

Title: Higher Spin Theories - Lecture 3

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Abstract:

VASILIEV'S EQUATIONS

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1. VARIABLES

x^μ

SPACE-TIME

$$(\gamma_\alpha, \bar{\gamma}_\alpha, z_\alpha, \bar{z}_\alpha) = ($$

1. VARIABLES

x^μ

SPACE-TIME

$$(\gamma_\alpha, \bar{\gamma}_\alpha, z_\alpha, \bar{z}_\alpha) = (Y, Z)$$

INTERNAL "TWISTORS"

x^μ SPACE-TIME

$$(\gamma_\alpha, \bar{\gamma}_\alpha, z_\alpha, \bar{z}_\alpha) = (Y, Z)$$

INTERNAL "TWISTORS"

$$f(Y, Z) * g(Y, Z) = \int d^4 u d^4 v e^{uv} f(Y+u, Z+u) g(Y+v, Z-v)$$

$$\gamma_\alpha \star z_\beta = \gamma_\alpha z_\beta - \epsilon_{\alpha\beta}$$

$$k = e^{z^\alpha \gamma_\alpha} \quad \bar{k}$$

$$\partial_\alpha f(z) = \int d^4 u d^4 v e^{f(Y+U, z+U)g(Y+V, z-V)}$$

$$Y_\alpha * Y_\beta = Y_\alpha Y_\beta + \epsilon_{\alpha\beta} \quad Z_\alpha * Z_\beta = Z_\alpha Z_\beta - \epsilon_{\alpha\beta}$$

$$Y_\alpha * Z_\beta = Y_\alpha Z_\beta - \epsilon_{\alpha\beta}$$

$$K = e^{z^\alpha Y_\alpha} \quad \bar{K} = e^{\bar{z}^{\dot{\alpha}} \bar{Y}_{\dot{\alpha}}}$$

$$K * 1$$

$$\delta(x, z) = \int d^4 u d^4 v e^{f(Y+u, z+u)g(Y+v, z-v)}$$

$$\begin{aligned} Y_\alpha * Y_\beta &= Y_\alpha Y_\beta + \epsilon_{\alpha\beta} & Z_\alpha * Z_\beta &= Z_\alpha Z_\beta - \epsilon_{\alpha\beta} \\ Y_\alpha * Z_\beta &= Y_\alpha Z_\beta - \epsilon_{\alpha\beta} \end{aligned}$$

$$K = e^{Z^\alpha Y_\alpha} \quad \bar{K} = e^{\bar{Z}^\alpha \bar{Y}_\alpha}$$

$$K * K = 1 \quad \bar{K} * \bar{K} = 1$$

$$K * f(Y, \bar{Y}, Z, \bar{Z}) * K = f(-Y, \bar{Y}, -Z, \bar{Z})$$

$$W(x|Y,z) = \dots$$

$$S(x|Y,z) = dz^\alpha S_\alpha + d\bar{z}^{\dot{\alpha}} S_{\dot{\alpha}}$$

$$B(x|Y,z) \quad \text{SCALAR}$$

$$S(x|Y,z) = dz^\alpha S_\alpha + d\bar{z}^{\dot{\alpha}} S_{\dot{\alpha}}$$

$B(x|Y,z)$

SCALAR

PHYSIC

$$S(x|y,z) = d\tau^\alpha S_\alpha + d\bar{\tau}^{\dot{\alpha}} S_{\dot{\alpha}}$$

$B(x|y,z)$

SCALAR

PHYSICAL D.O.F.

$$W(x|Y, z=0) = \sum W_{i_1 \dots i_L, \bar{i}_1 \dots \bar{i}_L}^{(s, m)} y^{i_1} \dots y^{i_L} \bar{y}^{\bar{i}_1} \dots \bar{y}^{\bar{i}_L}$$

$$(S-1+m, S-1-m)$$

$$m = -(S-1), \dots, (S-1)$$

$$2 + \omega$$

$$W(x|Y, z=0) = \sum W_{\alpha_1 \dots \alpha_n \beta_1 \dots \beta_n}^{(n,n)} \gamma^{\alpha_1} \dots \gamma^{\alpha_n} \bar{\gamma}^{\beta_1} \dots \bar{\gamma}^{\beta_n}$$

$$W^{(S-l+m, S-l-m)} \quad m = -(S-l), \dots, (S-l)$$

$$l + \omega$$

$$\beta^{(0,0)}$$

SCALAR FIELD

$$W(x|Y, z=0) = \sum W_{\alpha_1 \dots \alpha_n \bar{\alpha}_1 \dots \bar{\alpha}_n}^{(n,n)} Y^{\alpha_1} \dots Y^{\alpha_n} \bar{Y}^{\bar{\alpha}_1} \dots \bar{Y}^{\bar{\alpha}_n}$$

$$W^{(s-l+m, s-l-m)} \quad m = -(s-l), \dots, (s-l)$$

$$l + \omega$$

$$B^{(0,0)}$$

SCALAR FIELD

$$B^{(2s+m, m)}, B^{(m, 2s+m)}$$

GENERALIZED WEYL

$$W(x|Y, z=0) = \sum W_{\alpha_1 \dots \alpha_{l+m} \dot{\alpha}_1 \dots \dot{\alpha}_m}^{(l, m)} Y^{\alpha_1} \dots Y^{\alpha_{l+m}} \bar{Y}^{\dot{\alpha}_1} \dots \bar{Y}^{\dot{\alpha}_m}$$

$$W^{(s-l+m, s-l-m)} \quad m = -(s-l), \dots, (s-l)$$

$$l + m$$

$$B^{(0,0)}$$

SCALAR FIELD

$$B^{(2s+m, m)}, B^{(m, 2s+m)}$$

GENERALIZED WEYL

EQUATIONS

$$A = W + S$$

$$dA + A * A = F(B * K) dz^2 + \bar{F}(B * K) d\bar{z}^2$$

EQUATIONS

$$A = W + S$$

$$\begin{cases} dA + A * A = F(B * K) dz^2 + \bar{F}(B * K) d\bar{z}^2 \\ B + A * B - B * \pi(A) = 0 \end{cases}$$

$$\begin{aligned} \pi(f(\gamma, \bar{\gamma}, z, \bar{z}, d\gamma, d\bar{\gamma})) \\ = -f(-\gamma, -\bar{\gamma}, -z, -\bar{z}, -d\gamma, -d\bar{\gamma}) \end{aligned}$$

EQUATIONS

$$A = W + S$$

$$\begin{cases} A + A * A = F(B * K) dz^2 + \bar{F}(B * K) d\bar{z}^2 \\ B + A * B - B * \pi(A) = 0 \end{cases} \quad \text{TWISTED ANTI-SELF-DUAL}$$

$$\begin{aligned} \pi(f(\gamma, \bar{\gamma}, z, \bar{z}, dt, d\bar{t})) \\ = -f(-\gamma, \bar{\gamma}, -z, \bar{z}, -dt, d\bar{t}) \end{aligned}$$

HS GA

$(\epsilon)_*$

$B * \pi(\epsilon)$

EQUATIONS

$$d = d_Y + d_Z$$

$$A = W + S$$

$$\begin{cases} dA + A * A = F(B * K) dz^2 + \bar{F}(B * K) d\bar{z}^2 \\ dB + A * B - B * \pi(A) = 0 \end{cases}$$

TWISTED
ANALOG

$$\pi(f(Y, \bar{Y}, z, \bar{z}, dY, d\bar{Y}))$$

$$= -f(-Y, \bar{Y}, -z, \bar{z}, -dY, -d\bar{Y})$$

HS GAUGE SYMMETRIES

$$\delta A = d\epsilon + [A, \epsilon]_*$$

$$\delta B = \epsilon * B - B * \pi(\epsilon)$$

BOSONIC MODEL

$$W(X|Y, z) = W(X|-Y, -z)$$

$$S(X|Y, z) = -S(X|-Y, -z)$$

$$B(X|Y, z) = B(X|-Y, -z)$$

$$F(X) = X \exp_* (i\theta(X))$$

$$\theta(X) = \theta_0 + \theta_2 X * X + \theta_4 X * X * X * X + \dots$$

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$$\theta(X) = \theta_0 + \theta_2 X * X + \theta_4 X * X * X * X + \dots$$

PARITY : $\theta(X) = 0$, B PARITY EVEN "TYPE A"
 $\theta(X) = \frac{\pi}{2}$, B PARITY ODD "TYPE B"

$$F(X) = X \exp_* (i\theta(X))$$

$$\theta(X) = \theta_0 + \theta_2 X * X + \theta_4 X * X * X * X + \dots$$

PARITY : $\theta(X) = 0$, B PARITY EVEN "TYPE A"
 $\theta(X) = \frac{\pi}{2}$, B PARITY ODD "TYPE B"

$$d_x W + W +$$

$$d_x S + d_z W + S * W + W * S$$

$$d_z S + S * S = B * K d z^2$$

$$B * \pi(\epsilon)$$

$$S(x|y, z) = -S(x|y, -z)$$

$$B(x|y, z) = B(x|y, -z)$$

$$d_x W + W * W = 0$$

$$d_x S + d_z W + S * W + W * S = 0$$

$$d_z S + S * S = B * K d z^2 + B * K d \bar{z}^2$$

$$d_x B + \dots - B * \pi(\dots)$$

$$B(\lambda, \gamma, \xi) \in B(\lambda, \gamma, \xi)$$

$$d_1 W + W * W = 0$$

$$d_1 S + d_2 W + S * W + W * S = 0$$

$$d_2 S + S * S = B * K d_2^2 + B * K d_2^L$$

$$d_1 B + W * B - B * \pi(W) = 0$$

$$d_2 B + S * B - B * \pi(S) = 0$$

$$B(x|y,z) \in B(x|-y,-z)$$

$$d_x W + W * W = 0$$

$$d_x S + d_z W + S * W + W * S = 0$$

$$d_z S + S * S = B * K d\bar{z} + B * \bar{K} d\bar{z}^L$$

$$d_x B + W * B - B * \pi(W) = 0$$

$$d_z B + S * B - B * \pi(S) = 0$$

$$S \rightarrow S + \frac{z}{2} d\bar{z} + \frac{\bar{z}}{2} d\bar{z}^L$$

$$[z, \{(\gamma, z)\}] * = -\frac{2}{\partial z} \delta$$

$$0B = C * B - B * \pi(C)$$

$$S(x|y, z) = -S(x|y, -z)$$

$$B(x|y, z) = B(x|y, -z)$$

$$d_x W + W * W = 0$$

$$d_x S + d_z W + S * W + W * S = 0$$

$$d_z S + S * S = B * K d z^2 + B * K d \bar{z}^2$$

$$d_x B + W * B - B * \pi(W) = 0$$

$$d_z B + S * B - B * \pi(S) = 0$$

$$S \rightarrow S + \frac{z}{i} d z^2 + \frac{\bar{z}}{i} d \bar{z}^2$$

$$[z, \{(\gamma, z)\}]_* = -\frac{2}{\partial z} f$$

$$0 D = \{ \left. \begin{aligned} C * B - B * \pi(C) \end{aligned} \right\}$$

$$S(x|y, z) = -S(x|y, -z)$$

$$B(x|y, z) = B(x|y, -z)$$

$$d_x W + W * W = 0$$

$$d_x S + d_z W + S * W + W * S = 0$$

$$d_z S + S * S = B * K d z^2 + B * K d \bar{z}^2$$

$$d_x B + W * B - B * \pi(W) = 0$$

$$d_z B + S * B - B * \pi(S) = 0$$

$$S \rightarrow S + \frac{z_x}{1} d z^2 + \frac{\bar{z}_x}{1} d \bar{z}^2$$

$$[z_x, \{(\gamma, z)\}]_* = -\frac{z_x}{\partial_z} f$$

$$0 B = C * B - B * \pi(C)$$

$$\left. \begin{aligned} S(x|y, z) &= -S(x|-y, -z) \\ B(x|y, z) &= B(x|-y, -z) \end{aligned} \right\}$$

$$d_x W + W * W = 0$$

$$d_x S + d_z W + S * W + W * S = 0$$

$$d_z S + S * S = B * K d z^2 + B * K d \bar{z}^2$$

$$d_x B + W * B - B * \pi(W) = 0$$

$$d_z B + S * B - B * \pi(S) = 0$$

$$\boxed{\begin{aligned} S &\rightarrow S + \frac{z_x}{1} d z^2 + \frac{\bar{z}_x}{1} d \bar{z}^2 \\ [z_x, \{(\gamma, z)\}]_* &= -\frac{z_x}{\partial z} f \end{aligned}}$$

$$= C * B - B * \pi(C)$$

$$S(x|\gamma, z) = -S(x|-\gamma, -z)$$

$$B(x|\gamma, z) = B(x|-\gamma, -z)$$

$$d_x S + d_z W + S * W + W * S = 0$$

$$d_z S + S * S = B * K d z^2 + B * K d \bar{z}^2$$

$$d_x B + W * B - B * \pi(W) = 0$$

$$d_z B + S * B - B * \pi(S) = 0$$

$$\boxed{S \rightarrow S + \frac{2\mu}{1} dz + \frac{2\bar{\mu}}{1} d\bar{z}}$$

$$\boxed{[z, \{(\gamma, z)\}]_* = -\frac{2\mu}{1} \delta}$$

AdS vacuum $B=0$ $S=0$

$$W \in W_0 = \omega_{\mu\nu}^{\alpha\beta} \gamma^\mu \gamma^\nu + \omega_{\mu\nu}^{\alpha\beta} \gamma^\mu \gamma^\beta + \omega_{\mu\nu}^{\alpha\beta} \gamma^\mu \gamma^\alpha$$

$$dW_0 + W_0 * W_0 = 0$$

$$\left. \begin{aligned} S(x|\gamma, z) &= S(x|-\gamma, -z) \\ B(x|\gamma, z) &= B(x|-\gamma, -z) \end{aligned} \right\}$$

$$\left. \begin{aligned} W(x|\gamma, z) &= W(x|-\gamma, -z) \\ S(x|\gamma, z) &= -S(x|-\gamma, -z) \\ B(x|\gamma, z) &= B(x|-\gamma, -z) \end{aligned} \right\}$$

$$d_x S + d_z W + S * W + W * S = 0$$

$$d_z S + S * S = B * K d z^2 + B * K d \bar{z}^2$$

$$d_x B + W * B - B * \pi(W) = 0$$

$$d_z B + S * B - B * \pi(S) = 0$$

$$\boxed{S \rightarrow S + \frac{2\mu}{1} dz + \frac{2\bar{\mu}}{1} d\bar{z}}$$

$$\boxed{[z, \gamma(z)]_* = -\frac{2\mu}{1} \gamma}$$

Ans vacuum $\underline{B=0} \quad S=0$

$$W \in W_0 = \omega_{\mu\nu}^{\alpha\beta} \gamma^\mu \gamma^\nu + \omega_{\mu\nu}^{\alpha\beta} \gamma^\mu \gamma^\beta + \omega_{\mu\nu}^{\alpha\beta} \gamma^\mu \gamma^\alpha$$

$$dW_0 + W_0 * W_0 = 0$$

$$\delta C = \epsilon C + C * \epsilon$$

$$\delta B = \epsilon * B - B * \pi(C)$$

$$W(x|y, z) = W(x|-y, -z)$$

$$S(x|y, z) = -S(x|-y, -z)$$

$$B(x|y, z) = B(x|-y, -z)$$

$$d_x S + d_z W + S * W + W * S = 0$$

$$d_z S + S * S = B * K d z^2 + B * K d \bar{z}^2$$

$$d_x B + W * B - B * \pi(W) = 0$$

$$d_z B + S * B - B * \pi(S) = 0$$

$$\boxed{S \rightarrow S + \frac{2\mu}{1} dz^2 + \frac{2\bar{\mu}}{1} d\bar{z}^2}$$

$$\boxed{[z_\mu, \{(\gamma, z)\}]_* = -\frac{2\mu}{1} \delta}$$

AdS vacuum $\underline{B=0}$ $S=0$

$$W \in W_0 = \omega_{\mu\nu}^{\alpha\beta} \gamma^\mu \gamma^\nu + \omega_{\mu\nu}^{\alpha\beta} \gamma^\mu \gamma^\beta + \omega_{\mu\nu}^{\alpha\beta} \gamma^\alpha \gamma^\beta$$

$$dW_0 + W_0 * W_0 = 0$$

$$\left. \begin{aligned} \delta C &= \epsilon C + C * \epsilon \} \\ \delta B &= \epsilon * B - B * \pi(C) \end{aligned} \right\}$$

$$\left. \begin{aligned} W(x|y, z) &= W(x|-y, -z) \\ S(x|y, z) &= -S(x|-y, -z) \\ B(x|y, z) &= B(x|-y, -z) \end{aligned} \right\}$$

"UNFOLDED DYNAMICS"

"UNFOLDED DYNAMICS"

KLEIN GORDON IN FLAT SPACE

$$\partial^\mu \partial_\mu \varphi = 0$$

ψ^μ AUXILIARY VARIABLES $(\gamma_\alpha, \bar{\gamma}_\alpha)$

"UNFOLDED DYNAMICS"

KLEIN GORDON IN FLAT SPACE

$$\partial^\mu \partial_\mu \varphi = 0$$

γ^μ AUXILIARY VARIABLES $(\gamma_\alpha, \bar{\gamma}_\alpha)$

$$\Phi(x|\gamma) = \sum \frac{1}{k!} \varphi_{\mu_1 \dots \mu_k}(x) \gamma^{\mu_1} \dots \gamma^{\mu_k}$$

"UNFOLDED DYNAMICS"

KLEIN GORDON IN FLAT SPACE

$$\partial^\mu \partial_\mu \varphi = 0$$

γ^μ AUXILIARY VARIABLES $(\gamma_\alpha, \bar{\gamma}_\alpha)$

$$\Phi(x|\gamma) = \sum \frac{1}{k!} \varphi_{\mu_1 \dots \mu_k}(x) \gamma^{\mu_1} \dots \gamma^{\mu_k}$$

$$\frac{\partial}{\partial x^\mu} \Phi = \frac{\partial}{\partial y^\mu} \Phi$$

$$\frac{\partial}{\partial y^\mu} \frac{\partial}{\partial y^\mu} \Phi = 0 \rightarrow$$

$$\left[\frac{\partial}{\partial x^\mu} \Phi = \frac{\partial}{\partial y^\mu} \Phi \right]$$

$$\frac{\partial}{\partial y^\mu} \frac{\partial}{\partial y^\mu} \Phi = 0$$

$\rightarrow$

$$\psi^{\mu_1 \mu_2 \dots \mu_k} = 0 \quad k=0 \dots \infty$$

$$\left[\frac{\partial}{\partial x^\mu} \Phi = \frac{\partial}{\partial y^\mu} \Phi \right]$$

$$\left[\frac{\partial}{\partial y^\mu} \frac{\partial}{\partial y^\mu} \Phi = 0 \rightarrow \psi^\mu_{\mu\mu\ldots\mu k} = 0 \quad k=0 \ldots \infty \right]$$

$$\frac{\partial}{\partial x^\mu} \varphi$$

$$\left[\frac{\partial}{\partial x^\mu} \Phi = \frac{\partial}{\partial y^\mu} \Phi \right]$$

$$\frac{\partial}{\partial y^\mu} \frac{\partial}{\partial y^\mu} \Phi = 0 \rightarrow \psi^\mu_{\mu\nu\cdots\mu_k} = 0 \quad k=0\cdots\infty$$

$$\frac{\partial}{\partial x^\mu} \varphi = \varphi_\mu$$

$$\frac{\partial}{\partial x^\mu} \varphi_\nu = \varphi_{\mu\nu}$$

$$\left[\frac{\partial}{\partial x^\mu} \Phi = \frac{\partial}{\partial y^\mu} \Phi \right]$$

$$\frac{\partial}{\partial y^\mu} \frac{\partial}{\partial y^\mu} \Phi = 0 \rightarrow \psi^{\mu}{}_{\mu_1 \mu_2 \dots \mu_k} = 0 \quad k=0 \dots \infty$$

$$\frac{\partial}{\partial x^\mu} \varphi = \varphi_\mu$$

$$\frac{\partial}{\partial x^\mu} \varphi_\nu = \varphi_{\mu\nu}$$

$$\rightarrow \frac{\partial}{\partial x^\mu} \varphi_\mu = 0 \quad \frac{\partial}{\partial x^\mu} \frac{\partial}{\partial x^\mu} \varphi = 0$$

$$\varphi_{\mu_1 \dots \mu_k} = \partial_{\mu_1} \dots \partial_{\mu_k} \varphi$$

$$\left[\frac{\partial}{\partial x^\mu} \Phi = \frac{\partial}{\partial y^\mu} \Phi \right.$$

$$\left. \frac{\partial}{\partial y^\mu} \frac{\partial}{\partial y^\mu} \Phi = 0 \rightarrow \psi^\mu{}_{\mu_1 \mu_2 \dots \mu_k} = 0 \quad k=0 \dots \infty \right.$$

$$\frac{\partial}{\partial x^\mu} \varphi = \varphi_\mu$$

$$\frac{\partial}{\partial x^\mu} \varphi_\nu = \varphi_{\mu\nu}$$

$$\rightarrow \frac{\partial}{\partial x^\mu} \varphi_\mu = 0 \quad \frac{\partial}{\partial x^\mu} \frac{\partial}{\partial x^\mu} \varphi = 0$$

$$\varphi_{\mu_1 \dots \mu_k} = \partial_{\mu_1} \dots \partial_{\mu_k} \varphi$$

$$W \in W_0 = \omega_0^{\mu\nu} \gamma^\mu \gamma^\nu + \omega_0^{\mu 5} \gamma^\mu \gamma^5 + \omega_0^{\mu 5} \gamma^\mu \gamma^5$$

$$dW_0 + W_0 * W_0 = 0$$

$$A = W + S$$

$$\begin{cases} dA + A * A = F(B * K) dz^0 + 1 - (B * K) dz^1 \\ dB + A * B - B * \pi(A) = 0 \end{cases}$$

TWISTED
ANALOGY

$$\pi(f(\gamma, \bar{\gamma}, z, \bar{z}, dz, d\bar{z}))$$

$$= -f(-\gamma, \bar{\gamma}, -z, \bar{z}, -dz, d\bar{z})$$

HS GAUGE SYMMETRIES

$$\delta A = d\epsilon + [A, \epsilon]_*$$

$$\delta B = \epsilon * B - B * \pi(\epsilon)$$

$$\left\{ \begin{array}{l} \text{BOSONIC MODEL} \\ W(x|y, z) = W(x|-y, -z) \\ S(x|y, z) = -S(x|-y, -z) \\ B(x|y, z) = B(x|-y, -z) \end{array} \right.$$

"UNFOLDED DYNAMICS"

KLEIN GORDON IN FLAT SPACE

$$\partial^\mu \partial_\mu \psi = 0$$

γ^μ AUXILIARY VARIABLES $(\gamma_\alpha, \bar{\gamma}_\alpha)$

$$\Phi(x|\gamma) = \sum \frac{1}{k!} \varphi_{\mu_1 \dots \mu_k}(x) \gamma^{\mu_1} \dots \gamma^{\mu_k}$$

$$\frac{\partial}{\partial x^\mu} B \sim \frac{\partial}{\partial \gamma^\mu} \frac{\partial}{\partial \gamma^\mu} B$$

NON LOCALITY IN γ

↓

NON LOCALITY IN x

(INTERACTING)

"UNFOLDED DYNAMICS"

KLEIN GORDON IN FLAT SPACE

$$\partial^\mu \partial_\mu \psi = 0$$

ψ^μ AUXILIARY VARIABLES $(\psi_\alpha, \bar{\psi}_{\dot{\alpha}})$

$$\Phi(x|\psi) = \sum \frac{1}{k!} \varphi_{\mu_1 \dots \mu_k}(x) \psi^{\mu_1} \dots \psi^{\mu_k}$$

$$\frac{\partial}{\partial x^\mu} B \sim \frac{\partial}{\partial y^\mu} \frac{\partial}{\partial \psi^{\dot{\alpha}}} B$$

NON LOCALITY IN ψ

↓

NON LOCALITY IN x

(INTERACTING)

PHYSICAL D.O.F. $Z=0$ ($t_k = t_{k+1}$)

$$W(X|Y, Z=0) = \sum W_{\alpha_1 \dots \alpha_n, \bar{\alpha}_1 \dots \bar{\alpha}_n}^{(n_1, n_2)} Y^{\alpha_1} \dots Y^{\alpha_n} \bar{Y}^{\bar{\alpha}_1} \dots \bar{Y}^{\bar{\alpha}_n}$$

$$\partial^\mu \partial_\mu \varphi = 0$$

Y^μ AUXILIARY VARIABLES ($Y_\alpha, \bar{Y}_{\dot{\alpha}}$)

$$\Phi(X|Y) = \sum \frac{1}{k!} \varphi_{\mu_1 \dots \mu_k}(X) Y^{\mu_1} \dots Y^{\mu_k}$$

NON LOCALITY IN Y

↓

NON LOCALITY IN X

(INTERACTING)

2. MASTER FIELDS

$$W(x|Y, z) = dx^\mu W_\mu$$

$$S(x|Y, z) = dz^\alpha S_\alpha + d\bar{z}^{\dot{\alpha}} S_{\dot{\alpha}}$$

$$S|_{z_\mu = \bar{z}_{\dot{\mu}} = 0} = 0$$

$$B(x|Y, z)$$

SCALAR

PHYSICAL D.O.F. $z=0$ ($z_\mu = \bar{z}_{\dot{\mu}} = 0$)

$$W(x|Y, z=0) = \sum W_{\alpha_1 \dots \alpha_n \dot{\alpha}_1 \dots \dot{\alpha}_n}^{(n,n)} \gamma^{\alpha_1} \dots \gamma^{\alpha_n} \bar{\gamma}^{\dot{\alpha}_1} \dots \bar{\gamma}^{\dot{\alpha}_n}$$

$$d_2 B + S * B - B * \pi(S) = 0$$

AdS VAKUM

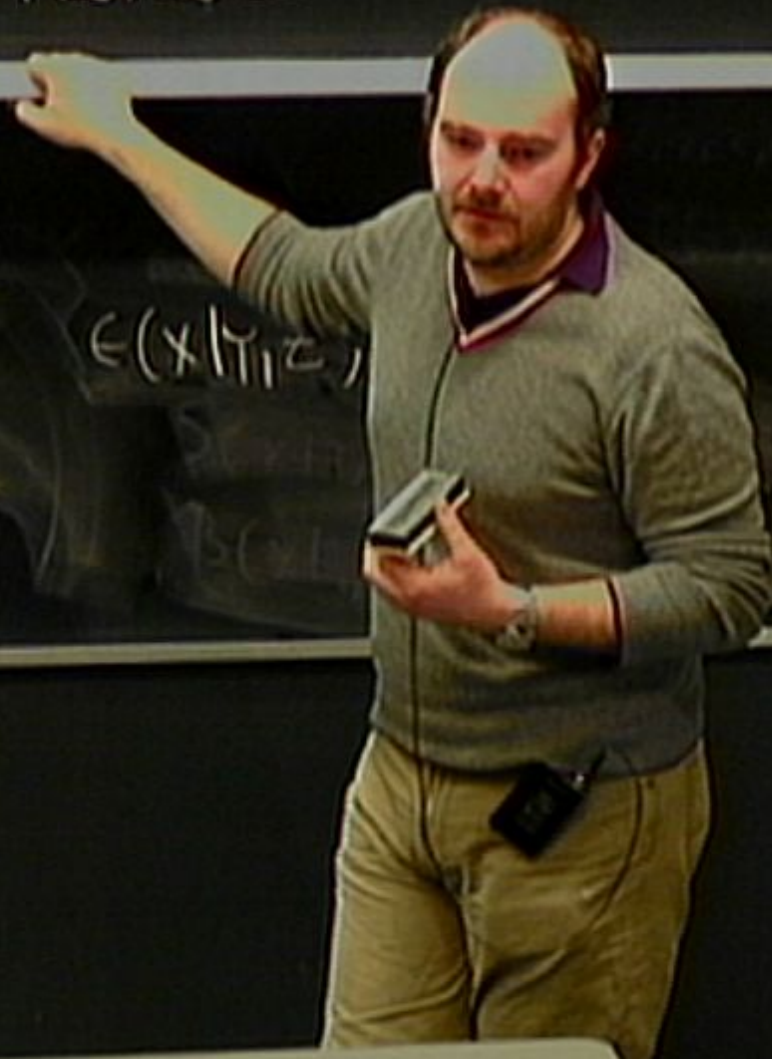
$$\underline{B=0} \quad S=0$$

$$W \in W_0 = \omega_{\alpha\beta}^{\mu\nu} \gamma^\mu \gamma^\nu + \omega_{\alpha\beta}^{\mu S} \gamma^\mu \gamma^\beta + \omega_{\alpha\beta}^{\mu\bar{S}} \gamma^\mu \gamma^{\bar{\beta}}$$

$$dW_0 + W_0 * W_0 = 0$$

$$S \rightarrow S + \frac{2\omega}{1} d\epsilon + \frac{2\omega}{1} d\bar{\epsilon}$$

$$[z_\mu, f(y, z)]_* = -2\frac{\omega}{\partial z_\mu} f$$



$$d_2 B + S * B - B * \pi(S) = 0$$

ADS VARIATION

$$\underline{B=0} \quad S=0$$

$$W \subset W_0 = \omega_{\alpha\beta}^{NS} \gamma^\alpha \gamma^\beta + \omega_{\alpha\beta}^{NS} \gamma^\alpha \gamma^\beta + \omega_{\alpha\beta}^{NS} \gamma^\alpha \gamma^\beta$$

$$dW_0 + W_0 * W_0 = 0$$

$$\left[z_\alpha, \int (\gamma, z) \right] \frac{\partial}{\partial z_\alpha}$$

$$C(W_0 + W_0 * W_0 = 0$$

LINEARIZED EQUATIONS

$$W = W_0 + W_1 + \dots$$

$$B = B_1 + \dots$$

$$S = S_1 + \dots$$

$$D_0 W_1 = 0$$

$$D_0 W_1 =$$

$$c(W_0 + W_0 * W_0) = 0$$

LINEARIZED EQUATIONS

$$W = W_0 + W_1 + \dots$$

$$B = B_1 + \dots$$

$$S = S_1 + \dots$$

$$D_0 W_1 = 0$$

$$d_z W_1 = -D_0 S_1$$

$$D_0 W_1 = dW_1 + W_0 * W_1 + W_1 * W_0$$

$$\pi((\pi, \pi, \pi, \pi))$$

$$= f(-\gamma, \gamma, -\gamma, \gamma, R)$$

$$C(\frac{1}{2}, \frac{1}{2}) = W(x| - \frac{1}{2}, -\frac{1}{2})$$

$$S(x| \frac{1}{2}, \frac{1}{2}) = (x| -\frac{1}{2}, -\frac{1}{2})$$

$$B(x| \frac{1}{2}, \frac{1}{2}) = (x| -\frac{1}{2}, -\frac{1}{2})$$

$$c(W_0 + W_0 * W_0) = 0$$

LINEARIZED EQUATIONS

$$W = W_0 + W_1 + \dots$$

$$B = B_1 + \dots$$

$$S = S_1 + \dots$$

$$D_0 W_1 = 0$$

$$D_0 W_1 = dW_1 + W_0 * W_1 + W_1 * W_0$$

$$d_z W_1 = -D_0 S_1$$

$$d_z S_1 = B_1 (k d_z^2 + k_c d_z^4)$$

$$c(W_0 + W_0 * W_0) = 0$$

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$$\tilde{D}_0 B_1 = 0$$

$$\tilde{D}_0 B = dB + [W_0, B]_{\pi}$$

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$$d_z B_1 \in \mathcal{O}(1)$$

$$c(W_0 + W_0 * W_0 = 0$$

LINEARIZED EQUATIONS

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$$d_z B_1 \in \mathcal{O}(1)$$

" $B_1 = B_1(x|y)$ DYNAMICS"

KLEIN-GORDON IN FLAT SPACE

$\partial_t^2 \phi = \Delta \phi$

ADDITIONAL VARIATION

$\partial_t^2 \phi = \Delta \phi$

" $B_1 = B_1(x|y)$ DYNAMICS"

$$k \ll S_1 = S_1(B_1) = -2\pi i \int_0^1 dt \, t \, (B * k) \Big|_{z \rightarrow t z} + c.c.$$



" $B_1 = B_1(x|y)$ DYNAMICS"

$$S_1 = S_1(B_1) = -\epsilon_0 \int_{t_1}^{t_2} dt \int d^3x (B \cdot k) \Big|_{z \rightarrow t_2} + c.c.$$

$$S_1 = -\epsilon_0 \int_{t_1}^{t_2} dt \int d^3x B(-t_2, \vec{r}) \cdot \vec{E}(t_2, \vec{r}) + c.c.$$

$$B_1 = B_1(x|y) \text{ DYNAMICS}$$

$$S_1 = S_1(B_1) = -\epsilon_0 d\tau \int_0^1 dt \, t \, (B * k) \Big|_{z \rightarrow t z} + c.c.$$

$$= -\epsilon_0 d\tau \int_0^1 dt \, t \, B(-t z, \bar{z}) e^{+i\gamma_k} + c.c.$$

$$B_1 = B_1(X|Y) \text{ DYNAMICS}$$

$$S_1 = S_1(B_1) = -\tau_0 d\tau \int_0^1 dt t (B * k) \Big|_{\tau \rightarrow t\tau} + c.c.$$

$$S_1(\tau=0)=0 = -\tau_0 d\tau \int_0^1 dt t B(-t\tau, \tau) e^{+i\gamma_k} + c.c.$$

• W

" $B_1 = B_1(x|y)$ DYNAMICS "

$$S_1 = S_1(B_1) = -z_0 dz \int_0^1 dt t (B * k) \Big|_{z \rightarrow t z} + c.c.$$

(since $S_1(z=0)=0$) $= -z_0 dz \int_0^1 dt t B(-t z, \bar{y}) e^{+t y_0} + c.c.$

PRIMARY DYNAMICS

$$W_1(x|y, z) = \Omega(x|y, \bar{y}) + W'(x|y, \bar{y}, z, z)$$

$$\bullet B_1 = B_1(x|y) \text{ "DYNAMICS"}$$

$$\bullet S_1 = S_1(B_1) = -z_0 dz \int_0^1 dt t (B \star k) \Big|_{z \rightarrow tz} + c.c.$$

$$\boxed{\text{Gauge } S_1(z=0)=0} = -z_0 dz \int_0^1 dt t B(-tz, \bar{y}) e^{+\varepsilon \gamma_4} + c.c.$$

$$\bullet W_1(x|y, z) = \Omega(x|y, \bar{y}) + W'(x|y, \bar{y}, z, z)$$

" $B_1 = B_1(x|y)$ DYNAMICS "

$k \cdot S_1 = S_1(B_1) = -z_\mu dz^\mu \int_0^1 dt \, t \, (B * k) \Big|_{z \rightarrow tz} + c.c.$

Given $S_1(z=0)=0$ $= -z_\mu dz^\mu \int_0^1 dt \, t \, B(-tz, \bar{y}) e^{+t\bar{y}y} + c.c.$

$W_1(x|y, z) = \Omega(x|y, \bar{y}) + W'_1(x|y, \bar{y}, z, z)$

$W_1 \rightarrow W'_1(S_1) = W_1(B_1)$

$$B_1 = B_1(x|y) \quad \text{DYNAMICS}$$

$$S_1 = S_1(B_1) = -z_0 dz \int_0^1 dt \, t \, (B * t) \Big|_{z \rightarrow t z} + c.c.$$

$$\boxed{\text{Gauge } S_1(z=0)=0} = -z_0 dz \int_0^1 dt \, t \, B(-t z, \bar{y}) e^{+t \bar{y} z_0} + c.c.$$

$$W_1(x|y, z) = \Omega(x|y, \bar{y}) + W'_1(x|y, \bar{y}, z, z)$$

$$W'_1 \rightarrow W'_1(S_1) = W'_1(B_1)$$

$$D_0 \Omega = -D_0 W_i \Big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$= \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, 0) dx^1 \wedge dx^2 \right. \\ \left. + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^3} \right]$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, 0) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|0, \bar{y}) dx^1 \wedge dx^2 \right]$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, 0) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|0, \bar{y}) dx^1 \wedge dx^2 \right]$$

$$\downarrow B + W_0 * B - B \wedge \pi(W_0) = 0$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, 0) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|0, \bar{y}) dx^1 \wedge dx^2 \right]$$

$$dB + W_0 * B_1 - B_1 \pi(W_0) = 0$$

$$[\omega_0, B]_* + \{e_0, B\}_*$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, 0) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|0, \bar{y}) dx^1 \wedge dx^2 \right]$$

$$dB + W_0 * B_1 - B_1 * \pi(W_0) = 0$$

$$dB + \pi(W_0, B)_* + \{e_0, B\}_* = 0$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, 0) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|0, \bar{y}) dx^1 \wedge dx^2 \right]$$

$$dB + W_0 * B_1 - B_1 * \pi(W_0) = 0$$

$$dB + \pi(W_0, B)_* + \{e_0, B\}_* = 0$$

$$(W_0 = \omega_1 \gamma_1 + \omega_2 \gamma_2 + \dots)$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, 0) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|0, \bar{y}) dx^1 \wedge dx^2 \right]$$

$$\bar{B}' + W_0 * B_1 - B_1 * \pi(W_0) = 0$$

$$\downarrow B + \pi(W_0, B)_* + \{e_0, B\}_* = 0$$

$$(W_0 = \omega_1 + \gamma_0 + \gamma_1 + c)$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B(x|y, \vec{0}) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^3} B_I(x|0, \vec{y}) dx^1 \wedge dx^3 \right]$$

$$dB + W_0 * B_1 - B_1 * \pi(W_0) = 0$$

$$dB + [\omega_0, B]_* + \{e_0, B\}_* = 0$$

$$\omega_0 = \omega_2^1 y_2 dy_1 + c_1$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8z^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, \vec{0}) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^3} B_1(x|0, \vec{y}) dx^1 \wedge dx^3 \right]$$

$$dB + W_0 * B_1 - B_1 * \pi(W_0) = 0$$

$$dB + [\omega_0, B]_* + \{e_0, B\}_* = 0$$

$$(\omega_0 = \omega_1^1 y_1^1 + \omega_1^2 y_1^2 + \dots)$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B(x|y, 0) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_I(x|0, \bar{y}) dx^1 \wedge dx^2 \right]$$

$$dB + W_0 * B_1 - B_1 * \pi(W_0) = 0$$

$$dB + [\omega_0, B]_* + \{e_0, B\}_* = 0$$

$$\omega_0 = \omega_1 \gamma_1 \gamma_2 + \dots$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$\left[D_0 \Omega = \frac{1}{8\pi^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_1(x|y, \vec{0}) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^3} B_1(x|0, \vec{y}) dx^1 \wedge dx^3 \right] \right]$$

$$B + W_0 * B_1 - B_1 * \pi(W_0) = 0$$

$$dB + [\omega_0, B]_* + \{e_0, B\}_* = 0$$

$$\Omega^{(s-1, n, s-1-m)}_{m=(s-1) \dots (s-1)}$$

$$B^{(s, n, n)}, B^{(s, n, n)}$$

$$D_0 \Omega = -D_0 W_i \big|_{z=\bar{z}=0} = -\{W_0, W_1'\}_*$$

$$D_0 \Omega = \frac{1}{8\epsilon^2} \left[\frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B(x|y, 0) dx^1 \wedge dx^2 + \frac{\partial}{\partial y^1} \frac{\partial}{\partial y^2} B_I(x|0, \bar{y}) dx^1 \wedge dx^2 \right]$$

$$dB + W_0 * B_1 - B_1 * \pi(W_0) = 0$$

$$dB + \pi(W_0, B)_* + \{e_0, B\}_* = 0$$

$$(W_0 = \omega_2 + \gamma_0 \gamma_1 + c)$$

$$\Omega^{(s-1, n, s-1, n)} \quad m = (s-1, \dots, s-1)$$

$$B^{(s, n, n)}, B^{(s, n, n)}$$

SPIN 1

$$\Omega = \Omega_\mu \equiv A_\mu$$

$$\partial_{(\alpha} A_{\beta\gamma)} = B_{\alpha\beta\gamma} \equiv F_{\alpha\beta\gamma}$$

SPIN 1

$$V_\mu \Omega = \Omega_\mu \equiv A_\mu$$

$$A_{\mu\nu} = B_{\mu\nu} \equiv F_{\mu\nu}$$

$$1^{st} \quad \partial_{(\alpha} A_{\beta)} = B_{\alpha\beta} \equiv F_{\alpha\beta}$$

1st + 2nd

$$\nabla^{\mu} F_{\mu\beta} = 0$$

PHYSICAL

$$F_{\mu\nu} = \partial_{\mu} A_{\nu} - \partial_{\nu} A_{\mu}$$

1st + 2nd

$$\nabla^2 \chi F_{\alpha\beta} = 0$$

$$\Omega^{(S-1, M, S-1, M)} \rightarrow \Omega^{(S-1, S-1)} = \Omega_{11}^{\alpha_1, \dots, \alpha_{S-1}, \beta_1, \dots, \beta_{S-1}}$$

$$\Omega(x, y) + W'_2(x|y, \bar{y}, z, \bar{z})$$

$$1'(\mathbb{B}_1)$$

1st + 2nd

$$\nabla^2 \psi + F_{\alpha\beta} = 0$$

$$\Omega(S-1, M, S-1, m) \longrightarrow \Omega(S-1, S-1) = \Omega_{11}^{\alpha_1, \dots, \alpha_{S-1}, \beta_1, \dots, \beta_{S-1}}$$

$$\longrightarrow \Omega_{11}^{\alpha_1, \dots, \alpha_{S-1}, \beta_1, \dots, \beta_{S-1}}$$

$$+ W_2'(x/y, \bar{y}, z, z)$$

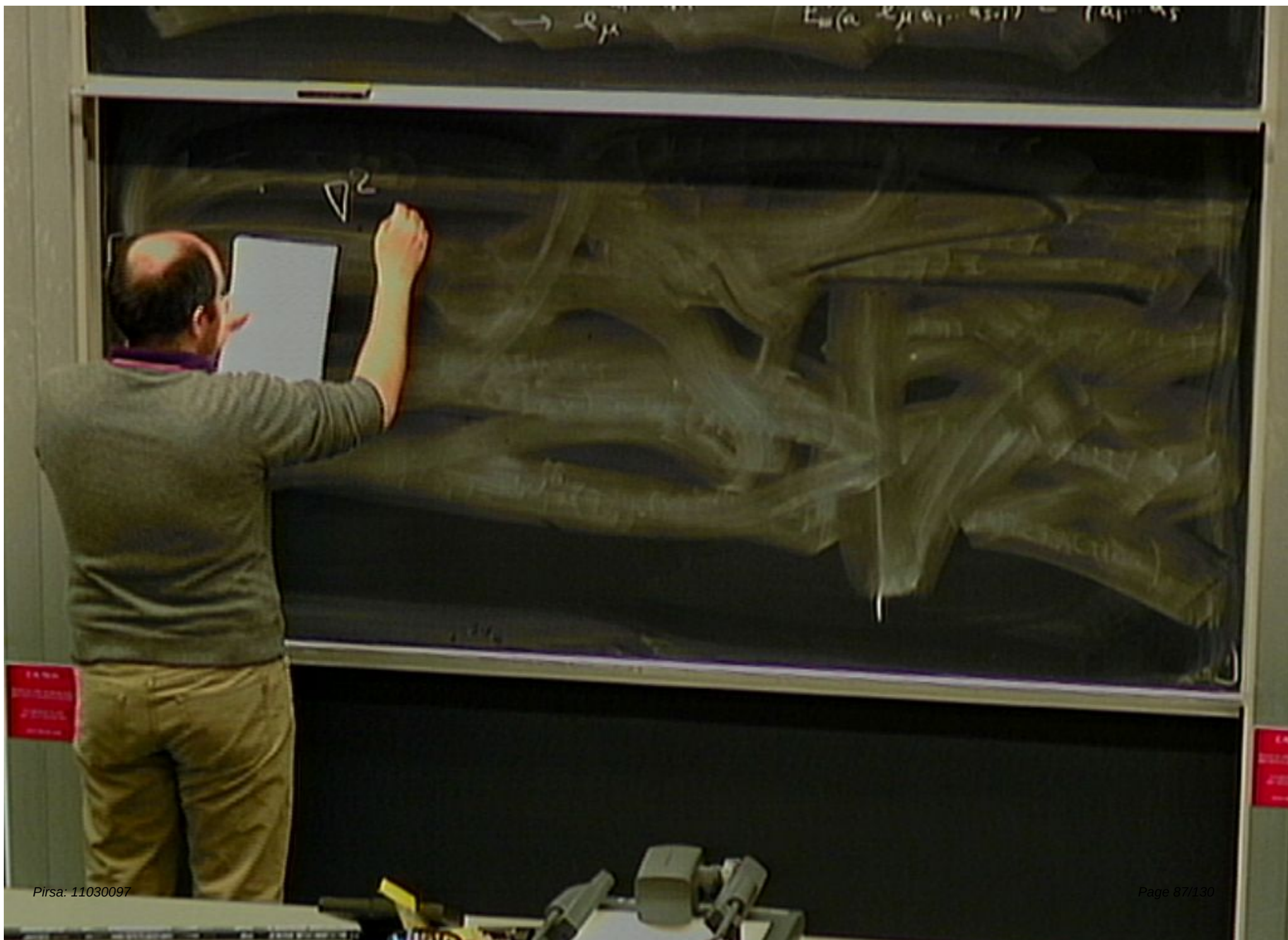
$$p_1 = W_1'(B_1)$$

$$\Omega(S-1, M, S-1, m) \rightarrow \Omega(S-1, S-1) = \Omega_{\mu}^{\alpha_1, \dots, \alpha_{S-1}, \beta_1, \dots, \beta_{S-1}}$$

$$\rightarrow e_{\mu}^{\alpha_1, \dots, \alpha_{S-1}} E_{\mu}^{\mu} e_{\mu}^{\alpha_1, \dots, \alpha_{S-1}}$$

$$W_1(x|y, z) = \Omega(x|y, \bar{y}) + W'_1(x|y)$$

$$W'_1 \rightarrow W'_1(S_1) = W'_1(B_1)$$



$$\rightarrow \epsilon_{\mu}$$

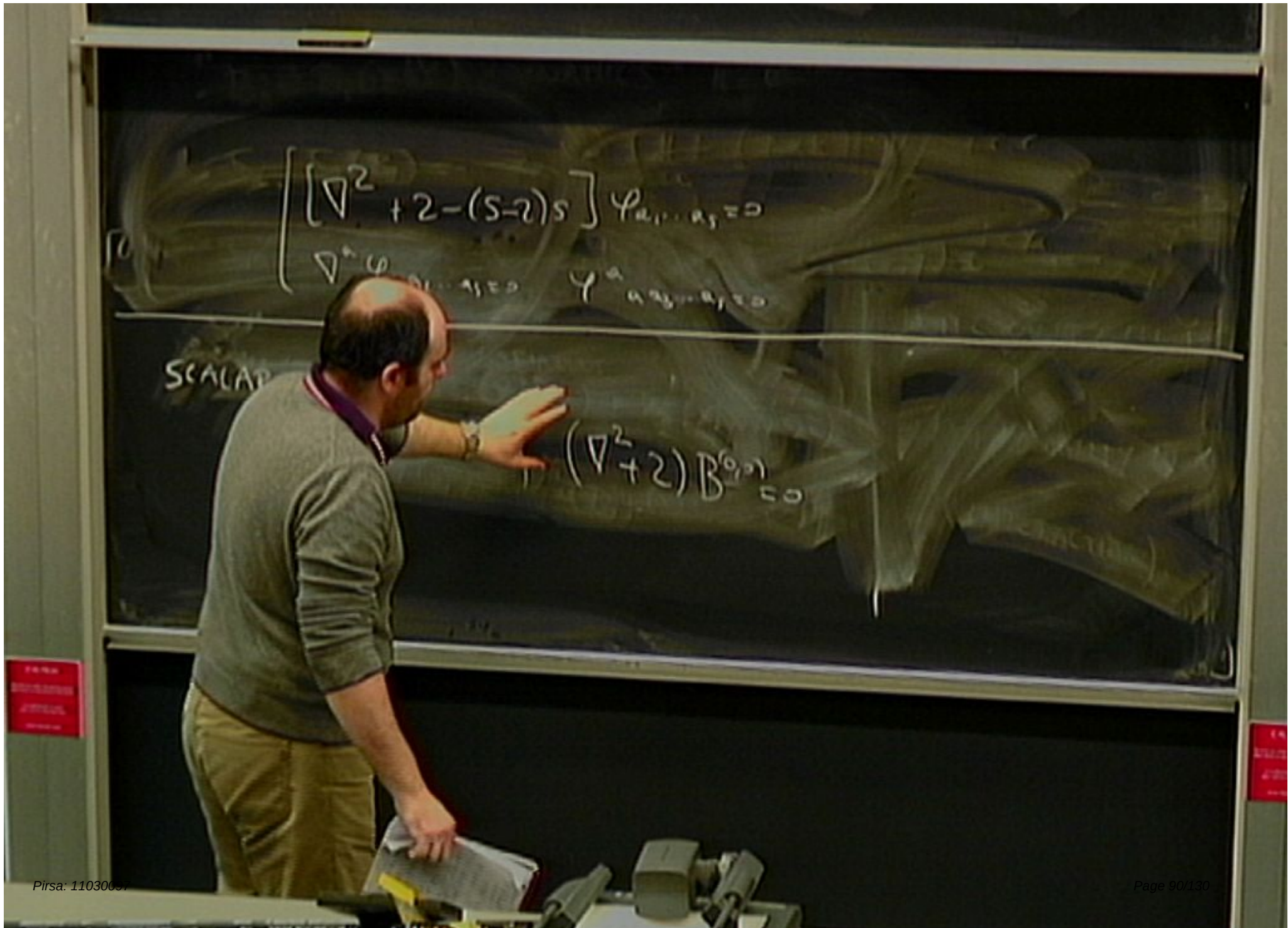
$$E_{\mu}(a, \epsilon_{\mu}, a_1, \dots, a_5) = (a_1, \dots, a_5)$$

$$\left[\begin{array}{l} [\nabla^2 + 2 - (s-2)s] \varphi_{a_1 \dots a_5} = 0 \\ \nabla^a \varphi_{a a_1 \dots a_5} = 0 \quad \varphi^a_{a a_1 \dots a_5} = 0 \end{array} \right]$$

$$\rightarrow \epsilon_{\mu}$$

$$E_{\mu}(a, \epsilon_{\mu} a_1 \dots a_s) = (a_1 \dots a_s)$$

$$\left\{ \begin{array}{l} [\nabla^2 + 2 - (s-2)s] \varphi_{a_1 \dots a_s} = 0 \\ \nabla^a \varphi_{a a_1 \dots a_s} = 0 \quad \varphi^a_{a a_1 \dots a_s} = 0 \end{array} \right.$$



$$\left[\nabla^2 + 2 - (s-2)s \right] \varphi_{a_1 \dots a_s} = 0$$
$$\nabla^a \varphi_{a_1 \dots a_s} = 0 \quad \varphi^a_{a_1 a_2 \dots a_s} = 0$$

SCALAR

$$(\nabla^2 + 2) B^{(0,1)} = 0$$

$$\left\{ \begin{array}{l} [\nabla^2 + 2 - (s-2)s] \varphi_{a_1 \dots a_s} = 0 \\ \nabla^a \varphi_{a a_1 \dots a_{s-1}} = 0 \quad \varphi^a_{a a_1 \dots a_{s-1}} = 0 \end{array} \right.$$

SCALAR EQ.

$$\left\{ \begin{array}{l} B^{(n)} \sim \partial B^{(n-1)} \\ (\nabla^2 + 2) B^{(0,1)} = 0 \end{array} \right.$$

" $B = B_s(x, y)$ " "DYNAMICS" $k = 0^{th}$

$$\left\{ \begin{array}{l} [\nabla^2 + 2 - (s-2)s] \varphi_{a_1 \dots a_s} = 0 \\ \nabla^a \varphi_{a a_1 \dots a_{s-1}} = 0 \quad \varphi^a_{a a_1 \dots a_{s-1}} = 0 \end{array} \right.$$

SCALAR EQ.

$$B^{(n)} \sim \partial B^{(n-1)} \quad \left\{ \begin{array}{l} (\nabla^2 + 2) B^{(0,1)} = 0 \end{array} \right.$$

" $B_{\mu\nu} \equiv B_{\mu\nu}(x)$ DYNAMICS" $k = 0$

$$\left\{ \begin{array}{l} [\nabla^2 + 2 - (s-2)s] \varphi_{a_1 \dots a_s} = 0 \\ \nabla^a \varphi_{a a_1 \dots a_{s-1}} = 0 \quad \varphi^a{}_{a a_1 \dots a_{s-1}} = 0 \end{array} \right.$$

SCALAR EQ.

$$\left\{ \begin{array}{l} B^{(11)} \sim \partial B^{(01)} \\ (\nabla^2 + 2) B^{(01)} = 0 \end{array} \right.$$

$$\underline{\underline{m^2 = -2}}$$

AdS/CFT

$$B^{(2,2)} \leftrightarrow \mathcal{O}_\Delta$$

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$$d=3, m^2=2$$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2}$$

AdS/CFT

$$B^{(0,2)} \leftrightarrow \mathcal{O}_\Delta$$

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$$d=3, m^2=-2$$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2} = \begin{cases} \Delta=1 \\ \Delta=2 \end{cases}$$

AdS/CFT

$$B^{(0,2)} \leftrightarrow \mathcal{O}_\Delta$$

φ

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$$d=3, m^2=2$$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2}$$

$$\left\{ \begin{array}{l} \Delta=1 \\ \Delta=2 \end{array} \right.$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

AdS/CFT

$$B^{(0,2)} \leftrightarrow \mathcal{O}_\Delta$$

$\parallel$
 φ

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$$d=3, m^2=-2$$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2} =$$

$$\left\{ \begin{array}{l} \Delta=1 \\ \Delta=2 \end{array} \right.$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

AdS/CFT

$$B^{(0,2)} \leftrightarrow \mathcal{O}_\Delta$$

φ

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$$d=3, m^2=-2$$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2} =$$

$$\Delta = 1$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

$$\varphi(z, x)$$

AdS/CFT

$$B^{(0,2)} \longleftrightarrow \mathcal{O}_\Delta$$

φ

$$\Delta(\Delta-1) = \dots$$

$$\Delta = \frac{d}{2} \pm \sqrt{\dots}$$

dec on 2

$$\Delta = \dots$$

$$\Delta = 1$$

$$\Delta = 2$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

$\beta(\vec{x})$ is AWAY FROM sources

AdS/CFT

$$B^{(0,1,2)} \leftrightarrow \mathcal{O}_\Delta$$

φ

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$$d=3, m^2=-2$$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2} = \begin{cases} \Delta=1 \\ \Delta=2 \end{cases}$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

$\beta(\vec{x})$ is AWAY FROM SOURCE

$$\alpha(\vec{x}) = \langle \mathcal{O}_{\Delta_+}(\vec{x}) \rangle$$

$$\beta(\vec{x}) = \mathcal{J}_0(\vec{x})$$

AdS/CFT

$$\mathcal{P}_2^{(0,1,2)} \longleftrightarrow \mathcal{O}_\Delta$$

φ

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$$d=3, m^2=-2$$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2} = \begin{cases} \Delta=1 \\ \Delta=2 \end{cases}$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

$\beta(\vec{x})$ is AWAY FROM $\mathcal{S}$

$$\alpha(\vec{x}) = \langle \mathcal{O}_{\Delta_+}(\vec{x}) \rangle$$

$$\beta(\vec{x}) = \mathcal{J}_\beta(\vec{x})$$

AdS/CFT

$$\beta^{(0,2)} \leftrightarrow \mathcal{O}_\Delta$$

"
 φ

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

dec $m^2 < 0$

$$\Delta = \frac{d}{2} \pm \sqrt{\frac{d}{4} - 2}$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

$\beta(\vec{x})$ is AWAY FROM SOURCE

$$\alpha(\vec{x}) = \langle \mathcal{O}_{\Delta_+}(\vec{x}) \rangle$$

$$\beta(\vec{x}) = \mathcal{J}_0(\vec{x})$$

AdS/CFT

$$B^{(2,2)} \leftrightarrow \mathcal{O}_\Delta$$

φ

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$$d=3, m^2=-2$$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2} =$$

$$\left\{ \begin{array}{l} \Delta=1 \\ \Delta=2 \end{array} \right.$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

$\beta(\vec{x})$ is AWAY FROM SOURCE

$$\langle \mathcal{O}_{\Delta_+}(\vec{x}) \rangle = \alpha(\vec{x})$$

ALT

AdS/CFT

$$\beta^{(2,2)} \leftrightarrow \mathcal{O}_\Delta$$

φ

$$\Delta(\Delta-1) = m^2$$

$$\Delta = \frac{d}{2} \pm \sqrt{\left(\frac{d}{2}\right)^2 + m^2}$$

$d=3$

$$\Delta = \frac{3}{2} \pm \sqrt{\frac{9}{4} - 2}$$

$$\Delta_- = 1$$

$$\Delta_+ = 2$$

$$\varphi(z, \vec{x}) = z^{\Delta_+} \alpha(\vec{x}) + z^{\Delta_-} \beta(\vec{x})$$

$\beta(\vec{x})$ is AWAY FROM sources

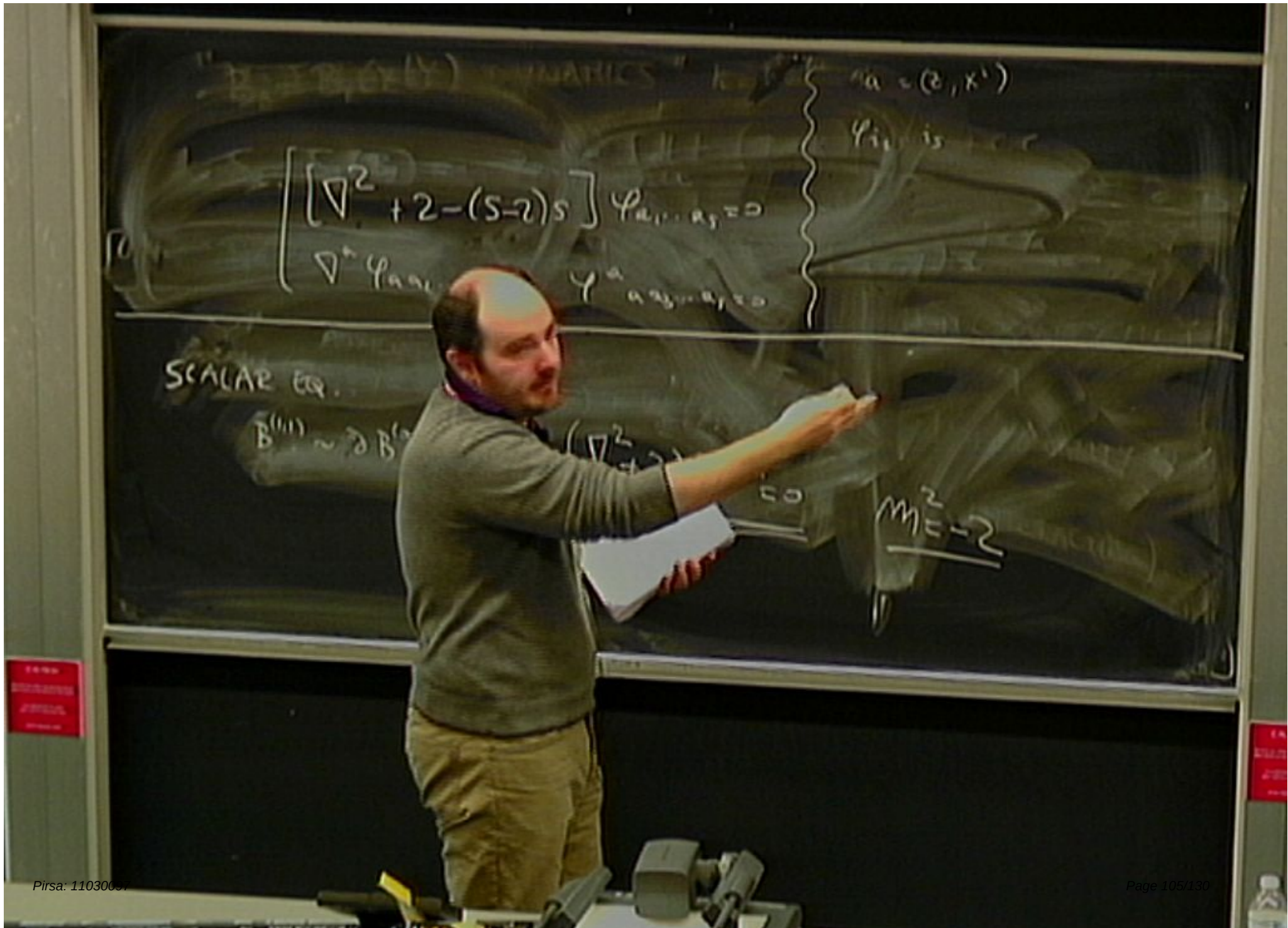
$$\alpha(\vec{x}) = \langle \mathcal{O}_{\Delta_+}(\vec{x}) \rangle$$

$$\beta(\vec{x}) = \mathcal{J}_0(\vec{x})$$

ALTERNATIVE

$$\alpha(\vec{x}) = \mathcal{J}_0(\vec{x})$$

$$\beta(\vec{x}) = \langle \mathcal{O}_{\Delta_-} \rangle$$



"DYNAMICS" $k = 1$ $a = (z, x^1)$

$$\begin{cases} [\nabla^2 + 2 - (5-2)s] \varphi_{a_1 \dots a_5} = 0 \\ \nabla^a \varphi_{a a_1 \dots a_4} = 0 \end{cases}$$

$\varphi_{i_1 \dots i_5} = 0$

SCALAR EQ.

$$\Box B^{(11)} \sim \partial B^{(11)}$$

$$(\nabla^2 + 2)$$

$$= 0$$

$$m^2 = -2$$

"DYNAMICS"

$$\left[\begin{array}{l} [\nabla^2 + 2 - (s-2)s] \varphi_{a_1 \dots a_s} = 0 \\ \nabla^a \varphi_{a a_1 \dots a_s} = 0 \end{array} \right. \quad \varphi^a{}_{a a_1 \dots a_s} = 0$$

$$a = (z, x^i)$$

$$\varphi_{i_1 \dots i_s} \leftrightarrow J_{i_1 \dots i_s} \quad \Delta(s) = s+1$$

$$\varphi_{i_1 \dots i_s} \sim z^{\Delta_s}$$

$$\underline{\Delta_+ = s+1}, \quad \underline{\Delta_- = 2-s}$$

SCALAR EQ.

$$\left. \begin{array}{l} B^{(n)} \sim \partial B^{(n-1)} \\ (\nabla^2 + 2) B^{(0,1)} = 0 \end{array} \right\}$$

$$\underline{m^2 = -2}$$

" $B_s \in B_s(\gamma)$ "

"DYNAMICS"

$$a = (z, x^i)$$

$$y_{i_1 \dots i_s} \leftrightarrow J_{i_1 \dots i_s} \quad \Delta(\gamma) = s+1$$

$$\left\{ \begin{array}{l} [\nabla^2 + 2 - (s-2)s] \varphi_{a_1 \dots a_s} = 0 \\ \nabla^a \varphi_{a a_1 \dots a_s} = 0 \quad \varphi^a_{a a_1 \dots a_s} = 0 \end{array} \right.$$

$$\varphi_{i_1 \dots i_s} \sim z^{\Delta_s}$$

$$\underline{\Delta_+ = s+1}, \quad \underline{\Delta_- = 2-s}$$

SCALAR EQ.

$$B^{(n)} \sim \partial B^{(n)}$$

$$\left\{ \begin{array}{l} (\nabla^2 + 2) B^{(0,1)} = 0 \end{array} \right.$$

$$\underline{m^2 = -2}$$

KLEBANOV-POLYAKOV - SERGIN - SUNDELL CONJECTURES

Pirsa: 11030097

KLEBANOV-POLYAKOV - SERGIN - SUNDELL CONJECTURES

1. MINIM

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1. MINIMAL "TYPE A"
VASILIEV THEORY ABS_4

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MINIMAL "TYPE A"

VASILIEV THEORY AdS_4



FREE $O(N)$ VECTOR MODEL
IN THE SINGLET SECTOR

KLEBANOV-POLYAKOV - SERGIN - SUNDELL CONJECTURES

1. MINIMAL "TYPE A"
VASILIEV THEORY MS_4



FREE $O(N)$ VECTOR MODEL
IN THE SINGLET SECTOR

$$S = \int d^4x \partial^\mu \phi^i \partial_\mu \phi_i \quad [\phi_i] = \frac{1}{2}$$

$$J_0 = \phi^i \phi_i \quad \Delta = 1$$

1. MINIMAL "TYPE A"
Vasiliev theory AdS_4



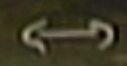
FREE $O(N)$ VECTOR MODEL
IN THE SINGLET SECTOR

$$S = \int d^4x \partial^\mu \phi^i \partial_\mu \phi_i \quad [\phi_i] = \frac{1}{2}$$

$$\mathcal{J}_0 = \phi^i \phi_i \quad \Delta = 1$$

$$\mathcal{J}_S = \phi^i \partial_{\mu_1} \dots \partial_{\mu_n} \phi_i \quad \Delta = n + 1$$

1. MINIMAL "TYPE A"
Vasiliev theory AdS_4



FREE $O(N)$ VECTOR MODEL
IN THE SINGLET SECTOR

$B^{(2,0)}$ $\Delta=1$ b.c.

$\varphi_{a_1 \dots a_5}$

$$S = \int d^4x \partial^\mu \phi^i \partial_\mu \phi_i \quad [\phi_i, \pi_j] = \frac{1}{2} \delta_{ij}$$

$$J_0 = \phi^i \phi_i \quad \Delta=1$$

$$J_{\mu_1 \dots \mu_5} = \phi^i \partial_{\mu_1} \dots \partial_{\mu_5} \phi_i + \dots$$

$$S = 2, 4, 6, \dots, \infty$$



"DYNAMICS" $K = \frac{1}{2} \dot{x}^2 - V(x)$

2. MINIMAL TYPE A

$\Delta = 2$ for $\beta^{(2n)}$



2. MINIMAL TYPE A

$\Delta = 2$ for $\beta^{(n)}$

IR FIXED POINT OF $O(N)$ VECTOR
MODEL WITH RELEVANT DEFORMATIONS

$$S = \int \left[\partial_\mu \phi^i \partial_\mu \phi^i + \frac{\lambda}{2} (\phi^i \phi^i)^2 \right]$$

2. MINIMAL TYPE A

$$\Delta = 2 \quad \text{for } \beta^{(2n)}$$

IR FIXED POINT OF $O(N)$ VECTOR
MODEL WITH RELEVANT DEFORMATIONS

$$S = \int \left[\partial_\mu \phi^i \partial_\mu \phi^i + \frac{\lambda}{2} (\phi^i \phi^i)^2 \right]$$

2. MINIMAL TYPE A

$$\Delta = 2 \text{ for } \beta^{(2n)}$$

$\beta^{(2n)}$

β_5

IR FIXED POINT OF $O(N)$ VECTOR
MODEL WITH RELEVANT DEFORMATIONS

$$S = \int \left[\partial^\mu \phi^i \partial_\mu \phi_i + \frac{\lambda}{2} (\phi^i \phi_i)^2 \right]$$

IR FIXED POINT

$$\Delta(\beta_0) = 2 + O\left(\frac{1}{N}\right)$$

$$\Delta(\beta_5) = 5 + 1 + O\left(\frac{1}{N}\right)$$

KLEBANOV-WITTEN
GUBER-KLEBANOV

2. MINIMAL TYPE A

$$\Delta = 2 \text{ for } \beta^{(2n)}$$

$$\beta^{(2n)}$$

$$\gamma_{n+1}$$

IR FIXED POINT OF $O(N)$ VECTOR
MODEL WITH RELEVANT DEFORMATION

$$S = \int \left[\partial^\mu \phi^i \partial_\mu \phi_i + \frac{\lambda}{2} (\phi^i \phi_i)^2 \right]$$

IR FIXED POINT

$$\Delta(\mathcal{O}_2) = 2 + O\left(\frac{1}{N}\right)$$

$$\Delta(\mathcal{O}_S) = S+1 + O\left(\frac{1}{N}\right)$$

KLEBANOV-WITTEN
GUBER-KLEBANOV

2. MINIMAL TYPE A

$$\Delta = 2 \text{ for } \beta^{(2n)}$$

$$\beta^{(2n)}$$

$$\gamma_{n-1}$$

IR FIXED POINT OF $O(N)$ VECTOR
MODEL WITH RELEVANT DEFORMATION

$$S = \int \left[\partial^\mu \phi^i \partial_\mu \phi_i + \frac{\lambda}{2} (\phi^i \phi_i)^2 \right]$$

IR FIXED POINT

$$\Delta(\mathcal{O}_0) = 2 + O\left(\frac{1}{N}\right)$$

$$\Delta(\mathcal{O}_S) = S+1 + O\left(\frac{1}{N}\right)$$

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$\Delta = 2, 4, \dots$ For $B^{(n)}$

$$S = \int \left[\partial'_\mu \phi'_i \partial_\mu \phi_i + \frac{1}{2} (\phi'_i \phi_i)^2 \right]$$

IR FIXED POINT

$$\Delta(J_0) = 2 + \mathcal{O}\left(\frac{1}{N}\right)$$

$$\Delta(J_5) = S + 1 + \mathcal{O}\left(\frac{1}{N}\right)$$

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$$S = 2, 4, 6, \dots, \infty$$

2. INITIAL STATE

$$\Delta = 2, 4, \dots \text{ for } B^{(m)}$$

$$B^{(m)}$$

$$Y_{(m)} = 95$$



MODEL WITH RELEVANT

$$S = \int \left[\partial^\mu \phi^\dagger \partial_\mu \phi + \frac{\lambda}{2} (\phi^\dagger \phi)^2 \right]$$

FIXED POINT

$$\beta(\lambda) = 2 + \mathcal{O}\left(\frac{1}{N}\right)$$

$$\beta(g) = S + 1 + \mathcal{O}\left(\frac{1}{N}\right)$$

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2. INITIAL STATE

$$\Delta = 2, 4, \dots \text{ for } B^{(m)}$$

$B^{(m)}$

$\psi_{m,1}, \dots, \psi_{m,n}$

$$S = 2, 4, 6, \dots, \infty$$

MODEL WITH RELEVANT

$$S = \int \left[\partial^\mu \phi^\dagger \partial_\mu \phi + \frac{\lambda}{2} (\phi^\dagger \phi)^2 \right]$$

IR FIXED POINT

$$\Delta(\mathcal{J}_0) = 2 + \mathcal{O}\left(\frac{1}{N}\right)$$

$$\Delta(\mathcal{J}_S) = S + 1 + \mathcal{O}\left(\frac{1}{N}\right)$$

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"TYPE B"

$$\Delta = 2 \text{ bc}$$

$\psi^{(0)}$

$\psi_{a_1 \dots a_r}$

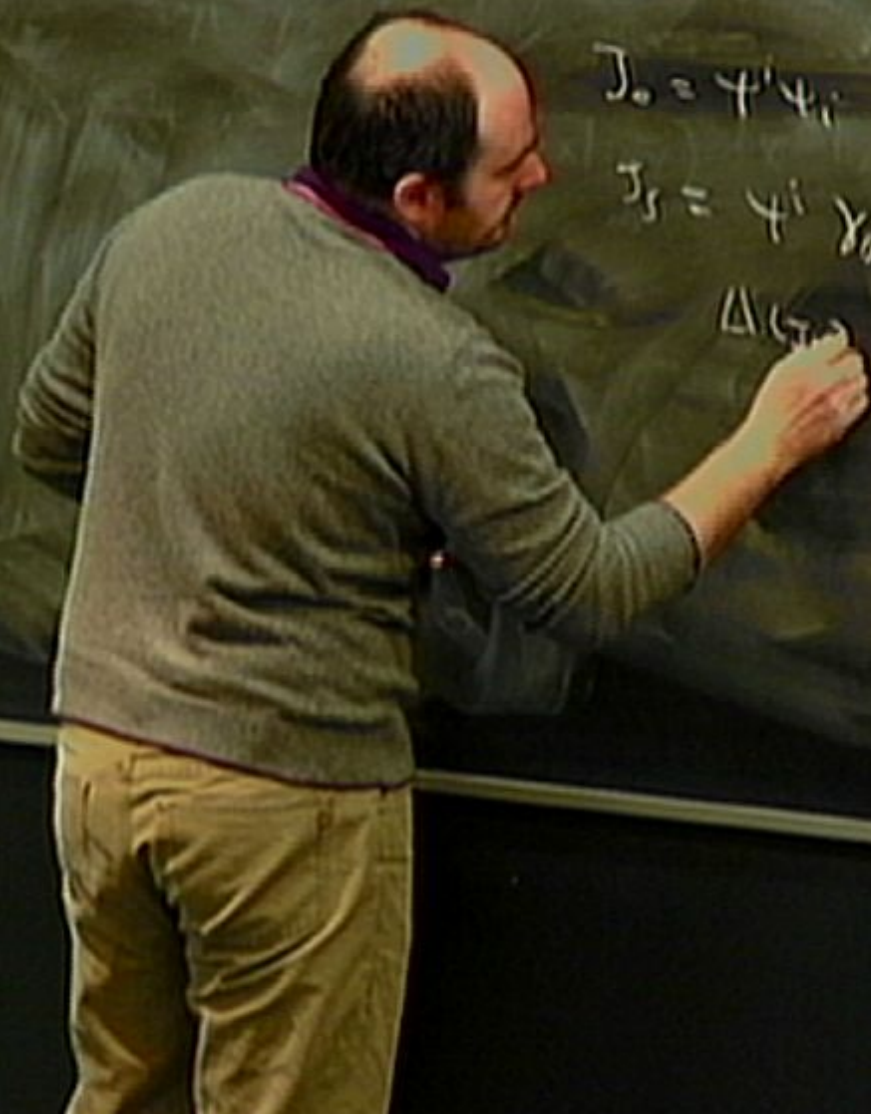


FREE $O(N)$ FERMIONS

$$S = \int d^d x \psi^\dagger \gamma^\mu \partial_\mu \psi \quad [\psi] = 1$$

$$J_0 = \psi^\dagger \psi \quad \Delta = 2$$

$$J_5 = \psi^\dagger \gamma_5 \partial_{\mu_1} \dots \partial_{\mu_r} \psi \quad \Delta = 2 + r$$



• "TYPE B"

$$\Delta = 2 \text{ bc}$$

$B^{(0)}$

$\psi_{1, \dots, n}$

FREE $O(N)$ FERMIONS

$$S = \int d^d x \psi^\dagger \gamma_\mu \partial_\mu \psi \quad [\psi] = 1$$

$$J_0 = \psi^\dagger \psi \quad \Delta = 2$$

$$J_S = \psi^\dagger \gamma_{\mu_1} \partial_{\mu_1} \dots \partial_{\mu_S} \psi \quad \dots$$

$$\Delta(J_S) = S+1 \quad S=2, 4, \dots$$

"TYPE B"

$$\Delta = 2 \text{ bc}$$

$B^{(n)}$

ψ

FREE $O(N)$ FERMIONS

$$S = \int d^d x \psi^\dagger \gamma^\mu \partial_\mu \psi \quad [\psi] = 1$$

$$J_0 = \psi^\dagger \psi \quad \Delta = 2$$

$$J_S = \psi^\dagger \gamma^\mu \partial_\mu \psi + \dots$$

$$\Delta(J_S) = S+1 \quad S=2,4,\dots$$

$$S = \int d^d x \psi^\dagger \gamma^\mu \partial_\mu \psi + \frac{1}{2} (\psi^\dagger \psi)^2$$

"TYPE B"

$$\Delta = 2 \text{ b.c.}$$

$$B^{(0)}$$

$$\psi_{\alpha \dots \alpha}$$

$$\Delta = 1 \text{ b.c.}$$

FREE $O(N)$ FERMIONS

$$S = \int d^4x \bar{\psi} \gamma^\mu \partial_\mu \psi \quad [\psi] = 1$$

$$J_0 = \bar{\psi} \psi \quad \Delta = 2$$

$$J_S = \bar{\psi} \gamma_{\alpha_1} \partial_{\alpha_2} \dots \partial_{\alpha_S} \psi + \dots$$

$$\Delta(J_S) = S+1 \quad S=2,4,\dots$$

$$S = \int d^4x \left[\bar{\psi} \gamma^\mu \partial_\mu \psi + \frac{1}{2} (\bar{\psi} \psi)^2 \right]$$

$$\Delta(J_0) = 1 + \mathcal{O}\left(\frac{1}{N}\right)$$

$$\Delta(J_S) = S+1 + \mathcal{O}\left(\frac{1}{N}\right)$$

$$S = 2, 4, 6, \dots, \infty$$

2. INITIAL STATE

$$\Delta = 2 \text{ for } B^{(2)}$$

$B^{(2)}$

$\phi_{\mu} \phi_{\nu}$



MODEL WITH RELEVANT DIAGRAMS

$$S = \int \left[\partial^{\mu} \phi^{\dagger} \partial_{\mu} \phi + \frac{1}{2} (\phi^{\dagger} \phi)^2 \right]$$

IR FIXED POINT

$$\Delta(\mathcal{O}_0) = 2 + \mathcal{O}\left(\frac{1}{N}\right)$$

$$\Delta(\mathcal{O}_S) = S + 1 + \mathcal{O}\left(\frac{1}{N}\right)$$

KLEBANOV-WITTEN
GUBER-KLEBANOV

$$d_1 B + W * B - B * \pi(W) = 0$$

$$d_2 B + S * B - B * \pi(S) = 0$$

AdS VAKUM

$$\underline{B=0} \quad S=0$$

$$W \in W_0 = \omega_{\mu\nu}^{\text{NS}} \gamma^\mu \gamma^\nu + \omega_{\mu\nu}^{\text{NS}} \gamma^\mu \gamma^\nu + \omega_{\mu\nu}^{\text{NS}} \gamma^\mu \gamma^\nu$$

$$dW_0 + W_0 * W_0 = 0$$

$$\boxed{S \rightarrow S + \frac{2\pi\alpha'}{l} \partial_t^2 + \frac{2\pi\alpha'}{l} \partial_t^2}$$

$$\boxed{[z_\mu, f(y, z)]_* = -\frac{2\pi\alpha'}{l} f}$$

des m₂ = 2

$$\Delta = \frac{2}{\epsilon} \sqrt{\frac{3}{4} - 2} =$$

$$\left\{ \begin{array}{l} \Delta_+ = 1 \\ \Delta_- = 2 \end{array} \right\}$$

ALG

$$J_0(z)$$

$$< 0.7$$