

Title: Beta-gamma systems and quantum Koszul resolution

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Abstract:

Feb-14/0602 . Grass, GP

Feb-14/0602 Grassi, GP

1. Paraspiner quantification

Feb-14/0602 Gross, QP

1. Paraspiner quantization
2. Beta-gamma system
- 3.

Feb-14/0602 Gross, GP

1. Paraspiner quantization
2. Beta-gamma system
3. Kernel resolution

Feb-14/0602 Grass, GP

45 finden x^{μ}, θ^{μ}

1. Paraspinner quantization
2. Beta-gamma system
3. Koszul resolution



Feb-14/0602 Grassi, GP

GS function x^{μ}, θ^{α} 10/2-14/2011

1. Paraspiner quantization
2. Beta-gamma system
3. Kac-Moody algebras



Feb-14/0602 Grass, GP

1. Paraspiner quantization
2. Bethe-ansatz system
3. Kosterlitz renormalization

GS function $x^{\uparrow}, 0^{\uparrow}$ 10 J. - 10 p. 1000

$$\frac{16}{8 \cdot 2}$$

Feb. 14/0602 Grass, GP

1. Paraspiner quantization
2. Beta-gamma system
3. Kowal resolution

GS function x^{μ}, θ^{α} 10/1-10/10/11

$$\frac{17}{8 \cdot 8}$$

Ses $dh = p_x - \frac{1}{2}(\theta \gamma^{-1})^2 x_m + \theta^3$



Feb-14/0602 Grass, GTP

1. Paraspiner quantization
2. Bethe-ansatz system
3. Kosterlitz renormalization

GS function x^m, θ^m 10 d. - 14 pages

$$\frac{\pi}{s \cdot s}$$

See $dx = p_x - \frac{1}{2}(\theta_x - 1) \dot{x} + \theta^3$

$$\{d_\alpha, d_\beta\} = \gamma_{\alpha\beta}^m \Pi_m$$

Feb 14/0602 Grass. GP

1. Paraspiner quantization
2. Beta-gamma system
3. Kowal resolution

GS function x^μ, θ^a 10 d. super

$$\begin{matrix} \overline{\psi} \\ s & s \end{matrix}$$

$$S_{GS} = p_\mu - \frac{1}{2}(\theta\gamma)^{\mu\nu} \partial_\nu x_\mu + \theta^3$$

$$\{d_\mu, d_\nu\} = \gamma_{\mu\nu}^\alpha \pi_\alpha$$

$$\pi_\mu = \partial x_\mu + \frac{1}{2}(\theta\gamma)^\mu \partial \theta$$



Feb 14/0602 Grass, GP

1. Paraspiner quantization
2. Beta-gamma system
3. Kowal resolution

GS fields x^μ, θ^a 10 d. super...

$$\begin{matrix} 16 \\ 8 & 8 \end{matrix}$$

Sec
$$d_t = p_\mu - \frac{1}{2}(\theta\gamma^m)\partial x_\mu + \theta^3$$

$$\{d_\mu, d_\nu\} = \gamma^m_{\mu\nu} \pi_m \quad \pi_m = \partial x_m + \frac{1}{2}(\theta\gamma^m)\partial\theta$$
$$\pi \cdot \pi = 0$$

Feb 14/0602 Grassi, GP

1. Paraspiner quantization
2. Beta-gamma system
3. Kac-Moody resolution

GS functions x^m, θ^s 10 d. super

$$\begin{matrix} 16 \\ 8 & 8 \end{matrix}$$

$$S_{GS} = \int dx = p_m - \frac{1}{2}(\partial_t \gamma^m) \partial x_m + \theta^s$$

$$\{d_\alpha, d_\beta\} = \gamma_{\alpha\beta}^m \pi_m$$

$$\pi_m = \partial x_m + \frac{1}{2}(\partial_t \gamma^m) \theta$$

$$\pi^m \pi_m = 0$$

$$\pi^m \gamma_m = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$$



Feb-14/0602 . Grass, QFT

1. Paraspiner quantization
2. Bethe-ansatz system
3. Kowal resolution

GS formalism x^μ, θ^a 10 d. super

$$\frac{1}{2} \frac{1}{p}$$

$$S_{GS} = \int dx^0 \left(p_x - \frac{1}{2} (\theta \dot{\gamma}) \dot{x}_\mu + \dot{\theta}^3 \right)$$

$$\{d_\alpha, d_\beta\} = \gamma_{\alpha\beta}^m \pi_m$$

$$\pi_m = \dot{x}_m + \frac{1}{2} (\theta \dot{\gamma}) \dot{\theta}$$

$$\pi^+ \pi_- = 0$$

$$\pi^+ \gamma_\mu = \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$$

$$\{K_\mu, \pi_\mu\} = 0$$

$$Q_{\text{NET}} = \lambda^{\text{net}} d_{\text{net}}$$

$$Q_{\text{inter}} = \lambda^m d_{\text{in}}$$

$$Q^2 = \lambda^m Y_{\text{op}} \lambda^m \pi_m$$

$$Q_{\text{BART}} = \lambda \sum c_k$$
$$Q^2 = \underbrace{X^T Y^T \lambda^T}_{\substack{= \\ 0}} \Pi_m$$



$$Q_{\text{bntt}} = \lambda^m d_m$$

$$Q^2 = \underbrace{\lambda^m Y_{m,p} \lambda^p}_{\text{0}} \pi_m$$

$$S_{\text{GS}} = \int \theta_k \sigma_k + p \partial \theta + \bar{p} \partial \bar{\theta} + \omega \partial \lambda + \bar{\omega} \partial \bar{\lambda} +$$

$$Q_{\text{data}} = \lambda^m d_m$$

$$Q^2 = \underbrace{X^T Y^{-1} X}_{\mathbf{0}} \Pi_m$$

$$S_{\text{LSS}} = \int \theta_k \sigma_k + p \gamma \theta + \beta \gamma \bar{\theta} + \omega \bar{\theta} \lambda + \epsilon \bar{\theta} \Sigma + Q(-)$$

$$Q_{\text{inter}} = \lambda^* d_{\lambda}$$

$$Q^2 = \underbrace{\lambda^* Y^* \lambda}_{=0}$$

$$S_{\text{reg}} = \int \theta_k \sigma_k + \dots + \beta \sigma \bar{\theta} + \omega \sigma \lambda + \epsilon \sigma \Sigma + Q(\cdot)$$

$$Q_{\text{net}} = \lambda^m d_m$$

$$Q^2 = \underbrace{\lambda^m Y_{-p}^m \lambda^p}_{\equiv 0} \pi_m$$

$$S_{\text{sys}} = \int \theta_x \delta x + p \delta \theta + \bar{p} \delta \bar{\theta} + w \delta \lambda + \bar{w} \delta \bar{\lambda} + Q(-)$$

$$Q_{\text{opt}} = \lambda^* d_x$$

$$Q^2 = \underbrace{\lambda^* Y_{-p}^* \lambda^*}_{\text{0}} \Pi_m$$

$$S_{\text{HS}} = \int \rho \delta x + p \delta \theta + \bar{p} \delta \bar{\theta} + w \delta \lambda + \bar{w} \delta \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^* A_2(x, \theta)$$

$\{0\}$

$$Q_{\text{input}} = \lambda^* d_{\text{in}}$$

$$Q^2 = \underbrace{\lambda^* Y_{-1} \lambda^*}_{\text{0}} \Pi_m$$

$$\lambda^* \lambda^* = \sum_i (Y^T)_{-1} (\lambda \delta_{-1} \lambda) =$$

$$S_{\text{sys}} = \int \left(\theta_x \sigma_x + p \sigma \theta + \bar{p} \sigma \bar{\theta} + w \delta \lambda + \sigma \delta \bar{\lambda} + Q(\cdot) \right)$$

$$U = \lambda^* A_{-1}(x, \theta)$$

$$\{Q, U\} =$$

$$Q_{\text{best}} = \lambda^* d_x$$

$$Q^2 = \underbrace{\lambda^* Y_{-p}^* \lambda^*}_{=0} \Pi_m$$

$$\lambda^* \lambda^* = \sum_i (Y^i)_{-p} (\Delta \delta_c \lambda) = (Y^*)_{-p} \lambda Y_{-p} \lambda$$

$$S_{45} = \int \rho x \sigma x + p \partial \theta + \bar{p} \partial \bar{\theta} + \omega \partial \lambda + \bar{\omega} \partial \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^* A_2(x, \theta) \quad \{Q, U\} =$$

$$Q_{\text{best}} = \lambda^* d_{\text{best}}$$

$$Q^2 = \underbrace{\lambda^* Y_{-p}^T \lambda^*}_{\text{0}} \Pi_m$$

$$S_{\text{HS}} = \int \theta_x \delta x + p \delta \theta + \bar{p} \delta \bar{\theta} + w \delta \lambda + \bar{w} \delta \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^* A_2(x, \theta)$$

$$\{Q, U\} =$$

$$\lambda^* \lambda^* = \sum_i (Y^T)_{-p} (\lambda \delta_i \lambda) = \begin{matrix} (Y^T)_{-p} \lambda \delta_i \lambda \\ (Y^T)_{-p} \lambda \delta_i \lambda \dots m \delta_i \lambda \end{matrix}$$

$$Q_{\text{best}} = \lambda^x d_x$$

$$Q^2 = \underbrace{\lambda^x Y_{\text{opt}}^x \lambda^x}_{\text{0}} \pi_m$$

$$\lambda^x \lambda^x = \sum_i (Y^i)_{\text{opt}} (\lambda^x \delta_i \lambda) = \frac{(Y^i)_{\text{opt}} \lambda^x \lambda}{(Y^i)_{\text{opt}} \lambda^x \lambda^{\dots m} \lambda}$$

$$S_{45} = \int \theta^x \sigma^x + p \partial \theta + \bar{p} \partial \bar{\theta} + \omega \partial \lambda + \bar{\omega} \partial \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^x A_x(x, \theta)$$

$$\{Q, U\} =$$

$$\frac{SO(10)}{U(5)}$$

$$Q_{\text{best}} = \lambda^k d_k$$

$$Q^2 = \underbrace{\lambda^k Y_{-1}^T \lambda^l}_{\text{0}} \pi_m$$

$$\lambda^k \lambda^l = \sum_i (Y^i)_{-1} (\lambda^k \delta_i \lambda^l) = \frac{(Y^i)_{-1} \lambda^k \lambda^l}{(1^m - \alpha^i)_{-1} \lambda^k \lambda^l \dots \lambda^m \lambda}$$

$$S_{45} = \int \theta_k \delta x + p \partial \theta + r \partial \bar{\theta} + w \partial \lambda + \bar{w} \partial \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^k A_k(x, \theta)$$

$$\{Q, U\} =$$

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

$$Q_{\text{Dirac}} = \lambda^\alpha d_\alpha$$

$$Q^2 = \underbrace{\lambda^\alpha \gamma_{\alpha\beta} \lambda^\beta}_{\equiv 0} \pi_m$$

$$S_{45} = \int \left(\theta_x \sigma_x + p \partial \theta + \bar{p} \partial \bar{\theta} + w \partial \lambda + \bar{w} \partial \bar{\lambda} + Q(\cdot) \right)$$

$$U = \lambda^\alpha A_\alpha(x, \theta)$$

$$\{Q, U\} = \lambda^\alpha \lambda^\beta D_\alpha A_\beta$$

$$\lambda^\alpha \lambda^\beta = \sum_i (\gamma^i)_{\alpha\beta} (\lambda \gamma_i \lambda) = \frac{(\gamma^i)_{\alpha\beta} \lambda \gamma_i \lambda}{(1^{n-1} \dots n)_{\alpha\beta} \lambda \gamma^{n-1} \dots n \lambda}$$

$$\frac{SO(10)}{U(5)} \times U^1$$

$$Q_{\text{matter}} = \lambda^{\mu} d_{\mu}$$

$$Q^2 = \underbrace{\lambda^{\mu} \gamma_{\mu}^{\nu} \lambda^{\rho}}_{\text{0}} \pi_{\nu}$$

$$\lambda^{\mu} \lambda^{\nu} = \sum_{\alpha} (\gamma^{\alpha})_{\mu\nu} (\lambda^{\alpha} \delta_{\alpha} \lambda) = \frac{(\gamma^{\alpha})_{\mu\nu} \lambda^{\alpha} \lambda}{(\gamma^{\alpha} \delta_{\alpha})_{\mu\nu} \lambda^{\alpha} \lambda^{\alpha} \dots m \lambda}$$

$$S_{45} = \int \theta_{\mu\nu} \delta x^{\mu} + p^{\mu} \delta \theta_{\mu} + \bar{p}^{\mu} \delta \bar{\theta}_{\mu} + \omega \delta \lambda + \bar{\omega} \delta \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^{\mu} A_{\mu}(x, \theta)$$

$$\{Q, U\} = \lambda^{\mu} \lambda^{\nu} D_{\mu} A_{\nu} = 0$$

$$\gamma^{\mu\nu} D_{\mu} A_{\nu} = 0$$

$\frac{SO(10)}{U(5)} \times U^1$

$$Q_{\text{brst}} = \lambda^m d_m$$

$$Q^2 = \underbrace{\lambda^m \gamma_{m-p} \lambda^p}_{0} \pi_m$$

$$S_{\text{HS}} = \int \left(\theta^x \delta x + p \delta \theta + \bar{p} \delta \bar{\theta} + w \delta \lambda + \bar{w} \delta \bar{\lambda} + Q(\cdot) \right)$$

$$U = \lambda^m A_m(x, \theta)$$

$$\{Q, U\} = \lambda^m \lambda^p D_m A_p = 0$$

$$\gamma^{m-n} D_m A_n = 0$$

$$\lambda^m \lambda^p = \sum_r (\gamma^r)_{m-p} (\lambda \delta_r \lambda) = \frac{(\gamma^m)_{m-p} \lambda \gamma_{m-p}}{(\gamma^{m-m})_{m-p} \lambda \gamma^{m-m-p} \lambda}$$

$$\frac{SO(10)}{U(5)} \times \mathcal{L}$$

$$N=1 \text{ SYM}_{10d}$$

$$Q_{\text{Dirac}} = \lambda^{\alpha} d_{\alpha}$$

$$Q^2 = \underbrace{\lambda^{\alpha} \gamma_{\alpha}^{\mu} \lambda^{\beta}}_{\equiv 0} \pi_{\mu}$$

$$S_{45} = \int \theta \times \sigma \times + p \partial \theta + \bar{p} \partial \bar{\theta} + \omega \partial \lambda + \bar{\omega} \partial \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^{\alpha} A_{\alpha}(x, \theta)$$

$$\lambda^{\alpha} \lambda^{\beta} = \sum_{\gamma} (\gamma^{\alpha} \gamma^{\beta})_{\alpha\beta} (\lambda^{\gamma} \gamma_{\gamma} \lambda) = \frac{(\gamma^{\alpha} \gamma^{\beta})_{\alpha\beta} \lambda^{\gamma} \gamma_{\gamma} \lambda}{(\gamma^{\alpha} \gamma^{\beta})_{\alpha\beta} \lambda^{\gamma} \gamma_{\gamma} \lambda}$$

$$\frac{SO(10)}{U(5)} \times U(1)$$

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

$$N=1 \text{ SYM}_{10d}$$

$$U A_{\alpha} = 0$$

$$Q_{\text{Dirac}} = \lambda^\alpha d_\alpha$$

$$Q^2 = \underbrace{\lambda^\alpha \gamma_{\alpha\beta} \lambda^\beta}_{\equiv 0} \pi_m$$

$$S_{45} = \int \left(\theta_x \bar{\theta}_x + p \bar{\theta} \theta + \bar{p} \theta \bar{\theta} + \omega \bar{\theta} \lambda + \bar{\omega} \theta \bar{\lambda} + Q(\cdot) \right)$$

$$U = \lambda^\alpha A_\alpha(x, \theta)$$

$$\lambda^\alpha \lambda^\beta = \sum_r (\gamma^r)_{\alpha\beta} (\lambda \gamma_r \lambda) = \frac{(\gamma^r)_{\alpha\beta} \lambda \gamma_r \lambda}{(\gamma^{m-1})_{\alpha\beta} \lambda \gamma^{m-1} \lambda}$$

$\frac{SO(10)}{U(5)} \times U(1)$

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

$$\gamma^{m-1} \lambda^\alpha D_\alpha A_\beta = 0$$

SYM

$$U A_\alpha = 0$$

$$A_\alpha = (\theta \gamma^\alpha \lambda)_m +$$

$$Q_{\text{matter}} = \lambda^{\mu} d_{\mu}$$

$$Q^2 = \underbrace{\lambda^{\mu} \gamma_{\mu}^{\nu} \lambda^{\rho}}_0 \pi_{\nu}$$

$$S_{\text{g.s.}} = \int \theta_{\mu} \sigma_{\mu} + p \partial \theta + \bar{p} \partial \bar{\theta} + \omega \partial \lambda + \bar{\omega} \partial \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^{\mu} A_{\mu}(x, \theta)$$

$$\lambda^{\mu} \lambda^{\nu} = \sum_{\alpha} (\gamma^{\alpha})_{\mu\nu} (\lambda \gamma_{\alpha} \lambda) = \frac{(\gamma^{\alpha})_{\mu\nu} \lambda \gamma_{\alpha} \lambda}{(\gamma^{\alpha} \gamma^{\beta})_{\mu\nu} \lambda \gamma^{\beta} \lambda \dots m_5 \lambda}$$

$$\frac{SO(10)}{U(5)} \times U(1)$$

$$\{Q, U\} = \lambda^{\mu} \lambda^{\nu} D_{\mu} A_{\nu} = 0$$

$$\gamma^{\mu} \gamma^{\nu} D_{\mu} A_{\nu} = 0$$

$$U A_{\mu} = 0$$

$$A_{\mu} = (\theta \gamma^{\mu})_{\alpha} \lambda^{\alpha} + \theta^2 \psi + \dots$$

$$Q_{\text{Dirac}} = \lambda^\alpha d_\alpha$$

$$Q^2 = \underbrace{\lambda^\alpha \gamma_{\alpha\beta} \lambda^\beta}_{=0} \pi_m$$

$$S_{\text{HS}} = \int \left(\theta_\mu \sigma^\mu + p \partial \theta + \bar{p} \partial \bar{\theta} + w \bar{\psi} \lambda + \bar{\psi} \partial \bar{\lambda} + Q(\cdot) \right)$$

$$U = \lambda^\alpha A_\alpha(x, \theta)$$

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

$$\gamma^{\alpha\beta} D_\alpha A_\beta = 0$$

$$U A_\mu = 0$$

$$A_\mu (\theta \gamma^\mu \lambda + \theta^2 \psi + \dots)$$

$$\lambda^\alpha \lambda^\beta = \sum_i (\gamma^i)_{\alpha\beta} (\lambda \gamma_i \lambda) = \frac{(\gamma^i)_{\alpha\beta} \lambda \gamma_{i-1}}{(\gamma^{i-1})_{\alpha\beta} \lambda \gamma^{i-1} \dots \gamma^1 \lambda}$$

$\frac{SO(10)}{U(5)} \times U(1)$

SYM

$$Q_{\text{matter}} = \lambda^\mu d_\mu$$

$$Q^2 = \underbrace{\lambda^\mu \gamma_{\mu\nu} \lambda^\nu}_{=0} \pi_m$$

$$\lambda^\mu \lambda^\nu = \sum_r (\gamma^r)_{\mu\nu} (\lambda \gamma_r \lambda) = \begin{matrix} (\gamma^1)_{\mu\nu} \lambda \gamma_1 \lambda \\ (\gamma^{n-1})_{\mu\nu} \lambda \gamma^{n-1} \lambda \end{matrix}$$

$$S_{\text{GS}} = \int \theta \kappa \sigma \kappa + p \partial \theta + \bar{p} \partial \bar{\theta} + \omega \partial \lambda + \bar{\omega} \partial \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^\mu A_\mu(x, \theta)$$

$\partial x, \partial \theta$

$$\{Q, U\} = \lambda^\mu \lambda^\nu D_\mu A_\nu = 0$$

$$\gamma^{\mu\nu} D_\mu A_\nu = 0$$

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

$$\theta^i A_i = 0$$

$$A_i = (\theta^j \gamma^j)_i + \theta^i \psi_i + \dots$$



$$Q_{\text{matter}} = \lambda^{\mu} d_{\mu}$$

$$Q^2 = \underbrace{\lambda^{\mu} \gamma_{\mu}^{\nu} \lambda^{\rho}}_0 \pi_{\nu}$$

$$\lambda^{\mu} \lambda^{\nu} = \sum_{\alpha} (\gamma^{\alpha})_{\mu\nu} (\lambda^{\alpha} \gamma_{\alpha} \lambda) = \frac{(\gamma^{\alpha})_{\mu\nu} \lambda^{\alpha} \lambda}{(\gamma^{\alpha} \gamma_{\alpha})_{\mu\nu} \lambda^{\alpha} \gamma^{\alpha} \lambda}$$

$$S_{\text{GS}} = \int \theta x \sigma x + p \partial \theta + \bar{p} \partial \bar{\theta} + \omega \bar{\theta} \lambda + \bar{\omega} \partial \bar{\lambda} + Q(\cdot)$$

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

$$U = \lambda^{\mu} A_{\mu}(x, \theta)$$

$\gamma_{\mu} \gamma_{\nu}$

$$\{Q, U\} = \lambda^{\mu} \lambda^{\nu} D_{\mu} A_{\nu} = 0$$

$$\gamma^{\mu} \gamma^{\nu} D_{\mu} A_{\nu} = 0$$

$$N=1 \text{ SYM}_{10d}$$

$$\theta^{\mu} A_{\mu} = 0$$

$$A_{\mu}(0) \gamma^{\mu} \lambda_{\alpha} + \theta^{\mu} \psi_{\mu} \dots$$

$\langle \psi | \hat{H} | \psi \rangle$

$$\langle \lambda^x \lambda^y \lambda^z \alpha^a \theta_2 \alpha^b \theta_1, \alpha^c \theta_1, \theta \gamma_{m-1} \theta \rangle = 1$$



$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta_{z-1} \theta \rangle = 1$$



$$Q_{\text{Dirac}} = \lambda^{\alpha} d_{\alpha}$$

$$Q^2 = \lambda^{\alpha} \gamma_{\alpha}^{\mu} \lambda^{\beta} \pi_{\mu}$$

$$S_{45} = \int (\rho \delta x + p \delta \theta + \bar{p} \delta \bar{\theta} + \omega \delta \lambda + \bar{\omega} \delta \bar{\lambda} + Q(\cdot))$$

$$U = \lambda^{\alpha} A_{\alpha}(x, \theta)$$

$$\{Q, U\} = \lambda^{\alpha} \lambda^{\beta} T_{\alpha\beta}$$

$$U^{\alpha} A_{\alpha} = 0$$

$$A_{\alpha} = (\theta^{\mu} \gamma_{\mu\alpha} + \theta^{\beta} \gamma_{\beta\alpha})$$

$$\lambda^{\alpha} \lambda^{\beta} = \sum_{\gamma} (\gamma^{\alpha\beta})_{\gamma} (\lambda^{\gamma} \delta_{\gamma} \lambda) = (\gamma^{\alpha\beta})_{\gamma} \lambda^{\gamma} \lambda_{\gamma}$$

$$\frac{SO(10)}{U(5)} \times \mathcal{L}'$$

$$N=1 \text{ SYM } 10d$$

$$Q_{\text{Dirac}} = \lambda^{\alpha} d_{\alpha}$$

$$Q^2 = \lambda^{\alpha} \gamma_{\alpha} \lambda^{\beta} \pi_m$$

$$S_{\text{CS}} = \int \theta \wedge \sigma_x + p \sigma_0 + \bar{p} \sigma_0 + \omega \delta \lambda + \bar{\omega} \delta \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^{\alpha} A_{\alpha}(x, 0)$$

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

$$\int^{m, m} D_{\alpha} A_{\beta} = 0$$

$$U^{\alpha} A_{\alpha} = 0$$

$$A_{\alpha}(0) \lambda_{\alpha} + U^{\beta} \psi_{\beta} \dots$$

$$\lambda^{\alpha} \lambda^{\beta} = \sum_{\gamma} (\gamma^{\alpha} \gamma^{\beta})_{\alpha\beta} (\lambda^{\gamma} \delta_{\gamma} \lambda) = \frac{(\gamma^{\alpha} \gamma^{\beta})_{\alpha\beta} \lambda^{\gamma} \lambda_{\gamma}}{(\gamma^{\alpha} \gamma^{\beta})_{\alpha\beta} \lambda^{\gamma} \lambda_{\gamma} \dots m_{\gamma} \lambda}$$

$$\frac{SO(10)}{U(5)} \times \mathbb{C}^1$$

$$N=1 \text{ SYM}_{10d}$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta), (\gamma^y \theta), (\gamma^z \theta), \theta \gamma_{x+1} \theta \rangle = 1$$



$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta), (\gamma^y \theta), (\gamma^z \theta), \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega \lambda^x \sim$$



$$\langle X^1 X^2 X^3 (Y^1 0), (Y^2 0), (Y^3 0), 0 \dots 0 \rangle = 1$$

$$w_1^1 \sim \frac{S^1}{2}$$



$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta x}{2}$$

$$\delta \omega_x = \Lambda_x (\gamma^x \lambda)_x$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_a (\gamma^y \theta)_b (\gamma^z \theta)_c \theta_{\gamma_{m+1} 0} \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta x^i}{x^i}$$

$$\delta u_a = \Lambda_a (\gamma^m \lambda)_a$$

$$J = \omega_x \lambda^x$$

$$J^{m+1} = \mu$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta), (\gamma^y \theta), (\gamma^z \theta), \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_0 \lambda^x \sim \frac{\delta x}{2}$$

$$\delta \omega_0 = \Lambda_0 (\gamma^x \lambda)$$

$$J = \omega_0 \lambda^x$$

$$J^{xx} = \omega_0 (\gamma^{xx})$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta), (\gamma^y \theta), (\gamma^z \theta), \theta \gamma_{x-1} \theta \rangle = 1$$

$$\omega \lambda^x \sim \frac{\delta^x}{2}$$

$$\delta \omega_x = \Lambda_x (\gamma^x \lambda)_x$$

$$J = \omega_x \lambda^x$$

$$J^{xx} = \omega_x (\gamma^{xx})^x \lambda^x$$

$$\delta J =$$

$$\langle \lambda^{\mu} \lambda^{\nu} \lambda^{\rho} (\gamma^{\mu} \theta)_{\alpha} (\gamma^{\nu} \theta)_{\beta} (\gamma^{\rho} \theta)_{\gamma} \theta^{\delta} \gamma_{\delta\epsilon} \rangle = 1$$

$$\omega_{\mu} \lambda^{\mu} \sim \frac{\delta J}{\delta \lambda}$$

$$\delta \omega_{\mu} = \Lambda_{\mu} (\gamma^{\nu} \lambda)_{\nu}$$

$$J = \omega_{\mu} \lambda^{\mu}$$

$$J^{\mu\nu} = \omega_{\rho} (\gamma^{\mu\nu})^{\rho} \lambda^{\rho}$$

$$\delta J = 0$$

$$\delta J^{\mu\nu} = 0$$



$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{n+1} \theta \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta J}{\delta \lambda^x}$$

$$\delta \omega_x = \Lambda_x (\gamma^x \lambda)_x$$

$$J = \omega_x \lambda^x$$

$$J^{x\dots} = \omega_x (\gamma^{x\dots})^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{x\dots} = 0$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_b \lambda^x \sim \frac{\delta \mathcal{L}}{\delta \lambda^x}$$

$$\delta \omega_b = \Lambda_b (\gamma^m \lambda)_m$$

$$\mathcal{J} = \omega_b \lambda^x$$

$$\mathcal{J}^{x^m} = \omega_b (\gamma^{m+1})^x \lambda^x$$

$$\delta \mathcal{J} = 0$$

$$\delta \mathcal{J}^{x^m} = 0$$



$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta_{\gamma_{m+1}} \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta J^x}{\delta \lambda^x}$$

$$\delta \omega_x = \Lambda_x (\gamma^x \lambda)_x$$

$$J = \omega_x \lambda^x$$

$$J^{m+1} = \omega_x (\gamma^x \lambda)_x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{m+1} = 0$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta), (\gamma^y \theta), (\gamma^z \theta), \theta (\gamma_{m+1}, 0) \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta J^x}{\delta \lambda^x}$$

$$\delta \omega_x = \Lambda_x (\gamma^x \lambda)_x$$

$$J = \omega_x \lambda^x$$

$$J^{x+} = \omega_x (\gamma^{x+})^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{x+} = 0$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_a (\gamma^y \theta)_b (\gamma^z \theta)_c \theta_{\gamma_{m+1} 0} \rangle = 1$$

$$\omega_s \lambda^s \sim \frac{\delta J}{\delta \lambda}$$

$$\delta \omega_s = \Lambda_s (\gamma^s \lambda)_a$$

$$J = \omega_s \lambda^s$$

$$J^{ab} = \omega_s (\gamma^s \lambda)^a \lambda^b$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$Q = \lambda^s \lambda_s$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_0 \lambda^x \sim \frac{\delta J}{\delta \lambda^x}$$

$$\delta \omega_0 = \Lambda_0 (\gamma^m \lambda)_x$$

$$J = \omega_0 \lambda^x$$

$$J^{m+1} = \omega_0 (\gamma^{m+1})^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{m+1} = 0$$

$$Q = \lambda^x d_x + \zeta^m \pi_m + \gamma_x \partial \theta^x$$



$$\langle \lambda^a \lambda^b \lambda^c (\gamma^a \theta)_d (\gamma^b \theta)_e (\gamma^c \theta)_f, \theta \gamma_{a-1} \theta \rangle = 1$$

$$\omega_a \lambda^a \sim \frac{\delta J}{\delta \lambda^a}$$

$$\delta \omega_a = \Lambda_a (\gamma^a \lambda)_a$$

$$J = \omega_a \lambda^a$$

$$J^{ab} = \omega_a (\gamma^{ab})^c \lambda^c$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$Q = \lambda^a \lambda_a + \zeta^a \Pi_a + \gamma_a \theta \theta^a$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^0 \theta), (\gamma^1 \theta), (\gamma^2 \theta), \theta \gamma_{n+1} \theta \rangle = 1$$

$$\omega_2 \lambda^x \sim \frac{\delta^x}{2}$$

$$\delta \omega_a = \Lambda_a (\gamma^m \lambda)_a$$

$$J = \omega_b \lambda^b$$

$$J^{ab} = \omega_b (\gamma^{ab})^c \lambda^c$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$Q = \lambda^x d_a + \xi^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$Q^2 = 0$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^0 \theta)_x (\gamma^1 \theta)_y (\gamma^2 \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_0 \lambda^x \sim \frac{\delta J}{\delta \lambda^x}$$

$$\delta \omega_0 = \Lambda_\mu (\gamma^\mu \lambda)_x$$

$$J = \omega_0 \lambda^x$$

$$J^{x\mu} = \omega_0 (\gamma^\mu \lambda)^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{x\mu} = 0$$

$$Q = \lambda^x \lambda_x + \zeta^m \Pi_m + \chi_a \theta \theta^a + \dots$$

$$Q^2 = 0$$

$$\{ \lambda, \theta \} = \pi$$



$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma \theta \gamma_{m+1} \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \mathcal{L}}{\delta \lambda^\alpha}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\mu \lambda)_\mu$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\mu\alpha} = \omega_\alpha (\gamma^\mu \lambda)^\alpha$$

$$\delta J = 0$$

$$\delta J^{\mu\alpha} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$Q^2 = 0$$

$$\{d, d\} = \pi$$

$$\{d, \pi\} = \partial$$

$$\langle \lambda^a \lambda^b \lambda^c (\gamma^a \theta)_d (\gamma^b \theta)_e (\gamma^c \theta)_f \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_a \lambda^a \sim \frac{\sum_i^1}{2}$$

$$\delta \omega_a = \Lambda_m (\gamma^m \lambda)_a$$

$$J = \omega_a \lambda^a$$

$$J^{m+1} = \omega_a (\gamma^{m+1})_b \lambda^b$$

$$\delta J = 0$$

$$\delta J^{m+1} = 0$$

$$Q = \lambda^a d_a + \xi^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$Q^2 = 0$$

$$d_a = 0$$

$$\pi_m = 0$$

$$\{d, d\} = \pi$$

$$\{d, \pi\} = \partial$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma \theta \gamma_{\alpha\beta} \rangle = 1$$

$$\omega_2 \lambda^\alpha \sim \frac{\delta_\alpha^\beta}{2}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\mu \lambda)_\mu$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\mu \lambda^\mu$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$Q^2 = 0$$

$$\{d, d\} = \pi$$

$$\{d, \pi\} = \partial$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma \theta \gamma_{m\alpha} \theta \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \mathcal{L}}{\delta \lambda}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\mu \lambda)_\mu$$

$$\mathcal{J} = \omega_\alpha \lambda^\alpha$$

$$\mathcal{J}^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\mu \lambda^\mu$$

$$\delta \mathcal{J} = 0$$

$$\delta \mathcal{J}^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$Q^2 = 0$$

$$\{d, d\} = \pi$$

$$\{d, \pi\} = \partial$$

$$\pi \pi = \frac{1}{2}, \quad \partial \partial = \frac{1}{2}$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_s \lambda^s \sim \frac{\delta \mathcal{L}}{\delta \lambda^s}$$

$$\delta \omega_s = \Lambda_{rs} (\gamma^r \lambda)^s$$

$$J = \omega_s \lambda^s$$

$$J^{rs} = \omega_s (\gamma^r \lambda)^s \lambda^r$$

$$\delta J = 0$$

$$\delta J^{rs} = 0$$

$$Q = \lambda^x d_x + \xi^m \pi_m + \chi_a \partial \theta^a + \dots$$

+ C

$$\{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$1 \pi \sim \frac{1}{2^2}, \quad 1 \partial \theta \sim \frac{1}{2^2}$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_2 \lambda^x \sim \frac{\delta x^x}{x}$$

$$\delta \omega_2 = \Lambda_m (\gamma^m \lambda)_x$$

$$J = \omega_2 \lambda^x$$

$$J^{m+1} = \omega_2 (\gamma^{m+1})^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{m+1} = 0$$

$$Q = \lambda^x d_x + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c \cdot b(\zeta^m \zeta_{m+1}) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial$$

$$= \frac{1}{x}, \quad \delta \theta = \frac{1}{x}$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma \theta \gamma_{m\alpha} \theta \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{S_\alpha^2}{2}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\alpha \lambda)_\alpha$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\beta \lambda^\alpha$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \xi^m \pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c_1 (b(\xi \gamma \lambda \gamma)) \{d, d\} - \pi$$

$$\delta \theta = \dots, \delta \theta = \frac{1}{c^2}$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_\alpha (\gamma^y \theta)_\beta (\gamma^z \theta)_\gamma \theta_{\gamma_{m+1}} \rangle = 1$$

$$\omega_2 \lambda^{\alpha} \sim \frac{S^{\alpha}}{2}$$

$$\delta \omega_2 = \Lambda_m (\gamma^m \lambda)_\alpha$$

$$J = \omega_2 \lambda^{\alpha}$$

$$J^{\alpha\beta} = \omega_2 (\gamma^{\alpha\beta})_c \lambda^c$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^{\alpha} d_{\alpha} + \xi^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c_1 \epsilon_{\alpha\beta\gamma} (\gamma^{\alpha\beta})_{\gamma} \{d, d\} = \pi$$

$$Qb =$$

$$\frac{1}{2}, \int \partial \theta = \frac{1}{2}$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z, \theta \gamma_{m+1}, 0 \rangle = 1$$

$$\omega_p \lambda^p \sim \frac{\delta p}{\hbar}$$

$$\delta \omega_p = \Lambda_p (\gamma^m \lambda)_p$$

$$J = \omega_p \lambda^p$$

$$J^{m+1} = \omega_p (\gamma^{m+1})^p \lambda^p$$

$$\delta J = 0$$

$$\delta J^{m+1} = 0$$

$$Q = \lambda^x d_x + \xi^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c_1 b(\gamma^m \lambda^m) \{d, d\} - \pi$$

$$Qb = 1$$

$$Q\pi = 0$$

$$\dots, \delta \theta \sim \frac{1}{\hbar}$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma \theta \gamma_{\alpha\beta} \rangle = 1$$

$$\omega_2 \lambda^\alpha \sim \frac{\delta \alpha}{2}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\mu \lambda)_\mu$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\mu \lambda^\mu$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^\mu \pi_\mu + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c_1 (\delta \zeta^\mu \zeta_\mu) \{d, \pi\} = \pi$$

$$Qb = 1$$

$$Qv = 0$$

$$v = \kappa(bv)$$

$$\{d, \pi\} = \partial 0$$

$$\pi \pi = \frac{1}{2}, J^2$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma \theta \gamma_{m+1} \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \mathcal{L}}{\delta \lambda}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\mu \lambda)_\mu$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})^\mu \lambda^\mu$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$\tau \in \{ \delta(\zeta \gamma \lambda \gamma) \} \{d, \pi\} = \pi$$

$$Qb = 1 \quad \{d, \pi\} = \partial 0$$

$$Qv = 0 \quad v = \mathcal{N}(b, v) \quad \pi \pi = \frac{1}{2}, \quad \partial \theta = \frac{1}{2}$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma, \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \mathcal{L}}{\delta \lambda^\alpha}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\mu \lambda)_\mu$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\mu \lambda^\mu$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \Pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c_1 \epsilon (\zeta \partial \zeta + \lambda \partial \lambda) \{1, 2\} = \pi$$

$$\delta J^{\alpha\beta} = 0$$

$$Qb = 1$$

$$Qv = 0$$

$$v = Q(bv)$$

$$J^{\alpha\beta} = \frac{1}{2}$$

$$\lambda \quad \zeta \quad \chi \quad c$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^a \theta)_x (\gamma^b \theta)_y (\gamma^c \theta)_z, \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_2 \lambda^a \sim \frac{\delta \lambda^a}{2}$$

$$\delta \omega_a = \Lambda_a (\gamma^m \lambda)_a$$

$$J = \omega_a \lambda^a$$

$$J^{ab} = \omega_a (\gamma^a \gamma^b) \lambda^c$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$Q = \lambda^a d_a + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c_1 b (\gamma^a \gamma^b \lambda^c) \{d, \pi\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$Qb = 1$$

$$Q\pi = 0$$

$$v = N(b, v)$$

$$\pi \pi = \frac{1}{2}$$

λ	ζ	χ	c
4	2	3	4

$$\langle \lambda^a \lambda^b \lambda^c (\gamma^a \theta)_d (\gamma^b \theta)_e (\gamma^c \theta)_f \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_a \lambda^a \sim \frac{\delta_{ab}}{2}$$

$$\delta \omega_a = \Lambda_m (\gamma^m \lambda)_a$$

$$J = \omega_a \lambda^a$$

$$J^{ab} = \omega_a (\gamma^a \lambda)^b \lambda^c$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$Q = \lambda^a d_a + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c_1 (\delta \zeta^m \lambda^m) \{d, \pi\} = \pi$$

$$Q^2 = 1 \quad \{d, \pi\} = \partial$$

$$Q^3 = 0 \quad v = \omega(LU) \quad \pi \pi = \frac{1}{2}, \quad J^2 = \frac{1}{2}$$

λ	ζ	χ	c	
4	2	3	4	grading

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^a \theta)_x (\gamma^b \theta)_y (\gamma^c \theta)_z, 0 \gamma_{n-1}, 0 \rangle \gg 1$$

$$\omega_2 \lambda^a \sim \frac{\delta \omega^a}{2}$$

$$\delta \omega_a = \Lambda_a (\gamma^m \lambda)_x$$

$$J = \omega_a \lambda^a$$

$$J^{ab} = \omega_a (\gamma^{ab})_x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$Q = \lambda^a d_a + \zeta^m \Pi_m + \chi_a \partial \theta^a \dots$$

$$+ c \cdot b (\zeta^a \zeta^b + \lambda^a \lambda^b) \{d, d\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = Q(LU)$$

$$\{d, \pi\} = \partial 0$$

$$\pi \pi \sim \frac{1}{2^2}; \delta \pi 0 \sim \frac{1}{2}$$

λ	ζ	χ	c	
1	2	3	4	guiding

$$Q = \sum_{i=1}^4 Q_i$$

$$\delta w_n = \Lambda_n (\gamma^n \lambda)_n$$

$$J = w_n \lambda^n$$

$$J^{*n} = w_n (\gamma^{*n})^t \lambda^n$$

$$\delta J = 0$$

$$\delta J^{*n} = 0$$

$$Q = \Delta \dots$$

$$+ c \dots \{d, d\} = \pi$$

$$\{d, \pi\} = \partial_0$$

$$\pi \pi \sim \frac{1}{\epsilon^2}, \delta \pi \sim \frac{1}{\epsilon^2}$$

$$Qb = 1$$

$$Qv = 0 \quad v = \mathcal{H}(bU)$$

$$\lambda \quad \sum \quad \chi \quad c$$

$$c \quad 2 \quad 3 \quad 4 \quad \text{grading}$$

$$Q = \sum_{n=1}^4 Q(n)$$

$$\mathcal{H} = \mathcal{O} \dots$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \mathcal{L}}{\delta \lambda^\alpha}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^m \lambda)_\alpha$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})^\mu \lambda^\mu$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c + b(\zeta \gamma \zeta + \lambda \gamma \lambda) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$Qb = 1$$

$$Qc = 0$$

$$v = Q(bv)$$

$$\pi \pi \sim \frac{1}{2^2}, \delta \theta \sim \frac{1}{c^2}$$

λ	ζ	χ	c	
4	2	3	4	grading

$$Q = \sum_{\alpha} Q_\alpha$$

$$\mathcal{H} = \bigoplus \mathcal{H}_\alpha$$

$$\mathcal{H}_+ = \bigoplus_{\alpha > 0} \mathcal{H}_\alpha$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \omega^\alpha}{2}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\alpha \lambda)_\alpha$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\alpha \lambda^\beta$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \Pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c + b(\zeta^\alpha \zeta_\alpha + \lambda^\alpha \lambda_\alpha) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$Qb = 1$$

$$Qc = 0$$

$$v = Q(bv)$$

$$\pi \pi \sim \frac{1}{2^2}, \delta \pi \sim \frac{1}{2^2}$$

λ	ζ	χ	c	
4	2	3	4	grading

$$Q = \sum_{\alpha=0}^3 Q_\alpha$$

$$\mathcal{H} = \bigoplus_{\alpha=0}^3 \mathcal{H}_\alpha$$

$$\mathcal{H}_\pm = \bigoplus_{\alpha=0}^3 \mathcal{H}_\alpha^\pm$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma, \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \lambda^\alpha}{2}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\alpha \lambda)_\alpha$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\alpha \lambda^\beta$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c + b(\zeta \partial \zeta + \lambda \partial \lambda) \{d, \pi\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = Q(bv)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{\epsilon^2}, \partial \theta \sim \frac{1}{\epsilon^2}$$

λ	ζ	χ	c	
4	2	3	4	grading

$$Q = \sum_{\alpha} Q_\alpha$$

$$\mathcal{H} = \bigoplus_{\alpha} \mathcal{H}_\alpha$$

$$\mathcal{H}_+ = \bigoplus_{\alpha} \mathcal{H}_\alpha$$

$$H^*(Q, \mathcal{H}_+) = H^*$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma, \theta (\gamma^{\alpha\beta} \theta)_\alpha \theta \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \mathcal{L}}{\delta \lambda^\alpha}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^\mu \lambda)_\mu$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\mu \lambda^\mu$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c + b(\zeta \partial \zeta + \lambda \partial \lambda) \quad \{d, d\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = \mathcal{R}(bv)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi = \frac{1}{\epsilon^2}, \quad \partial \partial = \frac{1}{\epsilon^2}$$

λ	ζ	χ	c	
1	2	3	4	grading

$$Q = \sum_{\alpha} Q_\alpha$$

$$\mathcal{H} = \bigoplus_{\alpha} \mathcal{H}_\alpha$$

$$\mathcal{H}_+ = \bigoplus_{\alpha > 0} \mathcal{H}_\alpha$$

$$H^*(Q, \mathcal{H}_+) = H^*(\mathcal{H}_+, \mathcal{H}_+)$$

$$\langle \lambda^\alpha \lambda^\beta \lambda^\gamma (\gamma^\alpha \theta)_\alpha (\gamma^\beta \theta)_\beta (\gamma^\gamma \theta)_\gamma, \theta (\gamma_{m+1} \theta)_\gamma \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta J}{\delta \lambda}$$

$$\delta \omega_\alpha = \Lambda_{\alpha\beta} (\gamma^\beta \lambda)_\alpha$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\gamma})_\beta \lambda^\gamma$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \zeta^m \Pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c + b(\zeta^\alpha \zeta_\alpha + \lambda^\alpha \lambda_\alpha) \{d, d\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = Q(bv)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{2^2}, \delta \pi \sim \frac{1}{2^2}$$

λ	ζ	χ	c	
1	2	3	4	grading

$$Q = \sum_{\alpha} Q_{(\alpha)}$$

$$\mathcal{H} = \bigoplus \mathcal{H}_\alpha$$

$$\mathcal{H}_+ = \bigoplus_{\alpha \geq 0} \mathcal{H}_\alpha$$

$$H''(Q, \mathcal{H}_+) = H''(\mathcal{H}_+, \mathcal{H}_+)$$

$$\langle \lambda^a \lambda^b \lambda^c (\gamma^a \theta)_d (\gamma^b \theta)_e (\gamma^c \theta)_f \theta \chi_{m+1} \rangle = 1$$

$$\omega_a \lambda^a \sim \frac{\delta_a^i}{2}$$

$$\delta \omega_a = \Lambda_a (\gamma^m \lambda)_a$$

$$J = \omega_a \lambda^a$$

$$J^{ab} = \omega_a (\gamma^{ab})_c \lambda^c$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$Q = \lambda^a d_a + \xi^m \Pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c + b(\xi^a \xi_a + \lambda^a \lambda_a) \quad \{d, d\} = \Pi$$

$$\{d, \Pi\} = \partial_0$$

$$Qb = 1$$

$$Qc = 0$$

$$v = Q(bv)$$

$$\Pi \Pi = \frac{1}{2^2}, \quad \partial \partial_0 = \frac{1}{c^2}$$

$$\lambda \quad \xi \quad \chi \quad c$$

grading

$$Q = \sum_{a=0}^3 Q_a$$

$$\mathcal{K} = \bigoplus \mathcal{K}_a$$

$$\mathcal{K}_+ = \bigoplus_{a=0}^3 \mathcal{K}_a$$

$$H^4(Q, \mathcal{K}_+) = H^4(\mathcal{K}_+)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta_x^1}{2}$$

$$\delta \omega_x = \Lambda_x (\gamma^m \lambda)_x$$

$$J = \omega_x \lambda^x$$

$$J^{mn} = \omega_x (\gamma^{mn})_x^1 \lambda^x$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

$$Q = \lambda^x d_x + \xi^m \Pi_m + \chi_x \partial \theta^x + \dots$$

$$+ c + b(\xi^m \gamma_m + \lambda \partial x) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$Qb = 1$$

$$Qc = 0$$

$$v = Q(bv)$$

$$\pi \pi = \frac{1}{2^2}, \delta \theta = \frac{1}{2}$$

$$\lambda \quad \xi \quad \chi \quad c$$

$$Q = \sum_{i=1}^4 Q_i$$

$$\mathcal{K} = \bigoplus_{i=1}^4 \mathcal{H}_i$$

$$\mathcal{K}_+ = \bigoplus_{i=1}^4 \mathcal{H}_i$$

$$H''(Q, \mathcal{H}_i) = H''(Q_i, \mathcal{H}_i)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta \omega^x}{2}$$

$$\delta \omega_x = \Lambda_x (\gamma^m \lambda)_x$$

$$J = \omega_x \lambda^x$$

$$J^{mn} = \omega_x (\gamma^{mn})_x^y \lambda^y$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

$$Q = \lambda^x d_x + \xi^m \Pi_m + \chi_x \partial \theta^x + \dots$$

$$+ c + b(\xi \gamma \xi + \lambda \partial \chi) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$Qb = 1$$

$$Qv = 0$$

$$v = \chi(bv)$$

$$\pi \pi = \frac{1}{2^2}, \partial \theta = \frac{1}{c^2}$$

$$\lambda \quad \xi \quad \chi \quad c$$

$$Q = \sum_{i=1}^4 Q_{(i)}$$

$$\mathcal{K} = \bigoplus_{i=1}^4 \mathcal{K}_i$$

$$\mathcal{K}_+ = \bigoplus_{i=1}^4 \mathcal{K}_{i+}$$

$$H^1(Q, \mathcal{K}_i)$$

$$H^1(Q, \mathcal{K}_i) = H^1(Q, \mathcal{K}_i)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_0 \lambda^x \sim \frac{\delta \ell^x}{2}$$

$$\delta \omega_x = \Lambda_x (\gamma^m \lambda)_x$$

$$J = \omega_0 \lambda^x$$

$$J^{mn} = \omega_0 (\gamma^{mn})^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

$$Q = \lambda^x d_x + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c + b(\zeta^2 \zeta + \lambda \partial \chi) \quad \{d, d\} = \pi$$

$$Qb = 1 \quad \{d, \pi\} = \partial \theta$$

$$Q\pi = 0 \quad \pi \pi = \frac{1}{2}, \quad d \partial \theta = \frac{1}{2}$$

$$\lambda \quad \zeta \quad \chi \quad c$$

$$Q = \sum_{i=1}^4 Q_i$$

$$\mathcal{K} = \bigoplus \mathcal{H}_i$$

$$\mathcal{K}_+ = \bigoplus_{i=1}^4 \mathcal{H}_i$$

$$H^i(Q, \partial \ell_{rs})$$

$$H^i(Q, \mathcal{K}_+) = H^i(\mathcal{K}_+, \mathcal{K}_+)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^a \theta)_x (\gamma^b \theta)_y (\gamma^c \theta)_z \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta x^t}{2}$$

$$\delta \omega_x = \Lambda_{xy} (\gamma^m \lambda)_x$$

$$J = \omega_b \lambda^b$$

$$J^{mn} = \omega_x (\gamma^{mn})^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

$$Q = \lambda^x d_x + \zeta^m \Pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c \cdot b (\zeta \gamma \zeta + \lambda \gamma \lambda) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{2^2}, \quad d \partial \theta \sim \frac{1}{2^2}$$

$$Qb = 1$$

$$QU = 0$$

$$U = \omega(b \theta)$$

$$\lambda \quad \zeta \quad \chi \quad c \quad \text{giving}$$

$$Q = \sum_{\lambda, \zeta, \chi, c} Q_{(\lambda, \zeta, \chi, c)}$$

$$K = \sum_{\lambda, \zeta, \chi, c} K_{(\lambda, \zeta, \chi, c)}$$

$$H_{\pm} = \sum_{\lambda, \zeta, \chi, c} H_{\pm, (\lambda, \zeta, \chi, c)}$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_a (\gamma^y \theta)_b (\gamma^z \theta)_c \theta_{\gamma_{m+1}} \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta x^i}{z}$$

$$\delta \omega_x = \Lambda_{ab} (\gamma^a \lambda)_b$$

$$J = \omega_x \lambda^x$$

$$J^{ab} = \omega_x (\gamma^{ab})^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$Q = \lambda^x d_x + \zeta^m \Pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c \cdot (b(\zeta \gamma \zeta + \lambda \partial \chi)) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{z^2}, \quad d \partial \theta \sim \frac{1}{z^2}$$

$$Qb = 1$$

$$QU = 0$$

$$U = \alpha(bU)$$

$$\lambda$$

$$\zeta$$

$$\chi$$

$$c$$

$$d$$

$$\pi$$

$$Q = \sum Q_m$$

$$K = \sum K_m$$

$$H_+ = \sum H_m$$

$$\langle \lambda^1 \lambda^2 \lambda^3 (\gamma^1 \theta)_1 (\gamma^2 \theta)_1 (\gamma^3 \theta)_1 \theta \gamma_{m+1} \theta \rangle = 1$$

$$\omega_2 \lambda^1 \sim \frac{\delta \lambda^1}{2}$$

$$\delta \omega_2 = \Lambda_{11} (\gamma^1 \lambda)_1$$

$$J = \omega_2 \lambda^1$$

$$J^{11} = \omega_2 (\gamma^1 \lambda)_1 \lambda^1$$

$$\delta J = 0$$

$$\delta J^{11} = 0$$

$$Q = \lambda^1 d_1 + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c_1 b (\zeta^2 \zeta^1 + \lambda^2 \lambda^1) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$Qb = 1$$

$$Q\pi = 0$$

$$v = \mathcal{Q}(b, v)$$

$$\pi \pi \sim \frac{1}{2^2}, \quad d \partial \theta \sim \frac{1}{2^2}$$

$$\lambda \quad \zeta \quad \chi \quad c$$

$$Q = \sum_{i=1}^n Q_{(i)}$$

$$\mathcal{H} = \mathcal{Q} \lambda_{i1}$$

$$\mathcal{H}_+ = \mathcal{Q}_+ \lambda_{i1}$$

$$H^1(Q, \partial \ell_{11})$$

$$\parallel$$

$$H^1(Q, \mathcal{H}_1) = H^1(Q, \mathcal{H}_1)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_a (\gamma^y \theta)_b (\gamma^z \theta)_c \theta \gamma_{m-1} \theta \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta_x^t}{2}$$

$$\delta u_a = \Lambda_a (\gamma^m \lambda)_a$$

$$J = \omega_b \lambda^b$$

$$J^{mn} = \omega_x (\gamma^{mn})_a^b \lambda^x$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

0 1 2 3

$$Q = \lambda^x d_x + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c \cdot b (\zeta \zeta + \lambda \lambda \gamma) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{2^2}, \quad d \partial \theta \sim \frac{1}{2^2}$$

$$Qb = 1$$

$$Q\theta = 0$$

$$v = \alpha(b\theta)$$

λ ζ χ c
 4 2 1 1
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 (a)
 $\lambda \ell_n$
 ℓ_n

$$H^1(Q_n, \partial \ell_{11})$$

$$\parallel$$

$$H^1(Q_n, \ell_1) = H^1(\ell_1, \ell_1)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_a (\gamma^y \theta)_b (\gamma^z \theta)_c \theta_{\gamma_{m+1}} \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta_x^t}{2}$$

$$\delta \omega_x = \Lambda_{xy} (\gamma^m \lambda)_x$$

$$J = \omega_x \lambda^x$$

$$J^{mn} = \omega_x (\gamma^{mn})_x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & \lambda & \lambda & c \end{matrix}$$

$$Q = \lambda^x d_x + \zeta^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c \cdot 1 \cdot 6 (\zeta \gamma \zeta + \lambda \gamma \lambda) \{d, d\} = \pi$$

$$Qb = 1$$

$$QV = 0$$

$$V = \kappa(bu)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{2}, \quad d \partial \theta \sim \frac{1}{2}$$

$$\begin{matrix} \lambda & \zeta & \chi & c \\ 4 & 2 & 3 & 1 \end{matrix}$$

$$Q = \dots$$

$$\kappa = \dots$$

$$\mathcal{H}_+ = \dots$$

$$H^1(Q, \partial \mathcal{L}_{11})$$

$$H^1(Q, \mathcal{H}_+) = H^1(b, \mathcal{H}_+)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_x (\gamma^y \theta)_y (\gamma^z \theta)_z \theta \gamma_{n-1} \theta \rangle = 1$$

$$\omega_x \lambda^x \sim \frac{\delta \omega}{2}$$

$$\delta \omega_x = \Lambda_x (\gamma^m \lambda)_x$$

$$J = \omega_x \lambda^x$$

$$J^{xx} = \omega_x (\gamma^{xx})_x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{xx} = 0$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & \lambda & \lambda^x & c^x \end{matrix}$$

$$Q = \lambda^x d_x + \xi^m \Pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c + b(\xi \partial \xi + \lambda \partial \lambda) \quad \{d, d\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = \mathcal{R}(b, c)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{2^x}, \quad \delta \theta \sim \frac{1}{2^x}$$

$$\begin{matrix} \lambda & \xi & \chi & c \\ 4 & 2 & 3 & \text{giving} \end{matrix}$$

$$Q = \sum_{\lambda} Q_{(\lambda)}$$

$$K = \textcircled{0} \lambda_{\lambda}$$

$$H_{\pm} = \textcircled{0} H_{\lambda}$$

$$H^x(Q, \dots)$$

$$H^x(Q, \dots)$$

Feb 14/0602 Grassi, GP

1. Paraspiner quantization
2. Bohr-Jamnia system
3. Kozul resolution

Feb-14/0602 Grassi, GP

1. Paraspiner quantization
2. Beta-gamma system
3. Koszul resolution

Feb. 14 / 0602 . Grass, GP

1. Paraspino quantization
2. Beta-gamma system
3. Kernel resolution

Beta-gamma system

$$S = \int \beta$$

Feb. 14/0602 Grass. GP

1. Paraspiner quantization
2. Beta-gamma system
3. Kernel resolution

Beta-gamma system

$$S = \int \beta_i$$

$$Y^i \quad \Sigma \rightarrow M$$

Ph-14/0602 - Graviton GP

1. Paraspinner quantization
2. Beta-gamma system
3. Kernal resolution

Beta-gamma system

$$S = \int \beta \cdot \bar{\sigma} \gamma^i$$

$$\gamma^i \quad \Sigma \rightarrow M$$

Feb 14/0602 Grace GP

1. Paraspiner quantization
2. Beta-gamma system
3. Koszul resolution

Beta-gamma system

$$S = \int \beta_i \bar{\sigma} \gamma^i$$

$$\gamma^i: \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

Feb 14/0602 Grass GP

1. Paraspino quantization
2. Beta-gamma system
3. Kernel resolution

Beta-gamma system

$$S = \int \beta \cdot \bar{\sigma} \gamma^i$$

$$\gamma^i \quad \Sigma \rightarrow M$$

$$\beta \in T^*M$$

$$M = \cup U_i$$

Math 14/0602 Grassmann

1. Paraspinor quantization
2. Beta-gamma system
3. Koszul resolution

Beta-gamma system

$$S = \int \beta_i \bar{\sigma}^i \gamma^i$$

$$\gamma^i \in \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \bigcup U_\alpha$$

$$U_\alpha \cong \mathbb{C}^n$$

2h-1h/0602 Grasse, GP

1. Parsimonious quantification
2. Beta-gamma system
3. Kernel resolution

Religioso system

$$S = \int \beta_i \bar{\sigma} \gamma^i$$

$$\gamma^i \quad \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \bigcup U_i$$

$$U_i \sim \mathbb{C}^n$$

$$S_{U_i} = S_{U_j}$$

24.11/0602 Grassmann

1. Paraspinner quantization
2. Beta-gamma system
3. Kowal resolution

Beta-gamma system

$$S = \int \beta_i \bar{\partial} \gamma^i$$

$$\gamma^i \in \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \cup U_{\alpha}$$

$$U_{\alpha} \sim \mathbb{C}^n$$

$$U_{\alpha} = S_{\alpha}$$

$$\beta_{\alpha i} = \beta_{\alpha i} \frac{\partial \gamma^i}{\partial x^j}$$

2h-14/0602 Grassmann

1. Paraspinner quantization
2. Beta-gamma system
3. Kernel resolution

Path-integral system

$$S = \int \beta^i \bar{\sigma} \gamma^i$$

$$\gamma^i \cdot \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \bigcup_{\alpha} U_{\alpha}$$

$$U_{\alpha} \sim \mathbb{C}^n$$

$$S_{i+1} = S_{i-1}$$

$$\beta_{i+1} = \beta_{i-1} \frac{\partial \gamma_{i+1}^i}{\partial \gamma_{i-1}^i}$$

Feb-14/0602 Grassi, GP

1. Para spinor quantization
2. Beta-gamma system
3. Koszul resolution

Beta-gamma system

$$S = \int \beta_i \bar{\sigma}^i \gamma^i$$

$$\gamma^i \in \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \cup_a U_a$$

$$U_a \sim \mathbb{C}^n$$

$$S_{U_a} = S_{U_b}$$

$$\beta_{U_a} = \beta_{U_b} \frac{\partial \gamma^i}{\partial \gamma^i}$$

12/11/0602 Grassi, GP

1. Paraspinoor quantization
2. Beta-gamma system
3. Kowul resolution

Beta-gamma system

$$S = \int \beta_i \partial \gamma^i$$

$$\gamma^i \quad \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = U \cup U_{(1)}$$

$$U_{(1)} \sim \mathbb{C}^n$$

$$S_{(1)} = S_{(1)}$$

$$\beta_{(1)} = \beta_{(1)}, \quad \frac{\partial \gamma_{(1)}^i}{\partial \gamma_{(1)}^i}$$

$$\beta_{(1)} \gamma_{(1)}$$

Inf. th / 0602 Gravit. QP

1. Phase space quantization

2. Bethe-ansatz system

3. Kosterlitz-Thouless transition

Path Integral System

$$S = \int p \cdot \dot{q} - H$$

$$Y^a \quad Z \rightarrow M$$

$$\beta \in C^{T^*M}$$

$$M = \cup U_i$$

$$U_i \sim C^n$$

$$S_{loc} = S_{cl}$$

$$\beta_{cl} = \beta_{cl} + \frac{\partial Y^a}{\partial Y^a}$$

$$\beta_{cl} Y^a = \frac{1}{2}$$

1. Paraspiner quantization
2. Beta-gamma system
3. Koszul resolution

$$S = \int \beta^a \partial \gamma^a$$

$$\gamma^a : \Sigma \rightarrow M$$

$$\beta_a \in T^*M$$

$$M = \bigcup_i U_i$$

$$U_i \sim \mathbb{C}^n$$

$$S_{i+1} = S_i \cap U_i$$

$$\beta_{i+1} = \beta_{i+1, S} \frac{\partial \gamma^a}{\partial \gamma^a}$$

$$\beta_{i+1, S} \gamma^a = \frac{1}{2}$$

$$\beta_{i+1, S} \gamma^a = \frac{1}{2}$$

1. Pure spinor quantization
2. Beta-gamma system
3. Koszul resolution

$$S = \int \beta \partial \gamma^a$$

$$Y^a \cdot \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \bigcup_i U_i$$

$$U_i \cong \mathbb{C}^n$$

$$S_{U_i} = S_{U_j}$$

$$\beta_{U_i} = \beta_{U_j} \frac{\partial \gamma^a_j}{\partial \gamma^a_i} +$$

$$\beta_{U_i} \gamma^a_i = \frac{1}{2}$$

$$\beta_{U_j} \gamma^a_j = \frac{1}{2}$$

1. Parameter quantization
2. Beta-gamma system
3. Kernel resolution

$$S = \int p(x) \gamma^x$$

$$Y^x \quad \Sigma \rightarrow M$$

$$\beta_x \in T^*M$$

$$M = \bigcup U_{i,j}$$

$$U_{i,j} \sim \mathbb{C}^n$$

$$S_{i,j} = S_{i,j}$$

$$Y_{i,j} = \text{top}(U_{i,j})$$

$$\beta_x = \beta_{x,i,j} \frac{\partial \gamma_{i,j}^x}{\partial Y_{i,j}^x} +$$

$$\beta_x \cdot Y_{i,j} = \frac{1}{2} \sum \gamma_{i,j}^x$$



1. Parameter quantization
2. Beta-gamma system
3. Kernel resolution

$$Y^a = \Sigma \rightarrow M$$

$$P_i \in T^*M$$

$$M = \cup U_i$$

$$U_i \sim \mathbb{C}^n$$

$$S_{i+1} = S_{i+1}$$

$$Y_{i+1} = f_{i+1}(x_i)$$

$$P_{i+1} = P_{i+1} \frac{\partial Y_{i+1}}{\partial Y_{i+1}} +$$

$$P_{i+1} Y_{i+1} \frac{1}{2}$$

$$P_{i+1} Y_{i+1} \frac{1}{2}$$

1. Paraspiner quantization
2. Beta-gamma system
3. Koszul resolution

$$Y^i: \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \bigcup_a U_a$$

$$U_a \sim \mathbb{C}^n$$

$$S_{U_a} = S_{U_b}$$

$$Y_{U_a} = f_{U_b}(Y_{U_b})$$

$$\beta_{U_a} = \beta_{U_b}$$

$$\frac{\partial \beta_{U_a}}{\partial Y_{U_a}^i} + \beta_{U_a} \frac{\partial Y_{U_a}^i}{\partial Y_{U_a}^j}$$

$$\beta_{U_a} Y_{U_a}^i = \frac{1}{2}$$

$$\beta_{U_b} Y_{U_b}^i = \frac{1}{2}$$

1. Paraspiner quantization
2. Beta-gamma system
3. Koszul resolution

$$Y^i \quad \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \bigcup_i U_{i, \alpha}$$

$$U_{i, \alpha} \sim \mathbb{C}^n$$

$$S_{i, \alpha} = S_{i, \beta}$$

$$Y_{i, \alpha} = f_{i, \beta}(\alpha_i)$$

$$\beta_{i, \alpha} = \beta_{i, \beta}$$

$$\frac{\partial \gamma_{i, \alpha}}{\partial \gamma_{i, \beta}} + B_{i, \alpha, \beta} \gamma_{i, \beta}$$

$$\beta_{i, \alpha} \gamma_{i, \alpha} = \frac{1}{2}$$

$$\beta_{i, \beta} \gamma_{i, \beta} = \frac{1}{2}$$

1. Parespinner quantization
2. Beta-gamma system
3. Koszul resolution

$$Y^i : \Sigma \rightarrow M$$

$$\beta_i \in T^*M$$

$$M = \bigcup_i U_{(i)}$$

$$U_{(i)} \sim \mathbb{C}^n$$

$$S_{(i)} = S_{(j)}$$

$$Y_{(i)}^i = f_{ij}(x_{ij})$$

$$\beta_{(i)} = \beta_{(j)}$$

$$\frac{\partial x_{ij}^i}{\partial Y_{(i)}^i} + B_{(i,j)} \partial Y_{(i)}^j$$

$$\beta_{(i)} Y_{(i)}^i = \frac{1}{2}$$

$$\beta_{(j)} Y_{(j)}^j = \frac{1}{2}$$



$$M = \int U_{i,t} \\ U_{i,t} = C^i$$

$$S_{i,t} = S_{i,t-1} \quad Y_{i,t} = F_{i,t}(K_{i,t})$$

$$P_{i,t} = P_{i,t-1} \frac{\partial Y_{i,t}}{\partial Y_{i,t-1}} + B_{i,t}(Y) \frac{\partial Y_{i,t}}{\partial Y_{i,t-1}}$$

$$P_{i,t} Y_{i,t} = \frac{1}{\sigma} \\ P_{i,t} Y_{i,t} = \frac{1}{\sigma}$$

$$\begin{aligned}
 & U_x = C^0 \\
 S_{10} &= S_{11} & Y_{10} &= f_{11}(Y_{11}) \\
 P_{10} &= P_{11} & \frac{\partial X_{11}}{\partial Y_{11}} &+ B_{11}(Y_{11}) \partial Y_{11} \\
 P_{10} Y_{10} &= \frac{1}{\alpha} \\
 P_{11} Y_{11} &= \frac{1}{\alpha}
 \end{aligned}$$

$P_{\text{app}} \rightarrow$

$f_{\text{app}} \rightarrow \hat{f}_{\text{app}}$



$P(Y) \rightarrow$

$f_{AP} \rightarrow \hat{f}_{AP}$
 $f_{AP} \rightarrow$

Prüfung

$$f_{ap} \rightarrow \hat{f}_{ap}$$

f_{ap}

$\beta_1 \beta_2 \dots \beta_n \rightarrow$

$$f_{xy} \rightarrow \hat{f}_{xy}$$

$$f_{xy} = 1, \quad f_{xy} = C_{xy}$$

Proposition 1

$$f_{\text{ap}} \rightarrow \hat{f}_{\text{ap}}$$

continuous

$$, \hat{f}_{\text{ap}} \in C^{\infty}(M, \mathbb{R}^2)$$



$\beta_{\text{Poincaré}} = \frac{1}{2}$

$$f_{\text{ap}} \rightarrow \hat{f}_{\text{ap}}$$

$$f_{\text{ap}}|_{M_1} = 1$$

$$, \hat{f}_{\text{ap}}|_{M_1} = C_{\text{ap}} \in H^2(M, \mathbb{R}^2)$$

Proprietà

$$f_{\text{ap}} \rightarrow \hat{f}_{\text{ap}}$$

$$\text{top} f_{\text{ap}} = 1$$

$$\text{top} \hat{f}_{\text{ap}} = \text{CART} \circ H^2(M, \mathbb{R}^2) \\ R(M)$$



$P_1(M) = \frac{1}{2}$

$f_{\text{up}} \rightarrow f_{\text{up}}$

$f_{\text{up}} f_{\text{up}} = 1$

$$f_{\text{up}} f_{\text{up}} = C_{\text{up}} \in H^2(M, \mathbb{R}^2)$$

$$P_1(M) = 0$$

$\rho_{\text{p}} \gamma_{\text{p}} = \frac{1}{2}$

$$f_{\text{sp}} \rightarrow f_{\text{sp}}$$

$$f_{\text{sp}} \gamma_{\text{sp}} = a$$

$$f_{\text{sp}} \gamma_{\text{sp}} \gamma_{\text{sp}} = C_{\text{sp}} \in H^2(M, \mathbb{R}^2)$$

$$P_i(M) = 0$$

$$C_i(M) \in \mathbb{Z}$$

$\text{Pen} \sim \frac{1}{2}$

$f_{\text{ap}} \rightarrow f_{\text{sp}}$

$f_{\text{ap}} f_{\text{sp}} = 1$

$f_{\text{ap}} f_{\text{sp}} = C_{\text{ap}} \in H^2(M, \mathbb{R}^2)$

$$P_1(M) = 0$$

$$C_1(M) \cap C_1(\mathbb{Z}) = 0$$

$\beta \rho \gamma \mu \rightarrow \frac{1}{4}$

$\log \rho \rho \rho = 1$

T

$$\log \rho \rho \rho = C_{arr} \circ H^2(M, \mathbb{Q}^2)$$

$$P_i(M) = 0$$

$$C_i(M) \cdot C_i(\mathbb{Z}) = 0$$

$\rho \chi_{\text{in}} = \frac{1}{2}$

$\text{top}(M) = \emptyset$

$\text{top}(M) = C \cup \gamma \in H^2(M, \mathbb{Z}^2)$

$$T_{\text{in}} = \rho_{\text{in}} \partial \chi_{\text{in}}$$

$$T_{\text{out}} = \rho_{\text{out}} \partial \chi_{\text{out}}$$

$$\rho_1(M) = 0$$

$$c_1(M) c_1(\Sigma) = 0$$

$$\rho_0 \gamma_{\text{in}} = \frac{1}{2}$$

$$t_{\text{opt}} = 1$$

$$t_{\text{opt}} = C_{\text{in}} \in H^2(M, \mathbb{R}^2)$$

$$T_{\text{in}} = \rho_0 \partial \chi_{\text{in}}$$

$$T_{\text{out}} = \rho_0 \partial \chi_{\text{out}}$$

$$R(M) = 0$$

$$G_i(M) G_i(\mathbb{R}) = 0$$



$\beta \text{Pr} \gamma \text{in} = \frac{1}{4}$

$$f_{\text{top}} f_{\text{bot}} = 1$$

$$f_{\text{top}} f_{\text{bot}} = C_{\text{top}} \in H^2(M, \mathbb{R}^2)$$

$$P_1(M) = 0$$

$$C_1(M) C_1(\mathbb{Z}) = 0$$

$$T_{\text{top}} = \beta_1 \partial \alpha_1$$

$$T_{\text{top}} - \beta_{\text{top}} \partial \gamma_{\text{top}} = T_{\text{top}} + \gamma^2 \log \det \left(\frac{\partial x_{\text{top}}}{\partial y_{\text{top}}} \right)$$

$$Q_{\text{Dirac}} = \lambda^* d\lambda$$

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

$$S_{\text{CS}} = \int \theta_x \sigma_x + p \partial \theta + \bar{p} \partial \bar{\theta} + \omega \bar{\psi} \lambda + \bar{\omega} \partial \bar{\lambda} + Q(\cdot)$$

$$U = \lambda^* A_x(x, \theta)$$

$$\lambda^* \lambda' = \sum_i (\gamma^i)_{\alpha\beta} (\delta_{ij} \lambda) = (\gamma^i)_{\alpha\beta} \lambda_i \lambda_j$$

$$\{Q, U\} = \lambda^* \lambda' D_x A_t = 0$$

$$\gamma^m \gamma^i D_t A_t = 0$$

$$\partial^i A_t = 0$$

$$A_t = (0) \gamma^i \lambda_i + \psi^i \gamma_i \dots$$

$$\frac{SO(10)}{U(5)} \times U^1$$

$$N=1, \frac{SU(1)}{U(1)}$$

$$T_{11} = \rho_1 \partial_t^2 \alpha_{11}$$

$$T_{11} - \rho_1 \partial_t^2 \alpha_{11} = T_{11} + \gamma^2 \det \left(\frac{\partial \alpha_{ij}}{\partial y_{ij}} \right) = 1 \rightarrow c^2$$

$$C_{11} \gamma \in H^2(M, \mathbb{R}^2)$$

$$P_1(M) = 0$$

$$C_1(H) C_1(\mathbb{Z}) = 0$$

$$p(\gamma) = \frac{1}{2}$$

$$f_{1,1} = C_{1,1} \in H^0(M, \Omega^2)$$

$$T_{1,1} = p_1 \partial \bar{\gamma}_{1,1}$$

$$p_1(M) = 0$$

$$c_1(M) c_1(\Sigma) = 0$$

$$T_{1,1} - p_1 \partial \bar{\gamma}_{1,1} = T_{1,1} + \gamma^2 \log \det \left(\frac{\partial \bar{\gamma}_{1,1}}{\partial \gamma_{1,1}} \right)$$

$$\det \left(\frac{\partial \bar{\gamma}}{\partial \gamma} \right) = 1 \Rightarrow c_1$$



$\int \rho \gamma \omega \rightarrow$

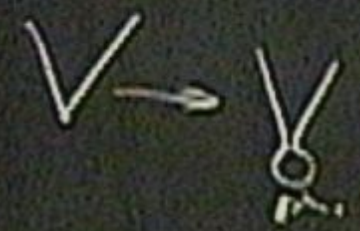
$$\int \rho \gamma \omega = \text{Curv} \in H^2(M, \mathbb{R}^2)$$

$$T_{\mathbb{C}^1} = \rho \gamma \omega$$

$$P_1(M) = 0$$

$$C_1(M) = C_1(\mathbb{C}^1) = 0$$

$$T_{\mathbb{C}^2} = \rho \gamma \omega = T_{\mathbb{C}^1} + \gamma^2 \frac{\log \det \left(\frac{\partial x_{ij}}{\partial y_{ij}} \right)}{\det \left(\frac{\partial x}{\partial y} \right)} = 1 \rightarrow \text{CY}$$



$$\int \rho \gamma \omega \rightarrow$$

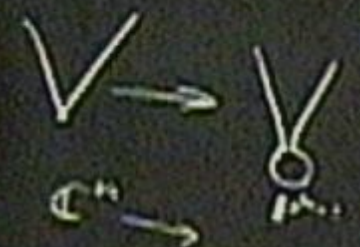
$$T(M) \otimes \mathbb{R} = C_{\text{alg}} \in H^2(M, \mathbb{R}^2)$$

$$P_1(M) = 0$$

$$C_1(M) C_1(\Sigma) = 0$$

$$T_{\text{cl}} = \rho_1 \partial \chi_{\text{cl}}$$

$$T_{\text{top}} = \rho_1 \partial \chi_{\text{top}} = T_{\text{cl}} + \gamma^2 \frac{\log \det \left(\frac{\partial \chi_{\text{cl}}}{\partial \chi_{\text{top}}} \right)}{\det \left(\frac{\partial \chi}{\partial \chi} \right)} = 1 \rightarrow C \gamma$$



$$|KpY| = \frac{1}{2}$$

$$\Gamma(M) \otimes_{\mathbb{R}} \mathbb{C} = H^2(M, \mathbb{C}^2)$$

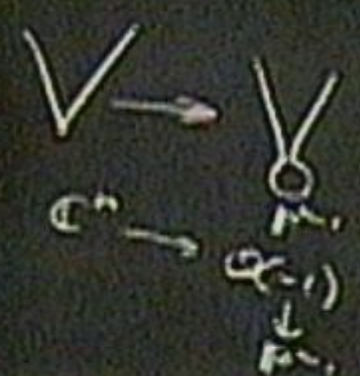
$$P_1(M) = 0$$

$$C_1(M) \otimes_{\mathbb{R}} \mathbb{C} = 0$$

$$T_{\mathbb{R}} = \beta_1 \otimes \alpha_1$$

$$T_{\mathbb{C}} = \beta_1 \otimes \alpha_1 \otimes \mathbb{C} = T_{\mathbb{R}} + \gamma^2 \log \det \left(\frac{\partial x_i}{\partial y_j} \right)$$

$$\det \left(\frac{\partial x_i}{\partial y_j} \right) = 1 \Rightarrow \gamma^2$$



$$p_i \gamma_{ij} = \frac{1}{\gamma}$$

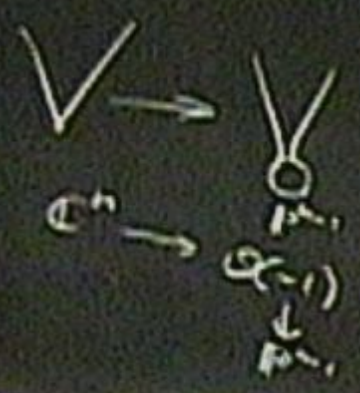
$$L_i = p_i \gamma_{ij} x_{ij}$$

$$T_{ij} = p_i \gamma_{ij} \partial \gamma_{ij} = T_{ij} + \gamma^2 \log \det \left(\frac{\partial \gamma_{ij}}{\partial \gamma_{ij}} \right)$$

$$\det \left(\frac{\partial \gamma_{ij}}{\partial \gamma_{ij}} \right) = 1 \Rightarrow c\gamma$$

$$p_i(H) = 0$$

$$c_i(H) c_i(\Sigma) = 0$$



$\frac{\partial \mathcal{L}}{\partial \gamma} = 0$

$\mathcal{L} = \beta \sum \chi_i$

$T_{ij} = \beta \sum \chi_{ij} = T_{ij} + \gamma^2 \log \det \left(\frac{\partial \chi_{ij}}{\partial T_{ij}} \right)$

$P(H) = 0$
 $C_i(H) C_i(\mathcal{Z}) = 0$

$\det \left(\frac{\partial \chi}{\partial T} \right) = 1 \rightarrow C \chi$

Nakazono



$$P_{in} = P_{in,1} \frac{\partial \chi_{in}^1}{\partial \chi_{in}} + P_{in,2} \frac{\partial \chi_{in}^2}{\partial \chi_{in}}$$

$$P_{in,1} \chi_{in} = \frac{1}{2}$$

$$P_{in,2} \chi_{in} = \frac{1}{2}$$

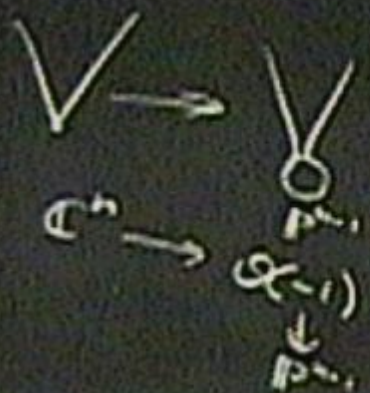
$$L_{in} = P_{in} \chi_{in}$$

$$T_{in} = P_{in} \frac{\partial \chi_{in}}{\partial \chi_{in}} = T_{in,1} + \gamma^2 \log \det \left(\frac{\partial \chi_{in}^i}{\partial \chi_{in}^j} \right)$$

$$\det \left(\frac{\partial \chi}{\partial \chi} \right) = 1 \rightarrow \text{CY}$$

$$P_i(H) = 0$$

$$C_i(H) C_i(E) = 0$$



$$\frac{\partial \text{Tr}(A)}{\partial A_{ij}} = \delta_{ij}$$



$$P_{in} = P_{in,1} \frac{\partial \chi_{in}^1}{\partial \chi_{in}} + P_{in,2} \frac{\partial \chi_{in}^2}{\partial \chi_{in}}$$

$$P_{in,1} \chi_{in} = \frac{1}{2}$$

$$P_{in,2} \chi_{in} = \frac{1}{2}$$

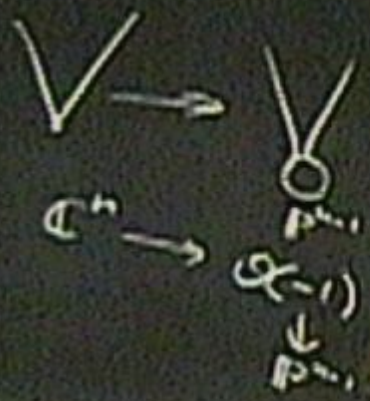
$$L_{in} = \beta_{in} \partial \chi_{in}$$

$$T_{in} = \beta_{in} \partial \chi_{in} = T_{in} + \gamma^2 \log \det \left(\frac{\partial \chi_{in}^i}{\partial \chi_{in}} \right)$$

$$\det \left(\frac{\partial \chi}{\partial \chi} \right) = 1 \rightarrow c \gamma$$

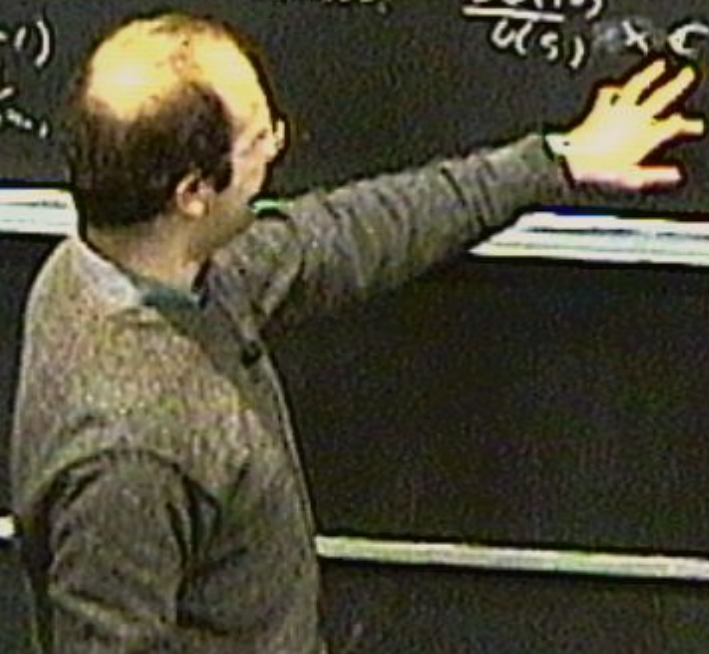
$$P_i(M) = 0$$

$$C_i(M) C_i(\Sigma) = 0$$



Nekrasov:

$$\frac{30(1-s)}{u(s)} \times c$$



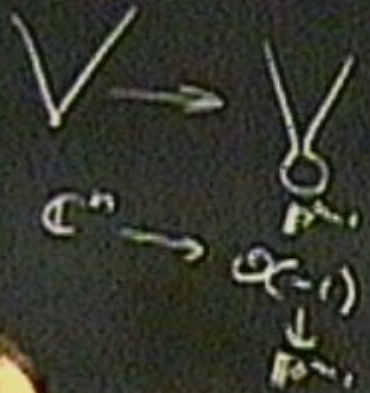
$$\beta_{in} = \beta_{out} \frac{\partial x_{in}}{\partial x_{out}} + B_{in}(y) \partial y^2$$

$$\beta_{in} \gamma_{in} = \frac{1}{\gamma}$$

$$\beta_{in} \gamma_{in} = \frac{1}{\gamma}$$

$$T_{in} = \beta_{in} \partial x_{in} = T_{out} + \gamma^2 \log \det \left(\frac{\partial x_{in}}{\partial x_{out}} \right)$$

$$c_1(H) c_1(\Sigma) = 0$$



$$\det \left(\frac{\partial x}{\partial y} \right) = 1 \Rightarrow c_1$$

$$N_{\text{Klein}} = \frac{10(10)}{6(6)} = \frac{100}{36} = \frac{25}{9}$$

$$B_{\text{top}} = B_{\text{top}} \frac{\partial x_i}{\partial y_i} + B_{\text{top}}(y) \frac{\partial y}{\partial y}$$

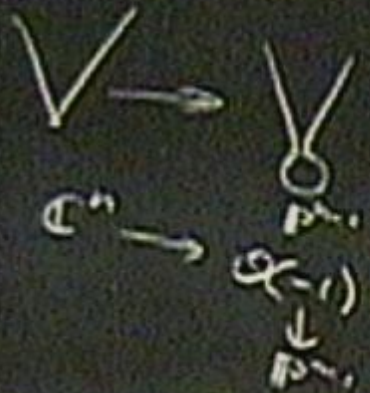
$$B_{\text{top}} y_i = \frac{1}{2}$$

$$B_{\text{top}} y_i = \frac{1}{2}$$

$$c_1(H) c_1(\Sigma) = 0$$

$$T_{\text{top}} = \beta_{\text{top}} \frac{\partial x_i}{\partial y_i} = T_{\text{top}} + \gamma^2 \log \det \left(\frac{\partial x_i}{\partial y_i} \right)$$

$$\det \left(\frac{\partial x_i}{\partial y_i} \right) = 1 \rightarrow c_1$$



Nekrasov:

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

$$C \rightarrow \Sigma$$

$P_1 \times Y_1 \rightarrow$

$\text{log det } \mu = \text{Carry} \in H^2(M, \mathbb{Z}^2)$

$P_1(M) = 0$

$G_1(M) \cap G_1(\mathbb{Z}) = 0$

(x, θ, λ)

$T_1 = P_1 \circ \Sigma_1$

$T_{11} = P_1 \circ \Sigma_{11} = T_{11} + \int \log \det \left(\frac{\partial X_{11}}{\partial Y_{11}} \right)$

$\det \left(\frac{\partial X_{11}}{\partial Y_{11}} \right)$

Nekrasov



Poincaré

$$T_{2,1} = \beta_1 \partial \alpha_1$$

$$T_{2,1} = \beta_1 \partial \delta_{ip} = T_{2,1} + \gamma^2 \log \det \left(\frac{\partial x_{ij}}{\partial y_{ij}} \right)$$

$$\det \left(\frac{\partial x}{\partial y} \right) = 1 \rightarrow c_1$$

Nekrasov $\frac{30(1,1)}{4(1,1)} = x \cdot c$
 $c = \frac{1}{2}$

$$P_1(M) = 0$$

$$c_1(H) c_1(E) = 0$$

(x, θ, γ)



$$\frac{\partial \gamma_{ij}}{\partial y^k} + B_{ij}(\gamma) \frac{\partial \gamma^j}{\partial y^k}$$

$$f_{ij} \rightarrow \hat{f}_{ij}$$

$$f_{ij} \gamma^j = 1$$

$$f_{ij} \gamma^j = c_{ij} \gamma \in H^2(M, \mathbb{R}^2)$$

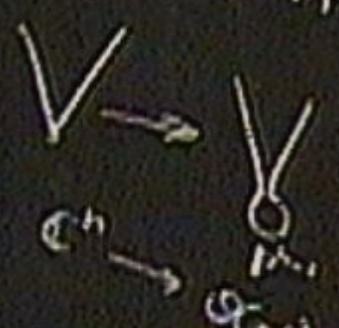
$$T_{ij} = \rho_{ij} \gamma^j$$

$$T_{ij} = \rho_{ij} \gamma^j$$

$$P_i(K) = 0$$

$$C_i(K) C_i(\mathbb{Z}) = 0$$

$$x, \theta, \gamma$$



$$\log \det \left(\frac{\partial \gamma_{ij}}{\partial y^k} \right)$$

$$\frac{\partial}{\partial y^k} \left(\frac{\partial \gamma_{ij}}{\partial y^l} \right) = 1 \rightarrow c_{ij}$$

$$\frac{\partial \gamma_{ij}}{\partial y^k} = c_{ij}$$

M



$$M \in \mathbb{C}^n \quad \Phi^*(\lambda)$$

$$M \subset \mathbb{C}^n \quad \Phi^*(\lambda) = 0$$



$$M \subset \mathbb{C}^n \quad \{\Phi^*(\lambda) = 0\} = M$$

$$M \subset \mathbb{C}^n \quad \{\Phi^*(\lambda) = 0\} = M$$

1

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

1) Solve the constraint

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow P-Y system

$$M \subset \mathbb{C}^n \quad \{\Phi^0(\lambda) = 0\} = M$$

- 1) Solve the constraint \rightarrow fix n lines
- 2) Construct group \rightarrow set of

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

- 1) Solve the constraint \rightarrow P-Y system
- 2) Construct generalized objects

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow p-y system

2) Construct generalized observables

$$\delta w_i = \Lambda_i \partial$$

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow fix n values

2) Construct generalized observables

$$\delta w_i = \Lambda_a \frac{\partial \Phi^a}{\partial \lambda^i}$$

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow p-y system

2) Construct gauge-invariant observables

$$\delta W_2 = \Lambda_a \frac{\partial \Phi^a}{\partial \lambda^i}$$

3) Kostant resolution

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow P-Y system

2) Construct gauge-invariant observables

$$\delta W_L = \Lambda_a \frac{\partial \mathcal{L}^a}{\partial \lambda^a}$$

3) Koszul resolution

$F(H)$

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow p-y system

2) Construct gauge-invariant observables

$$\delta W_0 = \Lambda_a \frac{\partial \mathcal{F}^a}{\partial \lambda^i}$$

3) Koszul resolution

$F(H)$

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow fix n values

2) Construct generalized observables

$$\delta W_L = \Lambda_a \frac{\partial \Phi^a}{\partial \lambda^i}$$

3) Koszul resolution

$F(H)$

$$0 \leftarrow F_0 \leftarrow F_1 \dots \leftarrow F_m \leftarrow$$

$$M \subset \mathbb{C}^n \quad \{\Phi^a(\lambda) = 0\} = M$$

- 1) Solve the constraint \rightarrow p-y system
- 2) Construct gauge-invariant observables
- 3) Koszul resolution

$$\delta W_L = \Lambda_a \frac{\partial F^a}{\partial \lambda^i}$$

$F(H)$

$$0 \leftarrow F_0 \leftarrow F_1 \dots \leftarrow F_m \leftarrow$$

$\mathbb{1} = 0$

$$M \subset \mathbb{C}^n \quad \{\bar{\Phi}^*(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow p.Y. system

2) Construct generalized observable

$$\delta w_0 = \Lambda_0 \frac{\partial \bar{\Phi}^*}{\partial \lambda}$$

3) Kernel resolution

$$F(M)$$

$$0 \in F_0 \leftarrow F_1 \dots \leftarrow F_n \leftarrow$$

$$\delta = 0$$

$$F(M) \cdot H_0(\delta) \neq 0$$

$$H_n(\delta) \neq 0$$

$(\pm (\lambda) \dots)$

1) Set the constraints \rightarrow by x

2) Construct Lagrangian $\delta W_L = \Lambda_i \frac{\partial E_i}{\partial x^i}$

3) Kernal solution

$F(x)$

$$0 \leftarrow F_0 \leftarrow F_1 \dots \leftarrow F_m \leftarrow$$

$$\delta = 0$$

$$i(n) = H_0(\delta) \neq 0$$

$$H_0(\delta) = 0 \quad \kappa > 0$$

1) Solve the constraints \rightarrow p.Y system

2) Construct generalized observables

$$\delta W_C = \Lambda_i \frac{\partial \mathcal{E}^i}{\partial \lambda^i}$$

3) Koszul resolution

$F(H)$

$$0 \leftarrow F_0 \leftarrow F_1 \dots \leftarrow F_m \leftarrow$$

$\delta^i = 0$

$$F(H) = H_0(\delta) \neq 0$$

$$H_k(\delta) = 0 \quad k > 0$$

$$F_0 =$$

1) Solve the constraints \rightarrow β, γ system

2) Construct generalized observables $\delta W_L = \Lambda_L \frac{\partial \mathcal{E}^L}{\partial \lambda^L}$

3) Kernel resolution

$F(H)$

$$0 \leftarrow \delta F_0 \leftarrow \delta F_1 \dots \leftarrow \delta F_m \leftarrow$$

$$\delta^L = 0$$

$$F(H) = H_0(\delta) \neq 0$$

$$H_k(\delta) = 0 \quad k > 0$$

$$F_0 = \{[x_1, \dots, x_n]\}$$

1) Solve the constraints \rightarrow p.Y system

2) Construct generalized observables

$$\delta W_L = \Lambda_L \frac{\partial \mathcal{E}^L}{\partial \lambda^L}$$

3) Koszul resolution

$F(H)$

$$0 \leftarrow F_0 \leftarrow F_1 \dots \leftarrow F_m \leftarrow$$

$$\delta^L = 0$$

$$F(H) = H_0(\delta) \neq 0$$

$$H_k(\delta) = 0 \quad k > 0$$

$$F_0 = C[\lambda_1, \dots, \lambda_n]$$

$$\delta C^L = \mathcal{E}^L(\lambda)$$

$$\delta \lambda = 0$$

1) Solve the constraints \rightarrow p-y system

2) Construct generalized observables

$$\delta W_C = \Lambda_a \frac{\partial \bar{E}^a}{\partial \lambda^a}$$

3) Kessell resolution

$F(H)$

$$0 \stackrel{\delta}{\leftarrow} F_0 \stackrel{\delta}{\leftarrow} F_1 \dots \stackrel{\delta}{\leftarrow} F_m \stackrel{\delta}{\leftarrow}$$

$$\delta^i = 0$$

$$\bar{H}(H) = H_0(\delta) \neq 0$$

$$H_K(\delta) = 0 \quad K > 0$$

$$F_0 = C[\lambda_1 \dots \lambda_n]$$

$$\delta C^a = \bar{E}^a(\lambda)$$

$$\delta \lambda = 0$$

$$F_i = C^i C(\dots)$$

1) Solve the constraints \rightarrow p, y, x given

2) Construct generalized observables

$$\delta W_C = \Lambda_i \frac{\partial \mathcal{E}^i}{\partial \lambda^i}$$

3) Kozul resolution

$F(H)$

$$0 \leftarrow \delta F_0 \leftarrow \delta F_1 \dots \leftarrow \delta F_m \leftarrow$$

$$\delta^i = 0$$

$$i(H) = H_0(\delta) \neq 0$$

$$H_k(\delta) = 0 \quad k > 0$$

$$F_0 = C[\lambda_1 \dots \lambda_n]$$

$$\delta C^i = \mathcal{E}^i(\lambda)$$

$$\delta \lambda = 0$$

$$F_1 = C^i C[\dots]$$

$$F_2 =$$

2) Construct generalized observables $\delta W_c = \Lambda_a \frac{\partial \Phi^a}{\partial \lambda^i}$

3) Kernal resolution

$F(H)$

$$0 \leftarrow^{\delta} F_0 \leftarrow^{\delta} F_1 \dots \leftarrow^{\delta} F_m \leftarrow$$

$$\delta^2 = 0$$

$$F(H) = H_0(\delta) \neq 0$$

$$H_k(\delta) = 0 \quad k > 0$$

$$\sum_a \Lambda^a \Phi^a = 0$$

$$F_0 = C[\lambda_1, \dots, \lambda_n]$$

$$\delta C^a = \Phi^a(\lambda)$$

$$\delta \lambda = 0$$

$$F_1 = C'[\dots]$$

2) Construct gauge invariant observables $\delta W_c = \Lambda_a \frac{\partial \Phi^a}{\partial \lambda^i}$

3) Kessels resolution

$F(H)$

$$0 \stackrel{\delta}{\leftarrow} F_0 \stackrel{\delta}{\leftarrow} F_1 \dots \stackrel{\delta}{\leftarrow} F_m \leftarrow$$

$$\delta^k = 0$$

$$F(H) = H_0(\delta) \neq 0$$

$$H_k(\delta) = 0 \quad k > 0$$

$$Z_a^A \Phi^a = 0 \quad C^A$$

$$F_0 = C[\lambda_1 \dots \lambda_n]$$

$$\delta C^a = \Phi^a(\lambda)$$

$$\delta \lambda = 0$$

$$F_1 = C^A C[\dots]$$

$$F_2 =$$

2) Construct generalized observables $\delta W_2 = \Lambda_a \frac{\partial W}{\partial \lambda^a}$

3) Koseul resolution

$$F(H) \quad 0 \leftarrow \delta F_0 \leftarrow \delta F_1 \dots \leftarrow \delta F_m \leftarrow$$

$$\delta^k = 0$$
$$F(H) = H_0(\delta) \neq 0$$
$$\underline{H_k(\delta) = 0} \quad k > 0$$
$$Z_k^A \Phi^k = 0 \quad C^k$$

$$F_0 = C[\lambda_1 \dots \lambda_n]$$
$$\delta C^k = \Phi^k(\lambda)$$
$$\delta \lambda = 0$$
$$F_1 = C^k C(\dots)$$
$$F_2 =$$



$$f(H) = H_0(\delta) \neq 0$$

$$\underline{H_k(\delta) = 0} \quad k > 0$$

$$\sum_k^N \Phi^k = 0 \quad C^A$$

$$F_0 = C[\lambda_1 \dots \lambda_n]$$

$$\delta C^k = \Phi^k(\lambda)$$

$$\delta \lambda = 0$$

$$F_1 = C^k C(\dots)$$

$$F_2 =$$

$$L_2 = 0 \quad C^m \quad F_1 = C^0 C(\dots) \\ F_2 =$$

δ

$$L_A \approx 0 \quad C^m \quad F_1 = C^0 \delta(\dots) \\ F_2 =$$

$$L_A] =$$

$$L_A E = 0 \quad C'' \quad F_1 = C' C(\dots) \\ F_2 =$$

$$[\lambda] = 1 \\ [c] =$$



$$L_A \cdot E = 0 \quad C^m \quad F_1 = C^0 C(\dots) \\ F_2 =$$

$$[A] = 1 \\ [c] = K$$



$$L_A \approx 0 \quad C^m \quad F_1 = C^T C [\dots] \\ F_2 =$$

$$[L] = 1 \\ [c] = K \\ [c] =$$



$$M \subset \mathbb{C}^n \quad \{\Phi^k(\lambda) = 0\} = M$$

1) Solve the constraint \rightarrow p.y. system

2) Construct generalized observables

$$\delta W_0 = \Lambda_k \frac{\partial \Phi^k}{\partial \lambda^i}$$

3) Kernel resolution

$F(\lambda)$

$$0 \leftarrow F_0 \leftarrow F_1 \dots \leftarrow F_m \leftarrow$$

$$\delta^k = 0$$

$$H_0(\delta) \neq 0$$

$$H_k(\delta) = 0 \quad k > 0$$

$$\sum \lambda^k \Phi^k = 0 \quad C^k$$

$$F_0 = C[\lambda_1 \dots \lambda_n]$$

$$\delta C^k = \Phi^k(\lambda)$$

$$\delta \lambda = 0$$

$$F_1 = C^k \Phi^k(\dots)$$

$$F_2 =$$

$$H_k(\lambda) = 0 \quad k > 0$$

$$Z_\lambda^A \Phi^A = 0 \quad C^A$$

$$0 = \Phi^A(\lambda)$$

$$\delta \lambda = 0$$

$$F_1 = C^A C(\dots)$$

$$F_2 =$$

$$Z_\lambda] = 1$$

$$[0] = K$$

$$[0] =$$

$$\sum_A \Phi^A = 0 \quad C^A \quad \begin{array}{l} \delta \lambda = 0 \\ F_1 = C^A C(\dots) \\ F_2 = \end{array}$$

$$\begin{array}{l} L(\lambda) = 1 \\ [0] = K \\ [0] = \end{array}$$



$$Z_A^A \Phi^A = 0 \quad C^A \quad \begin{matrix} \delta \lambda = 0 \\ F_1 = C^A \Theta(\dots) \\ F_2 = \end{matrix}$$

$$\begin{aligned} [\lambda] &= 1 \\ [c] &= K \\ [\phi] &= \end{aligned}$$

$$Z = \text{Tr} \left((C \cdot)^F \eta^{\mu\nu} \epsilon^{J\mu} \right)$$



$$Z_A^A \Phi^A = 0 \quad c^A \quad \delta\lambda = 0$$

$$F_1 = C^A \Phi^A \dots]$$

$$F_2 =$$

$$[Z] = 1$$

$$[c] = K$$

$$[c] =$$

$$Z = \text{Tr} \left((c)^F \eta^{L_0} e^{J^{\mu\nu}} s^{\nu\mu} \right)$$



$$\sum_a \Phi^a = 0 \quad c^a \quad \begin{array}{l} \delta \lambda = 0 \\ F_1 = c^a \theta(\dots) \\ F_2 = \end{array}$$

$$\begin{array}{l} [\lambda] = 1 \\ [c] = K \\ [a] = \end{array}$$

$$Z = \text{Tr} \left((c^a)^F \eta^{L_0} e^{J^{\mu\nu}} s^{\mu\nu} \right) = \sum s^a$$

$$Z_A \Phi^A = 0 \quad c^A \quad \begin{matrix} \delta \lambda = 0 \\ F_1 = c^A \mathcal{O}(\dots) \\ F_2 = \end{matrix}$$

$$\begin{aligned} [Z] &= 1 \\ [c] &= K \\ [v] &= \end{aligned}$$

$$Z = \text{Tr} \left((c \cdot)^F q^{L_0} e^{J^{\mu\nu}} s^{\nu\mu} \right) = \sum_{n=2}^{\infty} s^n Z_n(q, v)$$



$$Z_n^A \Phi^A = 0 \quad C^A \quad \delta\lambda = 0$$

$$F_1 = C^A C_A [\dots]$$

$$F_2 =$$

$$[L] = 1$$

$$[C] = K$$

$$[V] =$$

$$Z = \text{Tr} \left((C^A)^F q^{L_0} e^{J^{\mu\nu}} S^{\mu\nu} \right) = \sum_{n \in \mathbb{Z}} S^n Z_n(q, t)$$

$$Z_{11} = \sum_{n \in \mathbb{Z}} Z_{11}(q, t)$$

$$Z_A^A \bar{\Phi}^A = 0 \quad C^A$$

$$F_1 = C^A \Phi(\dots)$$

$$F_2 =$$

$$\begin{aligned} Z[\lambda] &= 1 \\ [c] &= K \\ [d] &= \end{aligned}$$

$$Z = \text{Tr} \left((-1)^F q^{L_0} e^{J_0^A} s^{J_0^A} \right) = \sum_{n=2}^{\infty} s^n Z_n(q, t)$$

$$Z_1 = \sum_{n=2}^{\infty} Z_n(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n=2}^{\infty} (1 - q^n t)^{-1} (1 - q^{n-1} t)^{-1}$$

$$Z^A \bar{\Phi}^A = 0$$

 C^A

$$F_1 = C^A \Phi(\dots)$$

$$F_2 =$$

$$\begin{aligned} Z[\lambda] &= 1 \\ [c] &= K \\ [v] &= \end{aligned}$$

$$Z = \text{Tr} \left(\left(\dots \right)^f q^{L_0} e^{J^{\alpha\beta}} S^{\alpha\beta} \right) = \sum_{n \geq 0} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n \geq 0} Z_n(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n \geq 1} (1 - q^n t)^{-1} (1 - q^{-n} t)^{-1}$$

$$Z_n^A \bar{\Phi}^n = 0$$

 C^n

$$F_1 = C' O(\dots)$$

$$F_2 =$$

$$\begin{aligned} Z[\lambda] &= 1 \\ [c] &= K \\ [0] &= \end{aligned}$$

$$Z = \text{Tr} \left((C)^F q^{L_0} e^{J^{01}} S^{22'} \right) = \sum_{n=2} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n=2} Z_n(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n=2} (1 - q^n t) (1 - q^{-n} t)^{-1}$$

$$Z_A^A \Phi^A = 0 \quad c^A$$

$$F_1 = C^1 C(\dots)$$

$$F_2 =$$

$$\begin{aligned} [Z_\lambda] &= 1 \\ [c] &= K \\ [v] &= \end{aligned}$$

$$Z = \text{Tr} \left((c \cdot)^F q^{L_0} e^{J^{\mu\nu}} s^{\mu\nu} \right) = \sum_{n \geq 0} s^n Z_n(q, t)$$

$$Z_n = \sum_{m \geq 0} Z_{nm}(q, t)$$

$$Z = \frac{1}{1-t^3} \prod_{n \geq 1} (1 - q^n t^3)^{-1} (1 - q^{-n} t^5)^{-1}$$

$$[x, y] \quad \Phi$$

$$Z_n^A \Phi^A = 0 \quad c^A$$

$$F_1 = C' \Phi(\dots)$$

$$F_2 =$$

$$\begin{aligned} Z[\lambda] &= 1 \\ [c] &= K \\ [d] &= \end{aligned}$$

$$Z = \text{Tr} \left((c \cdot)^F q^{L_0} e^{J \cdot} S^{J \cdot} \right) = \sum_{n=2}^{\infty} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n=2}^{\infty} Z_n(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n=2}^{\infty} (1-t^n)^{-1} (1-q^{-n} t^n)^{-1}$$

$$X, Y \quad \Phi = XY$$

$$Z_A^A \Phi^A = 0$$

C^A

$$F_1 = C^A \Phi^A$$

$$F_2 =$$

$$\begin{aligned} Z[\lambda] &= 1 \\ [0] &= K \\ [0] & \end{aligned}$$

$$Z = \text{Tr} \left((t \cdot)^F q^{L_0} t^{J^A} s^{S^A} \right) = \sum_{n \in \mathbb{Z}} s^n Z_n(q, t)$$

$$Z_n = \sum_{m \in \mathbb{Z}} Z_{n,m}(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n=1}^{\infty} (1-t^n)^{-1} (1-q^{-n} t^n)^{-1}$$

$$X, Y \quad \Phi = XY$$

$$Z_{l=0} = \frac{1}{1-t} + \dots$$

$$\sum_{\lambda} \Phi^{\lambda} = 0 \quad c^{\lambda}$$

$$F_1 = C' C (\dots)$$

$$F_2 =$$

$$\begin{aligned} [L] &= 1 \\ [C] &= K \\ [O] &= \end{aligned}$$

$$Z = \text{Tr} \left((-1)^F q^{L_0} t^{J_0^3} s^{J_0^5} \right) = \sum_{n \geq 0} s^n Z_n(q, t)$$

$$Z_1 = \sum_{n \geq 0} Z_n(q, t)$$

$$= \frac{1}{1-ts} \prod_{n \geq 1} (1-q^n t s)^{-1} (1-q^{-n} t s)^{-1}$$

$$= \frac{1 + 2t + 2t^2 + \dots}{1 - q^n t s}$$

$$q, t \quad \Phi = x y$$

Handwritten notes and symbols near the bottom left of the chalkboard.

$$Z_A^T \Phi^A = 0 \quad c^m$$

$$F_1 = C^T \Phi(\dots)$$

$$F_2 =$$

$$Z(\lambda) = 1$$

$$L_0 = K$$

$$L_0 =$$

$$Z = \text{Tr} \left((1-q)^F q^{L_0} e^{J^A S^A} \right) = \sum_{n=2}^{\infty} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n=1}^{\infty} Z_n(q, t)$$

$$Z = \frac{1}{1-ts} \prod_{n=1}^{\infty} (1 - q^{-n} ts)^{-1}$$

$$X, Y \quad \Phi = XY$$

$$Z_{t=0} = \frac{1 + 2t}{1 - X^A Y^A}$$

$$Z_A^T \Phi^A = 0 \quad C^A \quad \begin{matrix} 0 & n & 0 \\ F_1 = C^T C(\dots) \\ F_2 = \end{matrix}$$

$$\begin{aligned} [L] &= 1 \\ [C] &= K \\ [O] &= \end{aligned}$$

$$Z = \text{Tr} \left((C^T)^F q^{L_0} e^{J_0 t} S^{T_0} \right) = \sum_{n=1}^{\infty} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n=1}^{\infty} Z_n(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n=1}^{\infty} (1 - q^n t^n) (1 - q^{2n} t^{2n})^{-1}$$

$$X, Y \quad \Phi = XY \quad \left| \begin{matrix} X, Y, \dots \end{matrix} \right.$$

$$Z_{t=0} = \frac{1 + 2t + 2t^2 + \dots}{1 - X, Y, \dots}$$

$$Z_n^A \Phi^A = 0 \quad c^m$$

$$F_1 = c^1 c^1 \dots]$$

$$F_2 =$$

$$\begin{aligned} Z[\lambda] &= 1 \\ [c] &= K \\ [c] &= \end{aligned}$$

$$Z = \text{Tr} \left((-)^F q^{L_0} t^{J_0^3} s^{J_0^3} \right) = \sum_{n=2}^{\infty} s^n Z_n(q, t)$$

$$Z_1 = \sum_{n=2}^{\infty} Z_n(q, t)$$

$$Z = \frac{1}{1-ts} \prod_{n=2}^{\infty} (1 - q^{n-1} t - q^{-n} (ts))^{-1}$$

$$\begin{array}{l} \chi, \psi \\ \Phi = \chi \psi \\ \chi, \psi \end{array} \left| \right.$$

$$Z_{l=0} = \frac{1 + 2t + 2t^2}{1 - \chi_n \psi_n}$$

$$Z_{l=1} = 2 + 4t + 5t^2$$

$$Z^A \Phi^A = 0 \quad C^m$$

$$F_1 = C^T C(\dots)$$

$$F_2 =$$

$$Z[\lambda] = 1$$

$$[c] = K$$

$$[d] =$$

$$Z = \text{Tr} \left((-)^F q^{L_0} e^{J \psi} S^{22'} \right) = \sum_{n \in \mathbb{Z}} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n \in \mathbb{Z}} Z_n(q, t)$$

$$Z = \frac{1}{1-t^2} \prod_{n=1}^{\infty} (1 - q^n t^2)^{-1} (1 - q^{-n} t^2)^{-1}$$

$$x, y \quad \Phi = xy$$

$$x, y \rightarrow$$

$$Z_{l=0} = \frac{1 + 2t + 2t^2 + \dots}{1 - x_1 y_1}$$

$$Z_{l=1} = 2 + 4t + 5t^2 + \dots$$

$$Z_n^A \Phi^A = 0 \quad C^n \quad \begin{matrix} 0 & n & = & 0 \\ F_1 = C^1 C(\dots) \\ F_2 = \end{matrix}$$

$$\begin{aligned} [Z_\lambda] &= 1 \\ [C] &= K \\ [O] &= \end{aligned}$$

$$Z = \text{Tr} \left((C \cdot)^F q^{L_0} e^{J^{\mu\nu}} S^{\mu\nu} \right) = \sum_{n \geq 0} S^n Z_n(q, t)$$

$$Z_0 = \sum_{n \geq 0} Z_n(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n \geq 1} (1 - q^n t)^{-1} (1 - q^{-n} t)^{-1}$$

$$\begin{array}{l} x, y \\ \Phi = xy \\ \begin{array}{l} x, y, \dots \\ x, y, x, y, \dots \end{array} \end{array}$$

$$Z_{l=0} = \frac{1}{1-t} + \frac{2t}{1-t^2} + \frac{2t^4}{1-t^4} + \dots$$

$$Z_{l=1} = 2 + 4t + 5t^2 + \dots$$



$$Z_A^T \Phi^A = 0 \quad C^A \quad \begin{matrix} 0 & n & 0 \\ F_1 = C^T C(\dots) \\ F_2 = \end{matrix}$$

$$\begin{aligned} Z[\lambda] &= 1 \\ [c] &= K \\ [v] &= \end{aligned}$$

$$Z = \text{Tr} \left((C^T)^F q^{L_0} e^{J^A} S^{B^A} \right) = \sum_{n=0}^{\infty} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n=0}^{\infty} Z_n(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n=1}^{\infty} (1 - q^n t^3)^{-1} (1 - q^{-n} t^5)^{-1}$$

$$\begin{array}{l} x, y \\ \Phi = xy \\ \begin{array}{l} x, y, \dots \\ x, y, x, y, \dots \end{array} \end{array}$$

$$Z_{t=0} = \frac{1}{1} + \frac{2t}{1} + \frac{2t^4}{1} + \dots$$

$$Z_{t=1} = 2 + 4t + 5t^2 + \dots$$

$$\begin{array}{l} x, y \\ \textcircled{P_0} \\ \textcircled{P_1} \end{array} \quad \begin{array}{l} J_1 = P_1^y \\ J_2 = P_2^y \end{array}$$

$$Z_A^T \Phi^A = 0 \quad C^A$$

$$F_1 = C^T \Phi(\dots)$$

$$F_2 =$$

$$Z[\lambda] = 1$$

$$[0] = K$$

$$[0] =$$

$$Z = \text{Tr} \left((C^T)^F q^{L_0} t^{J^{01}} s^{J^{11}} \right) = \sum_{n=2} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n=2} Z_n(q, t)$$

$$Z = \frac{1}{1-t^2} \prod_{n=2} \left((1-q^n t^2) (1-q^{-n} t^2) \right)^{-1}$$

$$x, y \quad \Phi = x y$$

$$x, y, \dots$$

$$x y, x, y, \dots$$

$$Z_{t=0} = 1 + 2t + 2t^2 + \dots$$

$$1 \quad x, y, y$$

$$Z_{t=1} = 2 + 4t + 5t^2 + \dots$$

$$x, y \quad \Phi = \beta, x$$

$$y$$

$$Z_n^A \Phi^A = 0 \quad C^A$$

$$F_1 = C^A \Phi^A \dots]$$

$$F_2 =$$

$$[Z] = 1$$

$$[C] = K$$

$$[D] =$$

$$Z = \text{Tr} \left((C)^F q^{L_0} e^{J^A S^A} \right) = \sum_{n=2}^{\infty} S^n Z_n(q, t)$$

$$Z_1 = \sum_{n=2}^{\infty} Z_n(q, t)$$

$$Z = \frac{1}{1-t} \prod_{n=2}^{\infty} (1 - q^n t^n)^{-1} (1 - q^{-n} t^n)^{-1}$$

$$x, y \quad \Phi = x y$$

$$x, y, \dots$$

$$x y, x y, \dots$$

$$Z_{t=0} = 1 + 2t + 2t^2 + \dots$$

$$1 \quad x, y, y^2$$

$$Z_{t=1} = 2 + 4t + 5t^2 + \dots$$

$$x, y \quad \begin{matrix} \textcircled{P_2} & J_2 = |x, y \\ \textcircled{P_3} & J_3 = |x, y, y \end{matrix}$$

$$x, y, y \quad J_4 = |x, y, y, y$$

$$x, y, y, y \quad J_5 = |x, y, y, y, y$$

$$\langle \lambda^a \lambda^b \lambda^c (\gamma^a \theta)_\alpha (\gamma^b \theta)_\beta (\gamma^c \theta)_\gamma, \theta \gamma_{mn} \theta \rangle = 1$$

$$\omega_a \lambda^a \sim \frac{\delta \rho}{z}$$

$$\delta \omega_a = \Lambda_m (\gamma^m \lambda)_a$$

$$J = \omega_a \lambda^a$$

$$J^{mn} = \omega_a (\gamma^{mn})^a{}^b \lambda^b$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

$$xy - \mu = 0$$

$$y = \frac{\mu}{x}, \quad x \in \mathbb{C}^d$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & \lambda & \lambda^2 & c \end{matrix}$$

$$Q = \lambda^a d_a + \zeta^m \Pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c + b(\zeta \gamma \zeta + \lambda \gamma \lambda) \{d, d\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = \mathcal{R}(bU)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{z^2}, \quad d \partial \theta \sim \frac{1}{z^2}$$

$$\begin{matrix} \lambda & \zeta & \chi & c \\ 1 & 2 & 3 & 4 \end{matrix} \quad \text{grading}$$

$$Q = \sum_{i=1}^4 Q_i$$

$$\mathcal{H} = \bigoplus \mathcal{H}_i$$

$$\mathcal{H}_+ = \bigoplus_{i=0}^3 \mathcal{H}_i$$

$$H^i(Q, \mathcal{H}_+) = H^i(Q, \mathcal{H}_+)$$

$$H^i(Q, \mathcal{H}_+) = H^i(Q, \mathcal{H}_+)$$

$$\langle \lambda^a \lambda^b \lambda^c (\gamma^a \theta)_\alpha (\gamma^b \theta)_\beta (\gamma^c \theta)_\gamma, \theta \gamma_{mn} \theta \rangle = 1$$

$$\omega_a \lambda^a \sim \frac{\delta \theta^i}{\tau}$$

$$\delta \omega_a = \Lambda_m (\gamma^m \lambda)_a$$

$$J = \omega_a \lambda^a$$

$$J^{ab} = \omega_a (\gamma^{ab})_\alpha^\beta \lambda^\alpha$$

$$\delta J = 0$$

$$\delta J^{ab} = 0$$

$$xy - \mu = 0$$

$$y = \frac{\mu}{x}, \quad x \in \mathbb{C}^*$$

$$\varphi = -\log x$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & a & \lambda^a & c^a \end{matrix}$$

$$Q = \lambda^a d_\alpha + \xi^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c + b(\xi^a \gamma_a \lambda^b \gamma^c) \{d, d\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = \mathcal{R}(bU)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi \sim \frac{1}{\tau^2}, \quad \partial \pi \sim \frac{1}{\tau}$$

$$\begin{matrix} \lambda & \xi & \chi & c \\ 4 & 2 & 3 & \text{ghost} \end{matrix}$$

$$Q = \sum_{i=1}^n Q_i$$

$$\mathcal{H}_1 = \bigoplus \mathcal{H}_n$$

$$\mathcal{H}_+ = \bigoplus_{n=0}^{\infty} \mathcal{H}_n$$

$$H^1(Q_n, \mathcal{H}_{r,s})$$

$$H^1(Q, \mathcal{H}_1) = H^1(\mathcal{H}_1, \mathcal{H}_1)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^a \theta)_x (\gamma^b \theta)_y (\gamma^c \theta)_z \theta_{\gamma_{mn}, 0} \rangle = 1$$

$$\omega_0 \lambda^x \sim \frac{\delta x^i}{z}$$

$$\delta \omega_x = \Lambda_m (\gamma^m \lambda)_x$$

$$J = \omega_0 \lambda^x$$

$$J^{mn} = \omega_0 (\gamma^{mn})^x \lambda^x$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

$$xy - \mu = 0$$

$$y = \frac{\mu}{x}$$

$$\varphi = \log x$$

$$x \in \mathbb{C}^x$$

$$e^{i\varphi}$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & \lambda & \lambda^2 & c^3 \end{matrix}$$

$$Q = \lambda^x dx + \xi^m \pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c + b(\xi^m \zeta_m \lambda^2) \{d, d\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = \mathcal{R}(bU)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi = \frac{1}{z^2}, \quad d\pi = \frac{1}{z^2}$$

$$\begin{matrix} \lambda & \xi & \chi & c \\ 4 & 2 & 3 & \text{gauge} \end{matrix}$$

$$Q = \sum_{i=1}^n Q_i$$

$$\mathcal{H} = \bigoplus \mathcal{H}_i$$

$$\mathcal{H}_+ = \bigoplus_{i=1}^n \mathcal{H}_i$$

$$H^1(Q_n, \mathcal{H}_{\mathbb{R}})$$

$$\parallel$$

$$H^1(Q, \mathcal{H}_1) = H^1(\mathbb{C}, \mathcal{H}_1)$$

$$\langle \lambda^x \lambda^y \lambda^z (\gamma^x \theta)_a (\gamma^y \theta)_b (\gamma^z \theta)_c \theta \gamma_{mnp} \theta \rangle = 1$$

$$\omega_0 \lambda^a \sim \frac{\delta \omega^a}{2}$$

$$\delta \omega_a = \Lambda_a (\gamma^m \lambda)_a$$

$$J = \omega_0 \lambda^a$$

$$J^{mn} = \omega_0 (\gamma^{mn})_a \lambda^a$$

$$\delta J = 0$$

$$\delta J^{mn} = 0$$

$$xy - \mu = 0$$

$$y = \frac{\mu}{x}$$

$$\varphi = \log x$$

$$x \in \mathbb{C}^*$$

$$e^{i\varphi} \rightarrow 1, x_0, y_0$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & \lambda & \lambda^2 & c \end{matrix}$$

$$Q = \lambda^a d_a + \xi^m \Pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c + b(\xi^2 \xi_1 + \lambda \partial \gamma) \quad \{d, d\} = \pi$$

$$Qb = 1$$

$$Qc = 0$$

$$v = \mathcal{R}(bU)$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi = \frac{1}{2}, \quad \partial \theta = \frac{1}{2}$$

$$\begin{matrix} \chi & c \\ 3 & \textcircled{4} \end{matrix} \quad \text{grading}$$

$$Q = \sum_{i=0}^{\infty} Q^{(i)}$$

$$\mathcal{H} = \bigoplus_{i=0}^{\infty} \mathcal{H}_i$$

$$\mathcal{H}_+ = \bigoplus_{i=0}^{\infty} \mathcal{H}_i$$

$$H^i(Q, \mathcal{H}_i)$$

$$H^i(Q, \mathcal{H}_i) = H^i(\mathcal{H}_i, \mathcal{H}_i)$$

$$\langle \lambda^a \lambda^b \lambda^c (\gamma^a \theta)_\alpha (\gamma^b \theta)_\beta (\gamma^c \theta)_\gamma, \theta \gamma_{\alpha\beta\gamma} \rangle = 1$$

$$\omega_a \lambda^a \sim \frac{\delta \theta^i}{z}$$

$$\delta \omega_a = \Lambda_a (\gamma^m \lambda)_a$$

$$J = \omega_a \lambda^a$$

$$J^{ab} = \omega_a (\gamma^{ab})_\alpha \lambda^\alpha$$

$$\delta J = b$$

$$\delta J^{ab} = 0$$

$$xy - \mu = 0$$

$$y = \frac{\mu}{x}$$

$$\varphi = \log x$$

$$x \in \mathbb{C}^*$$

$$e^{i\varphi}$$

$$\partial \varphi e^{-i\varphi}$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & \lambda & \lambda^2 & c \end{matrix}$$

$$Q = \lambda^a d_a + \xi^m \Pi_m + \chi_a \partial \theta^a + \dots$$

$$+ c + b(\xi^2 \gamma^1 \lambda \gamma^2) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$Qb = 1$$

$$Q\psi = 0$$

$$v = \mathcal{R}(bU)$$

$$\pi \pi \sim \frac{1}{z^2}, \int \partial \theta \sim \frac{1}{z}$$

$$\begin{matrix} \lambda & \xi & \chi & c \\ 4 & 2 & 3 & \text{ghost} \end{matrix}$$

$$Q = \sum_{\alpha} Q_{(\alpha)}$$

$$\mathcal{H} = \bigoplus_{\alpha} \mathcal{H}_{\alpha}$$

$$\mathcal{H}_+ = \bigoplus_{\alpha} \mathcal{H}_{\alpha}$$

$$H^1(Q_n, \partial \mathcal{L}_{\text{res}})$$

$$H^1(Q, \mathcal{H}_1) = H^1(\mathcal{H}_1, \mathcal{H}_1)$$

$$\langle \lambda^{\alpha} \lambda^{\beta} \lambda^{\gamma} (\gamma^{\alpha} \theta)_{\alpha} (\gamma^{\beta} \theta)_{\beta} (\gamma^{\gamma} \theta)_{\gamma} \theta \gamma_{m\alpha} \theta \rangle = 1$$

$$\omega \lambda^{\alpha} \sim \frac{\delta \theta^{\alpha}}{2}$$

$$\delta \omega_{\alpha} = \Lambda_{\alpha} (\gamma^{\mu} \lambda)_{\alpha}$$

$$J = \omega_{\alpha} \lambda^{\alpha}$$

$$J^{\alpha\beta} = \omega_{\alpha} (\gamma^{\mu\nu})_{\alpha}^{\beta} \lambda^{\mu}$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^{\alpha} d_{\alpha} + \xi^{\mu} \Pi_{\mu} + \chi_{\alpha} \partial \theta^{\alpha} + \dots$$

$$+ c + b (\xi^{\mu} \gamma_{\mu} \lambda \gamma^{\nu}) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi = \frac{1}{2}, \quad \partial \theta = \frac{1}{2}$$

$$Qb = 1$$

$$Qc = 0$$

$$v = \mathcal{R}(LU)$$

$$xy - \mu = 0$$

$$y = \frac{\mu}{x}, \quad \varphi = \log x$$

$$x \in \mathbb{C}^{\times} \rightarrow e^{i\varphi} \rightarrow 1, x_0, y_0$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & \lambda & \lambda^2 & c \end{matrix}$$

$$\begin{matrix} \lambda & \xi & \chi & c \\ c & \xi & \chi & c \end{matrix} \quad \text{grading}$$

$$Q = \sum_{\alpha} Q_{(\alpha)}$$

$$\mathcal{H} = \bigoplus_{\alpha} \mathcal{H}_{\alpha}$$

$$\mathcal{H}_{+} = \bigoplus_{\alpha \geq 0} \mathcal{H}_{\alpha}$$

$$H^i(Q, \mathcal{H}_{\alpha})$$

$$H^i(Q, \mathcal{H}_{\alpha}) = H^i(\mathcal{H}_{\alpha})$$

$$\langle \lambda^1 \lambda^2 \lambda^3 (\gamma^1 \theta)_\alpha (\gamma^2 \theta)_\beta (\gamma^3 \theta)_\gamma, \theta \gamma_{\alpha\beta\gamma} \theta \rangle = 1$$

$$\omega_\alpha \lambda^\alpha \sim \frac{\delta \theta^i}{2}$$

$$\delta \omega_\alpha = \Lambda_\alpha (\gamma^m \lambda)_\alpha$$

$$J = \omega_\alpha \lambda^\alpha$$

$$J^{\alpha\beta} = \omega_\alpha (\gamma^{\alpha\beta})_\alpha \lambda^\beta$$

$$\delta J = 0$$

$$\delta J^{\alpha\beta} = 0$$

$$Q = \lambda^\alpha d_\alpha + \xi^m \Pi_m + \chi_\alpha \partial \theta^\alpha + \dots$$

$$+ c_1 b (\xi^2 \xi_1 \lambda^2 \gamma) \{d, d\} = \pi$$

$$\{d, \pi\} = \partial \theta$$

$$\pi \pi = \frac{1}{2}, \partial \theta = \frac{1}{2}$$

$$Qb = 1$$

$$Q\theta = 0$$

$$v = Q(bU)$$

$$xy - yx = 0$$

$$y = \frac{1}{x}$$

$$\varphi = \log x$$

$$x \in \mathbb{C}^\times$$

$$e^{i\varphi} \rightarrow 1, x_0, y_0$$

$$\partial \varphi e^{-i\varphi}, \rho e^{-i\varphi}$$

$$\begin{matrix} 0 & 1 & 2 & 3 \\ c & \lambda & \lambda^2 & c \end{matrix}$$

$$\lambda$$

$$\xi$$

$$\chi$$

$$c$$

grading

$$Q = \sum Q_i$$

$$H^1(Q, \mathcal{L}_{\mathbb{R}^3})$$

$$\parallel$$

$$H^1(Q, \mathcal{L}_{\mathbb{R}^3}) = H^1(\mathbb{R}^3, \mathcal{L}_{\mathbb{R}^3})$$

$$P_{\text{top}} = P_{\text{bot}} \frac{\partial \delta_{ij}}{\partial Y_{ij}} + B_{\text{top}} \frac{\partial Y}{\partial Y}$$

$$P_{\text{top}} Y_{ij} = \frac{1}{Y_{ij}}$$

$$P_{\text{top}} Y_{ij} = \frac{1}{Y_{ij}}$$

top \rightarrow bot

top \rightarrow bot, top \rightarrow bot = $C_{\text{top}} = H^2(M, \mathbb{Q}^2)$

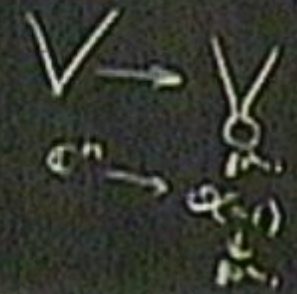
$$T_{\text{top}} = P_{\text{top}} \frac{\partial Y_{ij}}{\partial Y_{ij}}$$

$$T_{\text{top}} = P_{\text{top}} \frac{\partial Y_{ij}}{\partial Y_{ij}} = T_{\text{top}} + \gamma^2 \log \det \left(\frac{\partial Y_{ij}}{\partial Y_{ij}} \right)$$

$$P(M) = 0$$

$$C_i(h) C_j(\bar{h}) = 0$$

$$x_i, \theta_i$$



Nekrasov $\frac{\partial \log \det}{\partial Y_{ij}} = \frac{1}{Y_{ij}}$

