$$\mathcal{J} = \omega \lambda$$

φ, ρ

u_{ab}, v^{ab}

$$N^{ab} = v^{ab}$$

$$N_{ab} = u_{ac} v^{cb} + \delta_{ab} \left(2\varphi - \frac{1}{2}\rho \right)$$

$$N_{ab} = -\frac{1}{2} \delta_{ab} \rho + u_{ab} (2\varphi - \rho) + v_{ab} u_{ab}$$

$$J = \omega \lambda$$

φ, P

u_{ab}, v^{ab}

$\frac{so(10)}{u(5)} \times \mathbb{C}^4$

$$\begin{cases}
 N^{ab} = v^{ab} \\
 N_{ab} = u_{ac} v^{cb} + \delta_{ab} (2\varphi - \frac{1}{2}P) \\
 N_{ab} = -3\partial u_{ab} + u_{ab} (2\varphi - P) + v u \varphi
 \end{cases}$$

$J =$



$$J = \omega \lambda$$

φ, P

u_{ab}, v^{ab}

$\frac{so(10)}{u(5)} \times \mathbb{C}^4$

$$so(10) \left\{ \begin{array}{l} N^{ab} = v^{ab} \\ N_{ab} = u_{ac} v^{cb} + \delta_{ab} (2\varphi - \frac{1}{2}P) \\ N_{ab} = -\cancel{3} u_{ab} + u_{ab} (2\varphi - P) + v u_{ab} \end{array} \right.$$

$$J = P + 2\varphi$$

$$K = -4$$



$$J = \omega \lambda$$

φ, P

u_{ab}, v^{ab}

$$\frac{SO(10)}{U(5)} \times \mathbb{C}^4$$

$$\frac{SO(2n)}{U(n)} \times \mathbb{C}^4$$

$$SO(10) \left\{ \begin{array}{l} N^{ab} = v^{ab} \end{array} \right.$$

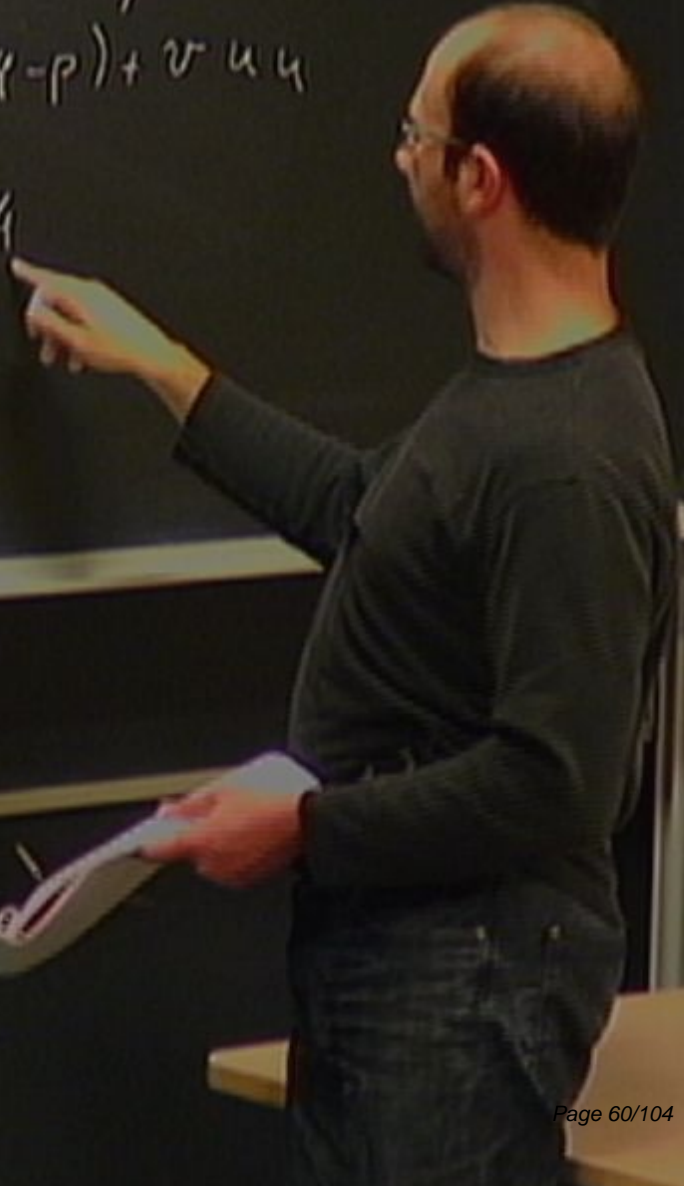
$$N_{ab} = u_{ac} v^{cb} + \delta_{ab} (2\varphi - \frac{1}{2}P)$$

$$N_{ab} = -\frac{1}{2} \delta_{ab} (2\varphi - P) + v u_{ab}$$

$$K = -3$$

$$J = P + 2\varphi$$

$$K = -4$$



$$T = \frac{1}{2(K+h)}$$



$$T = \frac{1}{2(k+h)} (N_1^k N_1^h - N_1^k N_1^h) + \frac{1}{8} JJ + 2J$$

$$C = n(n-1) + 2$$

$$T = \frac{1}{2(k+h)} (N_k^k N_h^k - N_{k+h}^{k+h}) + \frac{1}{8} J J + 2J$$

$$C = n(n-1) + 2 = 22 \quad n=5$$

$$T = \frac{1}{2(k+h)} (N_2^k N_1^k - N_{2k} N^{(k)}) + \frac{1}{T} \Gamma \Gamma + \partial J$$

$$C = n(n-1) + 2 = 22 \quad n=5$$

$$\Omega = e^{4\psi} d\psi \wedge \prod_{i=1}^n du_i$$

$$T = \frac{1}{2(k+h)} (N_e^k N_b^k - N_{e,b} N^{(k)}) + \frac{1}{\delta} J J + \partial J$$

$$C = n(n-1) + 2 = 22 \quad n=5$$

$$\Omega = e^{4\varphi} d\varphi \wedge \prod_{i=1}^n du_{i1} = d^{(11)} \Omega$$

$$T = \frac{1}{2(k+h)} (N_1^k N_1^k - N_{2k} N^{2k}) + \frac{1}{8} J J + 2J$$

$$C = n(n-1) + 2 = 22 \quad n=5$$

$$\Omega = e^{4\varphi} d\varphi \wedge \prod_{i=1}^n du_i = \frac{d^{4n} \lambda}{\lambda^2}$$

Unklass

$$\Psi = d \log u_{ss} \wedge d \log u_{ss} = \frac{1}{2} d \log u_{ss}^2$$
$$b_n = d \tilde{q} \wedge d \log \tilde{q} = \frac{1}{2} d \log \tilde{q}^2$$

$$T = \{Q, b\}$$



Univ. 11/15

$$\Psi = d \log u_{15} \wedge d \log u_{35} = b_1 \wedge b_2$$
$$b_1 \rightarrow d \tilde{q} \wedge d \log \tilde{u}_{15} = d \log u_{15}$$

$$T = \{Q, b\} \quad b \sim 0$$

Unkennlich

$$\Psi = d \log u_{ss} \wedge d \log u_{ss} = \text{hat } \text{hat}$$
$$b_n = d \tilde{Q} \wedge d \log u_{ss} = \text{hat } \wedge d \log u_{ss}$$

$$T = \{Q, b\} \quad b \sim 0$$

$$b = \sum_i b^{(i)}$$



Unkennlich

$$\Psi = d \log u_{ss} \wedge d \log u_{ss} = \text{Bilform}$$
$$b_n = d \log u_{ss} - 1 \wedge d \log u_{ss}$$

$$T = \{Q, b\} \quad b \sim 0$$

$$\delta b = \sum_{\dots} b^{(n)}$$

$b^{(n)}$
 $b^{(m)}$



Unkennlich

$$\Psi = d \log u_{ss} \wedge d \log u_{ss} = \text{Bilieblich}$$
$$b_n = d \log u_{ss} - d \log u_{ss}$$

$$T = \{Q, b\}$$

$$bb \sim 0$$

$\bar{\partial}$

$\bar{\lambda}$

$$\delta b = \sum_{\dots} b^{\dots}$$

$$b^{(n)}$$

$$b^{(m)}$$

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Unkennlich

$$\Psi = d \log u_{ss} \wedge d \log u_{ss} = \text{Bilform}$$
$$b_n = d\tilde{\varphi} \wedge d \log u_{ss} = 1\varphi \wedge d \log u_{ss}$$

$$T = \{Q, b\} \quad bb \sim 0$$

$$\delta b = \sum_{\dots} b^{(n)}$$

$$H^1(\Omega') = H^1_{\tilde{\varphi}}$$

$\bar{\varphi}$ λ

CAUTION

Unkennlich

$$\Psi = d \log u_{15} \wedge d \log u_{35} = \text{Bilform}$$
$$b_n = d\tilde{\varphi} \wedge d \log \tilde{u}_n = d\varphi \wedge d \log u_{15}$$

$$T = \{Q, b\} \quad bb \sim 0$$

$$\delta b = \sum_{\dots} b^{\dots}$$

$$b^{(1)}$$

$$b^{(n)}$$

$$H^1(\Omega') = H^1_{\tilde{\varphi}}$$

$\bar{\partial}$

$$\bar{\lambda}, \bar{w} \leftarrow g_{h=0}$$

$$r, s \leftarrow g_{h=-1}$$

$U \cap U_{ss} \cap U_{ss}$

$$\Psi = d \log u_{ss} \wedge d \log u_{ss} = b \wedge \tilde{b} \wedge \tilde{b}$$
$$b_n = d\tilde{q} \wedge d \log \tilde{u}_{ss} - d\varphi \wedge d \log u_{ss}$$

$$T = \{Q, b\} \quad b \sim 0$$

$$\delta b = \sum_{\dots} b^{(n)}$$

$$H^1(\Omega') = H^1_{\tilde{b}}$$

$$\bar{\partial} \quad \lambda, \bar{w} \leftarrow g \neq 0 \quad \text{conn}$$
$$r, s \leftarrow \dots \quad \text{at \infty}$$

$$\bar{\partial} = r$$

Unkennlich

$$\Psi = d \log u_{15} \wedge d \log u_{35} = \text{Bilieblich}$$
$$b_n \rightarrow d\bar{\varphi} \wedge d \log \bar{u}_n - d\varphi \wedge d \log u_n$$

$$T = \{Q, b\} \quad bb \sim 0$$

$$\delta b = \sum_{\dots} b^{(n)}$$

$$H^1(\Omega') = H^1_{\bar{\partial}}$$

$$\bar{\partial} \quad \lambda, \bar{w} \leftarrow g_{h=0} \quad \text{conn}$$
$$r, s \leftarrow g_{h=1} \quad \text{aktconn}$$
$$\bar{\partial} = r, \bar{w}^* \quad Q_{\text{ann}} \quad \bar{\partial}$$

Unkennlich

$$\Psi = d \log u_{ss} \wedge d \log u_{ss} = \text{Bilform}$$

$$b_n \rightarrow d\tilde{\varphi} \wedge d \log \tilde{u}_n - \text{Hilf} \wedge d \log u_{ss}$$

$$T = \{Q, b\} \quad bb \sim 0$$

$$\delta b = \sum_{\dots} b^{(n)}$$

$$H^1(\Omega') = H^1_{\bar{\partial}}$$

$$\bar{\partial} = \begin{matrix} r, \bar{w} \\ \bar{\lambda}, \bar{s} \end{matrix} \quad Q_{\text{neu}} = Q + \bar{\partial}$$

$$\lambda \gamma^* \bar{s} = 0 \quad \bar{s} \gamma^* r = 0$$

$$\bar{\lambda}, \bar{w} \leftarrow \gamma^* h = 0 \quad \text{comp}$$

$$r, \bar{s} \leftarrow \gamma^* h = 1 \quad \text{alt}$$



CAUTION

Unkennliss

$$\Psi = d \log u_{ss} \wedge d \log u_{ss} = \text{flat}$$

$$b_n \rightarrow d\bar{\varphi} \wedge d \log u_{ss} = d\varphi \wedge d \log u_{ss}$$

$$T = \{Q, b\} \quad bb \sim 0$$

$$\delta b = \sum_{\dots} b^{(n)}$$

$$H^1(\Omega') = H^1_{\bar{\partial}}$$

$\bar{\partial}$

$$\lambda, \bar{w} \leftarrow g_{h=0} \quad \text{conn}$$

$$r, s \leftarrow g_{h=1} \quad \text{not conn}$$

$$\bar{\partial} = \frac{r}{\lambda} \bar{w}^*$$

$$Q_{\text{em}} = Q + \bar{\partial}$$

$$= 0 \quad \text{not flat}$$

$$\rho = \frac{\lambda}{\bar{\lambda}}$$

$$\sum \rho = 1$$

$$\Psi^{n, \dots} \mapsto \sum \Psi^{n, \dots}$$

$$\sum \gamma^* \bar{\gamma} = 0 \quad \sum \gamma^* r = 0$$

$U \cap U_{ss} \cap U_{ss}$

$\Psi = d \log u_{ss} \wedge d \log u_{ss} = \text{flat}$
 $b_n \rightarrow d\bar{\varphi} \wedge d \log u_{ss} = d\varphi \wedge d \log u_{ss}$

$T = \{Q, b\} \quad b \sim 0$

$\delta b = \sum_{i=1}^n b^{(i)}$

$H^1(\Omega') = H^1_{\bar{\partial}}$

$\bar{\partial} \quad \lambda, \bar{w} \leftarrow g h = 0 \quad \text{conn}$
 $r, s \leftarrow g h = 1 \quad \text{not conn}$

$\bar{\partial} = \frac{r}{\lambda} \bar{w} \quad Q_{\text{ann}} = Q + \bar{\partial}$
 $= 0 \text{ on } U_{ss}$

$\psi^{n-2} \mapsto \sum_i \psi^{i-2} p_i \bar{\partial} p_i \dots \bar{\partial} p_i$

Unkennliss

$$\Psi = d \log u_{15} \wedge d \log u_{25} = \text{Bilform}$$

$$b_n \rightarrow d\bar{\varphi} \wedge d \log u_{15} - d\varphi \wedge d \log u_{25}$$

$$T = \{Q, b\} \quad bb \sim 0$$

$$\delta b = \sum_{\dots} b^{(n)}$$

$$H^1(\Omega') = H^1_{\bar{\partial}}$$

$$\bar{\partial} \quad \lambda, \bar{w} \leftarrow g_{11} = 0 \quad \text{conn}$$

$$r, s \leftarrow g_{12} = 1 \quad \text{not conn}$$

$$\bar{\partial} = r_s \bar{w}^s \quad Q_{\text{ann}} = Q + \bar{\partial}$$

$$= 0 \text{ auf } U_{15}$$

$$U_{15} \quad \rho_{15} = \frac{\bar{\lambda}_s \bar{\lambda}^s}{\lambda \lambda}$$

$$\sum \rho_i = 1$$

$$\Psi^{n-2} \mapsto \sum_i \Psi^{i-2} \rho_i \bar{\partial} \rho_{i+1} \bar{\partial} \rho_i$$

$$|g| = \frac{\partial x^i}{\partial x'^j}$$

$$B_{ab} = 2, \gamma_i, \gamma_j, \mu_{ab}$$

$$\mu = \mu_{ab} \delta^{ab}$$

$$d\mu = \text{tr}(g^{-1} dg)$$

$\sum =$

WS fields x, θ, p, λ, w

$$S = \int dx \partial x + p_a \partial \theta^a + \dot{p}_a \partial \bar{\theta}^a + w \partial \lambda + \dot{w} \partial \bar{\lambda}$$

$b \partial c$

$$c = -2$$

$$+ 2$$

$$c = 10$$

$$C = -32$$

$$C = 22$$



$$|g| = \frac{\partial x^i}{\partial \bar{x}^i}$$

$$B_{ab} = 2, \delta, 2, \delta, \mu, \nu$$

$$\mu = \mu_{ab} \delta^{ab}$$

$$d\mu = \text{tr}(g^{-1} d g)$$

$$\bar{z} = \frac{\bar{\lambda} \theta}{\lambda \bar{\lambda} + \nu \theta} = \sum \frac{\lambda \theta}{(\lambda \bar{\lambda})^2}$$

$$\{Q, \bar{z}\} = 1$$

$$P_C = 0$$

$$C = \{Q, \nu \theta\}$$

WS fields $x, \theta, p, \lambda, \nu$

$$S = \int \theta x \partial x + p_\mu \partial$$

$b \partial c$

$$c = -\frac{2}{+2}$$

$\partial \bar{z}$

$$\bar{z} e^{\mu} + \nu e^{\nu}$$



$$|g| = \frac{\partial x^i}{\partial \lambda^i}$$

$$B_{\mu\nu} = 2, g, 2, g, \mu, \nu$$

$$\mu = \mu_{\alpha\beta} \delta^{\alpha\gamma} \lambda^{\beta\gamma}$$

$$d\mu = \text{tr}(g^{-1} d g)$$

$$\int \frac{\lambda \theta}{\lambda \lambda + \nu \theta} = \int \frac{\lambda \theta}{(\lambda \lambda)^{n+1}} (\nu \theta)^n \frac{1}{(\lambda \lambda)^n}$$

$\{Q, \tilde{Q}\} = 1$
 $Q \subset -0$
 $C = \{Q, \nu \theta\}$

W.S fields x, θ, p, λ, w

$$S = \int \theta x \partial x + p_\alpha \partial \theta^\alpha + \tilde{p}_\alpha \partial \bar{\theta}^\alpha + w \partial \lambda + \tilde{w}_\alpha \partial \tilde{\lambda}^\alpha$$

$b \partial c$

$$c = -2$$

$$+2$$

$$Q = 10$$

$$C = -32$$

$$C = 22$$



$$|g| = \frac{\partial x^i}{\partial \bar{x}^i}$$

$$B_{\mu\nu} = 2, \delta, 2, \delta, \mu, \nu$$

$$\mu = \mu_{\nu\sigma} \delta^{\nu\sigma}$$

$$d\mu = \text{tr}(\delta^{-1} d\delta)$$

$$\int \frac{\lambda \theta}{\lambda \bar{\lambda} + \nu \theta} = \sum \frac{\lambda \theta}{(\lambda \bar{\lambda})^{n+1}} (\theta)^n \frac{1}{(\lambda \bar{\lambda})^n}$$

$$\{Q, \bar{Q}\} = 1$$

$$P_C = 0$$

$$C = \{Q, \nu \theta\}$$

W.S. fields x, θ, p, λ, w

$$S = \int \theta x \partial x + p_x \partial \theta^x + \bar{p}_x \partial \bar{\theta}^x + w \partial \lambda^x + \bar{w}_x \partial \bar{\lambda}^x$$

$b \partial c$

$$c = -2$$

$$+2$$

$$c_1 = 10$$

$$c_2 = -32$$

$$c_3 = 22$$



Unkennlich

$$\Psi = d \log u_{45} \wedge d \log u_{35} = \text{Hilfshilfe}$$

$$b_{45} = d \log u_{45} - d \log u_{35} = d \log u_{45} - d \log u_{35}$$

$$T = \{Q, b\}$$

$$bb \sim 0$$

$\bar{\partial}$

$$\lambda \gamma^* \bar{\partial} = 0 \quad \gamma^* r = 0$$

$\lambda, \bar{w} \leftarrow \gamma^* h = 0$ conn
 r, s ...

$$P \cdot b = S^k$$

ERLEN

ERLEN

Unknullss

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = \text{flat connection}$$

$$b_n = d\tilde{\varphi} \wedge d \log \tilde{u}_n = d\varphi \wedge d \log u_{1s}$$

$$T = \{Q, b\} \quad bb \sim 0$$

∂

$$\lambda \gamma^* \bar{\lambda} = 0 \quad \lambda \gamma^* r = 0$$

$\bar{\lambda}, \bar{w} \leftarrow \gamma^* h = 0$ conn
 r s... value

$$P \cdot b = S^* \partial \bar{\lambda}^* + \frac{\bar{\lambda} d \dots}{\lambda \bar{\lambda}} + \frac{\lambda \gamma d}{(\lambda \bar{\lambda})^2} + \dots + \frac{(a \gamma^* r)(\lambda \bar{\lambda} \gamma^* r)}{(\lambda \bar{\lambda})^2}$$

[Faded handwritten notes and scribbles on the chalkboard]



Unk₁U₂₅

$$\Psi = d \log u_{15} \wedge d \log u_{25} = \frac{1}{2} \frac{1}{u_{15} u_{25}} (u_{15}^2 + u_{25}^2 - u_{15}^2 - u_{25}^2)$$

$$b_n = d\tilde{\varphi} \wedge d \log \tilde{u}_n = d\varphi \wedge d \log u_{15}$$

$$T = \{Q, b\}$$

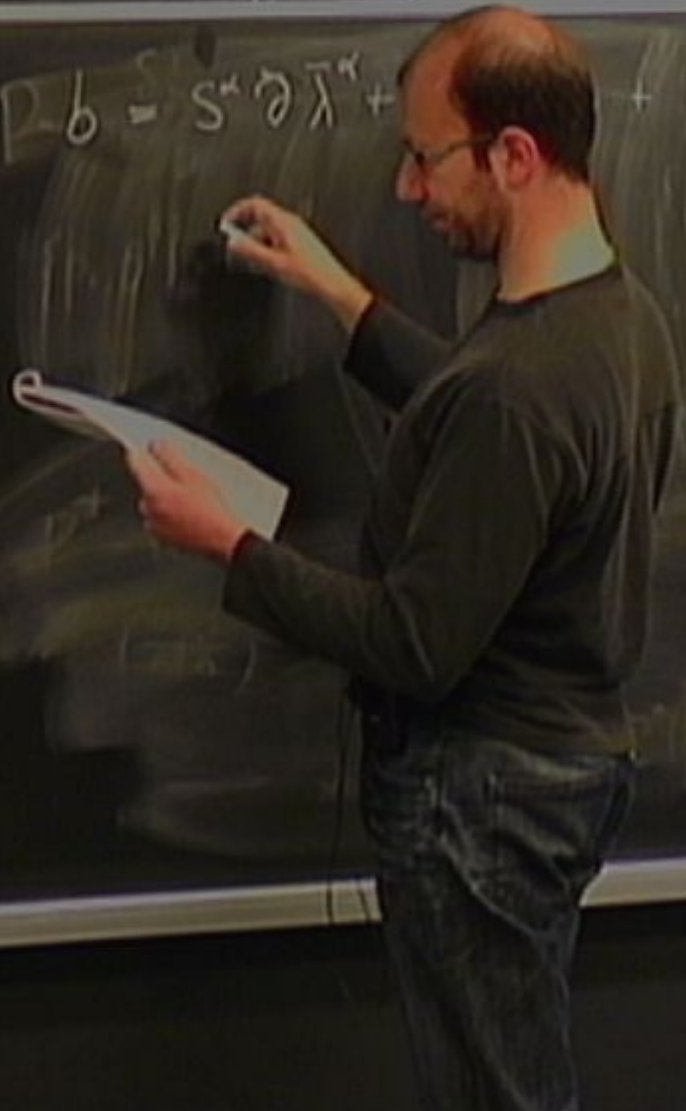
$$bb \sim 0$$

$\bar{\partial}$

$$\lambda \gamma^* \bar{\gamma} = 0 \quad \lambda \gamma^* r = 0$$

$\bar{\lambda}, \bar{w} \leftarrow \gamma^* h = 0$ conn
 r s. ...

$$Rb = S^* \bar{\partial} \bar{\lambda}^x + \frac{d\gamma^d}{(\lambda \gamma)^d} + \dots + \frac{(a\gamma^2)(\bar{\lambda}\gamma^2)}{(\lambda \gamma)^2}$$



Unknullss

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = b_1 + i b_2$$

$$b_n = d \tilde{\varphi} \wedge d \log \tilde{u}_n - d \varphi \wedge d \log u_{1s}$$

$$T = \{Q, b\} \quad bb \sim 0$$

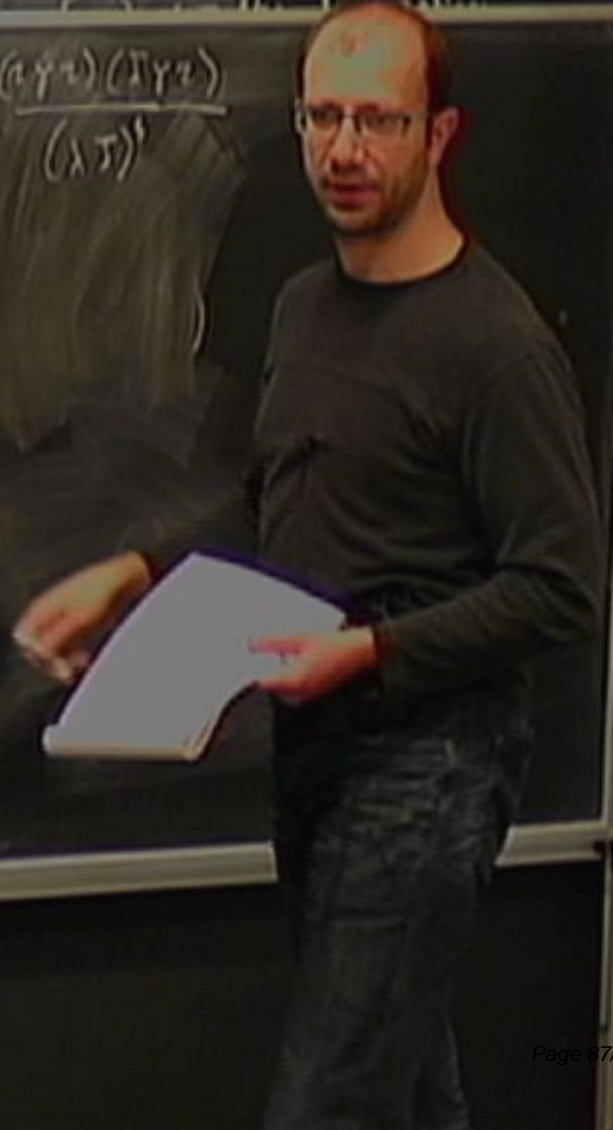
$\bar{\partial}$

$$\lambda \gamma^* \bar{\lambda} = 0 \quad \lambda \gamma^* r = 0$$

$\bar{\lambda}, \bar{w} \leftarrow \gamma^* h = 0$ conn
 r s something value

$$P \cdot b = S^{\alpha} \partial \bar{\lambda}^{\alpha} + \frac{\bar{\lambda} d \dots}{\lambda \bar{\lambda}} + \frac{d \gamma d}{(\lambda \bar{\lambda})^2} + \dots + \frac{(a \gamma^* r)(\bar{\lambda} \gamma^* r)}{(\lambda \bar{\lambda})^2}$$

$$\Omega = \frac{d^2 \lambda}{\lambda^2} \quad w. \ 11g$$



Unknullss

$$\Psi = d \log u_{15} \wedge d \log u_{35} = b_{11} + b_{12} + b_{13}$$

$$b_{11} = d\tilde{\varphi} \wedge d \log \tilde{u}_{11} = d\varphi \wedge d \log u_{15}$$

$$T = \{Q, b\} \quad bb \sim 0$$

$$\bar{\partial} \quad \bar{\lambda}, \bar{w} \leftarrow \gamma \bar{h} = 0 \quad \text{conn}$$

$$\bar{\lambda} \gamma^{\mu} \bar{\lambda} = 0 \quad \bar{\lambda} \gamma^{\mu} \bar{r} = 0$$

$$P \cdot b = S^{\alpha} \partial \bar{\lambda}^{\alpha} + \frac{\bar{\lambda} d \dots}{\lambda \bar{\lambda}} + \frac{d \gamma d}{(\lambda \bar{\lambda})^2} + \dots \quad \frac{(a \gamma v)(\bar{\lambda} \gamma v)}{(\lambda \bar{\lambda})^2}$$

$$\Omega = \frac{d^2 \lambda}{\lambda^2}$$

w. 11g

$$D\lambda D\bar{w} = \Omega^{2-3}$$

Unknullss

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = \frac{1}{2} \tilde{u}_1 \tilde{u}_2$$

$$b_n = d\tilde{\varphi} \wedge d \log \tilde{u}_n = d\varphi \wedge d \log u_{1s}$$

$$T = \{Q, b\} \quad bb \sim 0$$

∂

$$\lambda \gamma^a \bar{\lambda} = 0 \quad \lambda \gamma^a r = 0$$

$\lambda, \bar{\lambda} \in \mathbb{C}^2$ conn
 $r \in \mathbb{C}^2$ null vector

$$P \cdot b = S^\alpha \partial \bar{\lambda}^\alpha + \frac{\lambda d \dots}{\lambda \bar{\lambda}} + \frac{d \gamma d}{(\lambda \bar{\lambda})^2} + \dots \frac{(a \gamma r)(\lambda \gamma r)}{(\lambda \bar{\lambda})^3}$$

$$\Omega = \frac{d^2 \lambda}{\lambda^3}$$

w. 11g

$$D\lambda D\bar{\lambda} = \Omega^{1-3}$$

$$D\bar{\lambda} D\bar{w} D r D s = \bar{\Omega}^{1-3}$$

Unkennlich

$$\Psi = d \log u_{15} \wedge d \log u_{35} = \frac{1}{2} \frac{d^2 u_{15}}{u_{15}^2} + \dots$$

$$b_n = d^2 \log u_{15} - d \log u_{15} \wedge d \log u_{35}$$

$$\lambda \gamma^* \bar{\lambda} = 0 \quad \lambda \gamma^* \gamma = 0$$

$$R_b = S^{\alpha} \partial \bar{\lambda}^{\alpha} + \frac{\lambda d \dots}{\lambda \bar{\lambda}} + \frac{d \gamma d}{(\lambda \bar{\lambda})^2} + \dots \frac{(\alpha \gamma^* \gamma)(\lambda \gamma^* \gamma)}{(\lambda \bar{\lambda})^3}$$

$$\Omega = \frac{d^2 \lambda}{\lambda^3} \quad \text{w. } 11g$$

$$D \lambda D \bar{\lambda} = \Omega^{2-3}$$

$$D \bar{\lambda} D \bar{\lambda} D \gamma D \delta = \bar{\Omega}^{2-3}$$

$$\bar{\Omega} = d^2 \lambda d^2 \bar{\lambda} - 11$$

$$g \delta \pi = -3(1-g)$$

ENTEN

Nullvektor

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = b_1 + i b_2$$

$$b_1 = d \log u_{1s} \wedge d \log u_{2s} - d \log u_{1s}$$

$$\Omega = \frac{d^2 \lambda}{\lambda^2}$$

$\lambda \Sigma$

$w_1 \quad 11g$

$$D\lambda D\omega = \Omega^{2-3}$$

$(\lambda \Sigma)^2$

$$D\bar{\lambda} D\bar{\omega} D\tau Ds = \bar{\Omega}^{2-3} \quad \bar{\Omega} = d^2 \Sigma d^2 F - 11$$

$$g^{\frac{1}{2}} \kappa = -3(11-g)$$

$$A = \int_{M_{3N}} d^{3g-3} \tau dz_i \quad \prod b(\omega_i)$$

Unkennlich

$$\Psi = d \log u_{15} \wedge d \log u_{25} = b_{11} + b_{12} + b_{13}$$

$$b_{11} = d \log u_{15} \wedge d \log u_{25} = d \log u_{15}$$

$$\Omega = \frac{d^2 \lambda}{\lambda^2}$$

$$\lambda \Sigma$$

$$D \lambda D \omega = \Omega^{2-3}$$

$$D \bar{\lambda} D \bar{\omega} D \tau D s = \bar{\Omega}^{2-3}$$

$$\bar{\Omega} = d^2 \lambda d^2 \bar{\omega} - 11$$

$$Q \int V d_4 = 0$$

$$g^{\dagger \dagger} = -3(11-3)$$

$$A = \int_{M_{3,1}} d^3 z \tau dz \prod_{i=1}^3 b(\omega_i) \prod_{i=1}^3 V_i(z_i)$$

Unknullss

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = b_1 + i b_2$$

$$b_1 = d \tilde{\varphi} \wedge d \log \tilde{u}_1 - d \varphi \wedge d \log u_{1s}$$

$$\Omega = \frac{d^2 \lambda}{\lambda^2}$$

$$\lambda \Sigma$$

$$(\lambda \Sigma)$$

$$(\lambda \Sigma)^2$$

$$D\lambda D\omega = \Omega^{2-\beta}$$

$$D\bar{\lambda} D\bar{\omega} D\tau Ds = \bar{\Omega}^{2-\beta}$$

$$\bar{\Omega} = d^* \Sigma d^* F - 11$$

$$Q \int V d_4 = 0$$

$$g^{\frac{1}{2}} \# = -3(1-\beta)$$

$$A = \left\langle \int_{M_{3N}} d^{3\beta-3} z_i \prod_{i=1}^{3N} b(\omega_i) \prod_{i=1}^{3N} V_i(z_i) \right\rangle$$

Unkennlich

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = \tilde{h}_1 + i \tilde{h}_2$$

$$b_n = d \tilde{g}_n \wedge d \log \tilde{u}_n - d \log \wedge d \log u_{1s}$$

$$\Omega \Rightarrow \frac{d^2 \lambda}{\lambda^2}$$

$$w_n = 12g$$

$$D\lambda D\bar{w} = \Omega^{2-3}$$

$$D\bar{\lambda} D\bar{w} D\tau Ds = \bar{\Omega}^{2-3}$$

$$\bar{\Omega} = d^* \bar{\lambda} d^* F - 11$$

$$g^{\frac{1}{2}} \mu = -3(1-g)$$

$$A = \int_{M_{3g-3}} d^{3g-3} z_i$$

$$\prod_{i=1}^{3g-3} b(\omega) \prod_{i=1}^{3g-3} V_i(z_i) e^{\{Q, z_i\}}$$

$$\lambda = \bar{\lambda}$$

Unknullung

$$\Psi = d \log u_{15} \wedge d \log u_{35} = b_n + \tilde{b}_n + \tilde{b}_n$$

$$b_n = d\tilde{\varphi} \wedge d\log \tilde{u}_n = d\tilde{\varphi} \wedge d \log u_{15}$$

$$\Omega = \frac{d^3 \lambda}{\lambda^3}$$

$$w = 12g$$

$$D\lambda D\bar{\lambda} = \Omega^{1-3}$$

$$D\bar{\lambda} D\bar{\lambda} D\lambda D\lambda = \bar{\Omega}^{1-3}$$

$$\bar{\Omega} = d^3 \bar{\lambda} d^3 \lambda = -11$$

$$Q \int \nu_{d_0} = 0$$

$$g \frac{1}{2} \mu = -3(1-g)$$

$$A = \int_{M_{3g-3}} d^{3g-3} z_i$$

$$\prod_{i=1}^{3g-3} b(\omega_i)$$

$$\prod_{i=1}^{3g-3} V_i(z_i) e^{\langle \rho, \chi \rangle}$$

$$\chi = \sum \lambda_i \theta_i^*$$

Nullvektor

$$\Psi = d \log u_{15} \wedge d \log u_{25} = \eta_1 + \eta_2 + \eta_3$$

$$b_n = d \tilde{\varphi}_n \wedge d \log \tilde{u}_n = d \varphi_n \wedge d \log u_{15}$$

$$\Omega = \frac{d\lambda}{\lambda^2}$$

$w_1 = 1/2g$

$$D\lambda D\omega = \Omega$$

$$D\tilde{\lambda} D\tilde{\omega} D\tau Ds = \tilde{\Omega}$$

$$\tilde{\Omega} = d^2 \lambda d^2 \tau - 11$$

$$R \int V d\omega = 0$$

$$g^{\frac{1}{2}} \# = -3(1-g)$$

$$A = \iint_{M_{3N}} d^{3N-3} \tau dz_i$$

$$\prod_{i=1}^N b(\omega) \prod_{i=1}^N V_i(z_i) e^{\sum \rho_i \lambda}$$

$$\chi = \tilde{\lambda}_2 \theta^k + \dots$$

Unkennlich

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = b_1 + i b_2$$

$$b_1 = d \tilde{\varphi} \wedge d \log \tilde{u}_1 - d \varphi \wedge d \log u_{1s}$$

$$\Omega = \frac{d\lambda}{\lambda^2}$$

W. 128

$$D\lambda D\omega = \Omega^{1,1}$$

$$D\tilde{\lambda} D\tilde{\omega} D\tilde{\nu} D\tilde{s} = \tilde{\Omega}^{1,1}$$

$$\tilde{\Omega} = d\tilde{\lambda} d\tilde{\omega} - \tilde{\nu} \tilde{s}$$

$$Q \int \nu d\omega = 0$$

$$g^{\frac{1}{2}} \# = -3(11-g)$$

$$A = \int_{M_{3N}} d^{3N-3} z_i$$

$$\prod_{i=1}^{3N} \frac{b(\omega)}{(\lambda \tilde{\omega})} \prod_{i=1}^{3N} V_i(z_i) e^{\langle \Omega, \chi \rangle}$$

$$\frac{1}{(\lambda \tilde{\omega})}$$

$$\chi = \tilde{\lambda} \tilde{\omega}^{\otimes 3} + \dots$$

$$b(\omega)$$

Nullvektor

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = b_{11} + b_{12} + b_{21} + b_{22}$$

$$b_{11} = d \log u_{1s} \wedge d \log u_{1s} = 0$$

$$\Omega = \frac{d\lambda}{\lambda^2}$$

W. 128

$$D\lambda D\omega = \Omega^{2-3}$$

$$D\tilde{\lambda} D\tilde{\omega} D\tau Ds = \tilde{\Omega}^{2-3}$$

$$\tilde{\Omega} = d^2 \tilde{\lambda} d^2 \tilde{\omega} - 11$$

$$Q \int \gamma d\omega = 0$$

$$g^{\mu\nu} = -3(11-g)$$

$$A = \int_{M_{3N}} d^{3N-3} z_i$$

$$\prod_{i=1}^N \frac{b(\omega_i)}{(\lambda_i)^{1/2}} \prod_{i=1}^N V_i(z_i) e^{\{Q, \chi\}}$$

$$\chi = \tilde{\lambda}_i \theta^i + \dots$$

$$\frac{1}{(\lambda_i)^{1/2}} = \frac{1}{(\lambda_i + \epsilon)^{1/2}} \frac{1}{(\lambda_i - \epsilon)^{1/2}}$$

Unkennlich

$$\Psi = d \log u_{15} \wedge d \log u_{25} = \tilde{h}_1 + \tilde{h}_2 + \tilde{h}_3$$

$$b_n = d \tilde{\varphi}_n \wedge d \log \tilde{u}_n = d \varphi_n \wedge d \log u_n$$

$$\Omega = \frac{d^n}{\lambda^n}$$

$w_n = 1 \pm 1$

$$D\lambda D\omega = \Omega$$

$$D\tilde{\lambda} D\tilde{\omega} D\tilde{\tau} D\tilde{s} = \tilde{\Omega}^{-1-3} \quad \tilde{\Omega} = d^n \tilde{\lambda} d^n \tilde{\tau} \quad -11$$

$$Q \int \tilde{v}_n = 0$$

$$g^{\frac{1}{2}} \# = -3(1-g)$$

$$A = \int_{H_{3g}} d^{3g-3} \tau dz_i$$

$$\prod_{i=1}^{3g} b(\omega_i) \prod_{r=1}^n V_r(z_r) e^{\{Q, \chi\}}$$

$$\chi = \tilde{\lambda}_n \theta^{\chi} + \dots$$

$$\frac{1}{(\tilde{\lambda})^n} \Big|_{\tilde{\lambda} = \tilde{\lambda} + \epsilon} = \frac{1}{(\tilde{\lambda} + \epsilon)^n} = \frac{1}{\tilde{\lambda}^n} \left(1 - \frac{n\epsilon}{\tilde{\lambda}} + \dots \right)$$

Unknullss

$$\Psi = d \log u_{1s} \wedge d \log u_{2s} = \tilde{h}_1 + \tilde{h}_2 + \tilde{h}_3$$

$$b_n = d \tilde{\varphi}_n \wedge d \log \tilde{u}_n - d \varphi_n \wedge d \log u_n$$

$$\Omega = \frac{d^n}{\lambda^n}$$

$w_n = 1 \pm \delta$

$$D\lambda D\bar{\lambda} = \Omega$$

$$D\bar{\lambda} D\tilde{\lambda} D\tilde{\lambda} D\lambda = \bar{\Omega}^{-1-3}$$

$$\bar{\Omega} = d^n \tilde{\lambda} d^n \tilde{F}^{-1-1}$$

$$Q \int \tilde{V}_n = 0$$

$$g^{\frac{1}{2}} \# = -3(1-g)$$

$$A = \left\langle \int_{H_{3g}} d^{3g-3} z_i \right\rangle$$

$$\prod_{i=1}^{3g-3} \frac{b(\omega_i)}{(\bar{\lambda})^n} \prod_{r=1}^n V_r(z_r) e^{\langle \rho, \chi \rangle}$$

$$\chi = \bar{\lambda}_v \theta^x + \dots$$

$$\frac{1}{(\lambda \bar{\lambda})^n} = \frac{1}{(\lambda \bar{\lambda} + \epsilon)^n} \frac{1}{(\lambda \bar{\lambda})^n}$$

$$|g| = \frac{\partial x}{\partial x'}$$

$$B_{ab} = 2, g, 2, g, \mu, \mu, \mu, \mu$$

$$\mu = \mu_{ab} g^{ab}$$

$$d\mu = \text{tr}(g^{-1} dg)$$

$A_{g,4}$



WS fields x, θ, p, λ, w

$$S = \int \theta \dot{x} + p_a \dot{\theta}^a + \beta_a \dot{\bar{\theta}}^a + w \dot{\lambda} + \dot{w}_a \dot{\lambda}^a$$

$b \partial_c$

$$c = -2$$

$$+ 2$$

$$c = 10$$

$$c = -32$$

$$c = 22$$

$$c =$$



$$|g| = \frac{\partial x^\mu}{\partial x'^\nu}$$

$$B_{ab} = 2, \delta, 2, 2, \dots, \mu_{ab}$$

$$\mu = \mu_{ab} \delta^{ab}$$

$$d\mu = \text{tr}(g^{-1} d g)$$

$$= \int d^{16} \theta \int d^{11} v \int \mathcal{H} \mathcal{S} d^4 p \cdot \langle \psi^{35-7} \nu^{-4} \rangle$$

x, θ, p, λ, w

$$\int \partial x \partial x + p_\alpha \partial \theta^\alpha + \beta_\alpha \partial \bar{\theta}^\alpha + w \partial \lambda + \dot{w}_\alpha \partial \dot{\lambda}^\alpha$$

-2
+2
C = 10
C = -32
C = 2
C = 2



$$|g| = \frac{\partial x^i}{\partial \tau^i}$$

$$B_{\mu\nu} = 2, \delta, 2, \gamma, \mu, \nu$$

$$\mu = \mu_{\alpha\beta} \delta^{\alpha\gamma} \lambda^{\beta\gamma}$$

$$d\mu = \text{tr}(\delta^{-1} d\delta)$$

$$A_{g,4} = \int d^{16}\theta \int d^{11}x \int \sqrt{g} d^4p \cdot \langle \delta^{35-2} \mathcal{V}^{-4} \rangle$$

$$\mathcal{V} = d_\alpha W^\alpha \sim \int d^{16}\theta \theta^{12-2\beta} W^\beta \rightarrow \partial^{2\beta} R^4$$

W.S. fields x, θ, p, λ, w

$$S = \int \partial x \partial x + p_\alpha \partial \theta^\alpha + \dot{p}_\alpha \partial \bar{\theta}^\alpha + \underbrace{w \partial \lambda + \dot{w} \partial \dot{\lambda}}_{\text{triangle diagram}}$$

$b \partial c$

$$c = -2$$

$$+2$$

$$c = 10$$

$$c = -32$$

$$c = 2$$

$$c = 2$$



$$|g| = \frac{2\lambda}{\lambda^2}$$

$$B_{\mu\nu} = 2, \delta, 2, 2, \dots, \mu_{\nu\sigma}$$

$$\mu = \mu_{\nu\sigma} \delta^{\nu\sigma}$$

$$d\mu = \text{tr}(\delta^{-1} d\delta)$$

$$A_{g,4} = \int d^{16}\theta \int d^4x \int \mathcal{H} \mathcal{L} \mathcal{P} \cdot \langle \mathcal{G}^{35-2} \mathcal{V}^{-4} \rangle$$

$$\mathcal{V} = d_\alpha W^\alpha \sim \int d^{16}\theta \theta^{12-2j} W^4 \rightarrow \mathcal{G}^{2j} \mathbb{R}^4 \quad \underline{\mathcal{G}^{12} \mathbb{R}^4}$$

W.S. fields x, θ, p, λ, w

$$S = \int \partial x \bar{\partial} x + p_\alpha \bar{\partial} \theta^\alpha + \bar{p}_\alpha \partial \bar{\theta}^\alpha + w \bar{\partial} \lambda + \bar{w}_\alpha \partial \lambda^\alpha$$

$b \partial c$

$$c = -2$$

$$+2$$

$$c = 10$$

$$c = -32$$

$$c = 22$$

