Linearized gauge functions and the COMST in Vasiliev's higher spin gravity

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Higher spin gauge fields

Gauge connection in $hs(4) \subset \mathcal{U}(so(2,3))$

$$W(x,Y) = \sum_{s=1}^{\infty} W_s(x,Y)$$

- $W_1 = A$
- $W_2 = e^a P_a + \omega^{ab} M_{ab}$
- $W_3 = e^{aa} P_a P_a + \omega^{aa,b} M_{ab} P_a + X^{aa,bb} M_{ab} M_{ab}$
- ...

Oscillator realisation of $so(2,3) \sim sp(4)$

- Weyl algebra $(Y_{\underline{\alpha}} = (y_\alpha, \bar{y}_{\dot{\alpha}}), \star)$ $sp(4)$ oscillators : $[Y_{\underline{\alpha}}, Y_{\underline{\beta}}]_\star = 2iC_{\underline{\alpha\beta}}$
- $M_{ab} \sim y_\alpha y_\alpha + \bar{y}_{\dot{\alpha}} \bar{y}_{\dot{\alpha}}$ $\quad P_a \sim y_\alpha \bar{y}_{\dot{\alpha}}$

Spectrum

Coefficients of $Y^{2(s-1)}$ are spin s gauge fields

- Bosonic model : integer spins $W(x;Y) = W(x;-Y)$
- Minimal bosonic model : even spins $W(x;Y) = -W(x, iY)$

Why studying massless higher spin fields?

- They correspond to existing representations of Poincaré/(anti-)de Sitter algebra
- Draw the line between no-go theorems and yes-go examples
- Expected to behave well in the UV because of the infinitely many symmetries
- Proposed holographic dualities with theories with various conserved currents (e.g. free fields)
- Appear in string theory

Propagating d.o.f. : Central On Mass Shell Theorem (COMST)

AdS_4 vacuum

- $\Omega = h^a P_a + \varpi^{ab} M_{ab}$
- $d\Omega + \Omega \star \Omega = 0$

Weyl zero-form

- $C_0 = \phi$
- $C_1 = F^{ab} M_{ab}$
- $C_2 = C^{aa,bb} M_{ab} M_{ab}$
- ...

Free unfolded equations

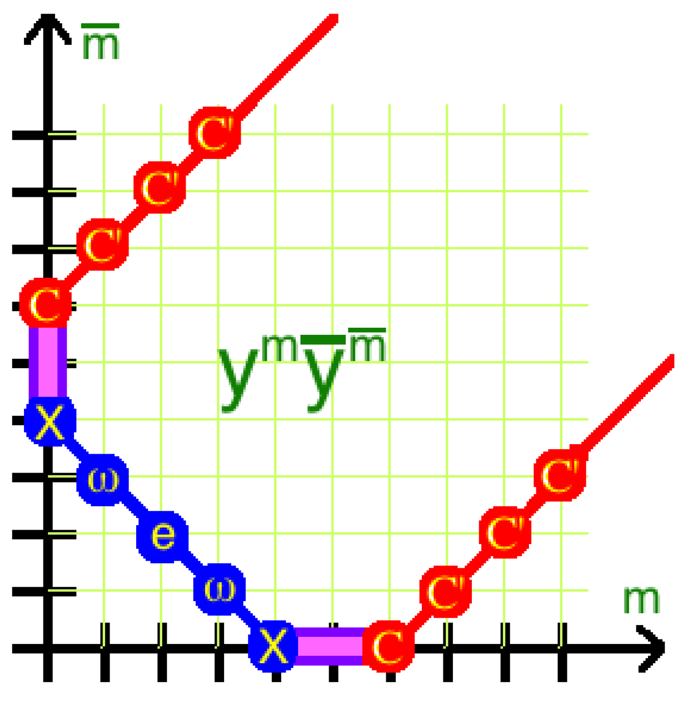
$$dC + \Omega \star C - C \star \pi(\Omega) = 0$$
$$dW + [\Omega, W]_\star = \Sigma(h,h,C)$$

Spin 2 example

$$\nabla^L e^a + \omega^a{}_b e^b = 0$$
$$\nabla^L \omega^{ab} + \Lambda h^{[a} e^{b]} = e^c e^d C_{ac,bd}$$

Infinite tower of equations for C and its derivatives.
In particular:

$$\Box C_{aa,bb} = m_{\Lambda,2} C_{aa,bb}$$



Spin 3

Master fields

Auxiliary coordinates $Z_{\underline{\alpha}}$

- $[Z_{\underline{\alpha}}, Z_{\underline{\beta}}]_\star = -2iC_{\underline{\alpha\beta}}$ $\quad [Y_{\underline{\alpha}}, Z_{\underline{\alpha}}] = 0$
- Usually, normal ordering of $Y - Z$ and $Y + Z$

Master fields on $\mathcal{X}_4 \times \mathcal{Y}_4 \times \mathcal{Z}_4$

- Connection $A = dx^\mu A_\mu + dZ^{\underline{\alpha}} A_{\underline{\alpha}}$
- Zero-form Φ

$\mathcal{X}_4 \times \mathcal{Z}_4$ is the base manifold while $\mathcal{Y}_4$ is the fiber

Vasiliev's equations

Field equations

- $dA + A \star A = \Phi \star J$
- $d\Phi + A \star \Phi - \Phi \star \pi(A) = 0$

The source J is a Z-space 2-form and a space-time 0-form.

Cartan integration

- $A^{(G)} = G^{-1} \star (d + A') \star G$
- $\Phi^{(G)} = G^{-1} \star \Phi' \star \pi(G)$
- $A'_\mu = 0$
- $d_x A' = d_x \Phi' = 0$

Perturbation theory

Perturbative expansion

- AdS vacuum $A^{(0)} = \Omega \quad \Phi^{(0)} = 0$
- Perturbative moduli : $(\Phi'^{(n)}, G^{(n)})$
- Linearized Weyl tensors $\Phi^{(1)} = C^{(1)}$

Normal ordered homotopy integration

- $W := A|_{Z=dZ=0}$
- Linearization gives COMST
- Adding $O(Z^2)$ to $G^{(1)}$ preserves COMST
- Non-local interactions

Weyl ordered homotopy integration

- Perturbatively exact solution
- Z-dependence of master fields factorises
- $\Phi = \Phi^{(1)} = C$ $\quad A = \Omega$

At linear order, $G^{(1)}$ relates them

Particle and black hole modes

Initial data

$$C^{(1)} = L^{-1} \star \Phi'^{(1)} \star L$$

- L is AdS gauge function: $\Omega = L^{-1} \star dL$

Particle mode

$$\Phi'^{(1)}_{\text{pt.}} = \mathcal{P}_{e_1, j_1 | e_2, j_2}$$
$$\sim p_{e_1, j_1 | e_2, j_2}(y, \bar{y}) \exp(iyM\bar{y})$$

- $p_{e_1, j_1 | e_2, j_2}(y, \bar{y})$ are polynomials
- eigenfunctions of the Cartan generators

Black-hole-like mode

$$\Phi'^{(1)}_{\text{bh.}} = \mathcal{P}_{e_1, j_1 | e_2, j_2} \star \kappa_y$$
$$\sim p_{e_1, j_1 | e_2, j_2}(i\partial_y, \bar{y}) \delta^2(y + iM\bar{y})$$

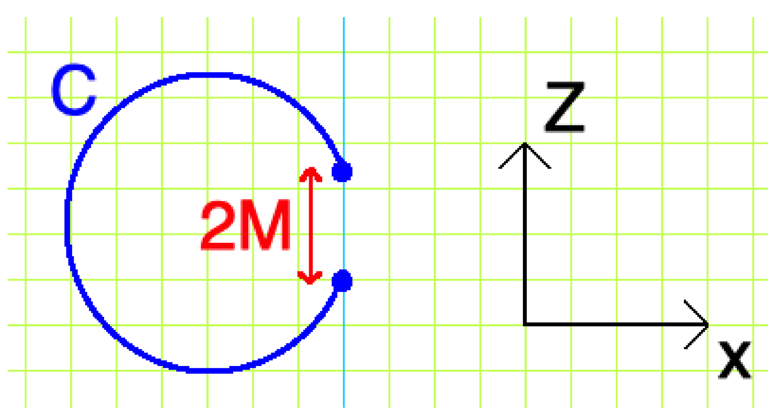
- $C^{(1)}_{\text{bh.}}$ is singular at the origin of global coordinates
- $j = 0$: static and spherically symmetric

Observables

Zero-form charges

$$\int d^4 Z \, \mathrm{Tr}_Y [W(C) \star e^{iMZ}]$$

- Constructed from Wilson lines



- Factorize with master fields
- Give CFT_3 correlators in factorised gauge
- Fully gauge invariant
  Sensible to integration constants $\Phi'^{(n)}$

p-form observables

- Involve generalised frame field
- Sensible to large gauge functions

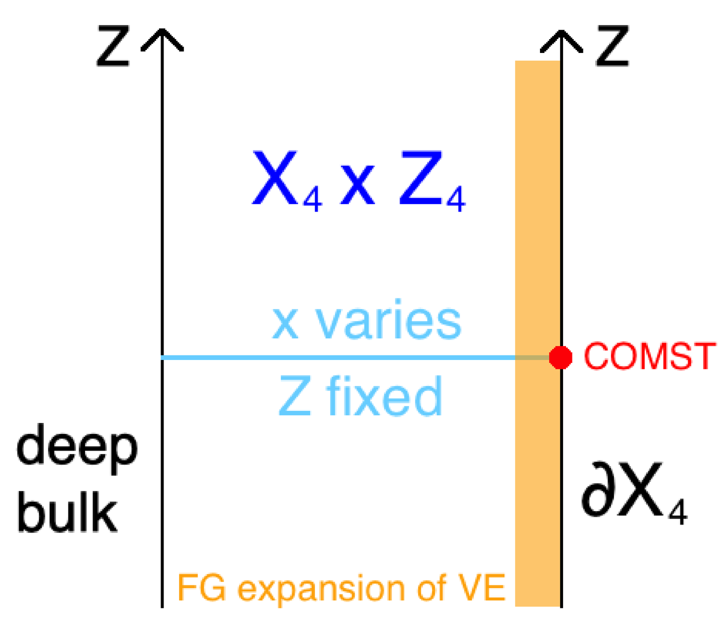
Asymptotically anti-de Sitter perturbative scheme

Minimally non-local scheme

- Deformed COMST on $\mathcal{X}_4 \times \mathcal{Y}_4$
- Use higher order moduli to impose minimal non-locality of interaction vertices
- Compute observables on $\mathcal{X}_4 \times \mathcal{Y}_4$

Asymptotically AdS scheme

- Use higher order moduli to impose asymptotically AdS boundary conditions
- COMST on $\partial\mathcal{X}_4 \times \mathcal{Y}_4$
- Compute observables on $\mathcal{X}_4 \times \mathcal{Y}_4 \times \mathcal{Z}_4$



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Reference

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