FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

Finite-coupling spectrum of O(N) model in AdS

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Petr Vaško

March 27, 2025

O(N) model

N scalar fields $\{\phi^i\}$

$\mathbf{O}(N)$ model

N scalar fields $\{\phi^i\}$

$$\mathcal{S}[\phi^\bullet] = \int_{\mathcal{M}} \mathrm{d}^{d+1}x \sqrt{g} \left[\frac{1}{2}(\partial\phi^\bullet)^2 + \frac{1}{2}m^2(\phi^\bullet)^2 \right]$$

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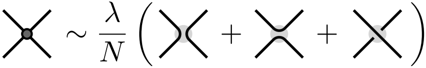

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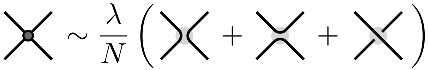

large N expansion

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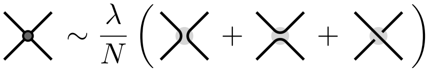

large N expansion $\overset{\text{allows}}{\rightsquigarrow}$ finite coupling λ

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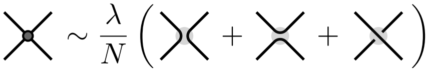

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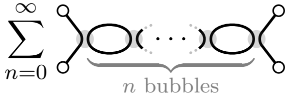

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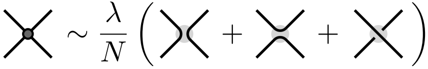

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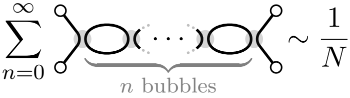
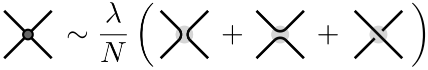


Hubbard–Stratonovich transformation

$$\mathcal{S}[\phi^{\bullet}] = \int_{\mathcal{M}} \mathrm{d}^{d+1}x \, \sqrt{g} \left[\frac{1}{2} (\partial \phi^{\bullet})^2 + \frac{1}{2} m^2 (\phi^{\bullet})^2 + \frac{\lambda}{2N} \left((\phi^{\bullet})^2 \right)^2 \right]$$



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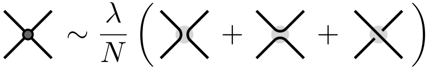

$\mathcal{S}_{\mathrm{HS}}[\phi^{\bullet}, \sigma]$

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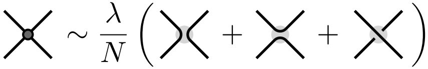

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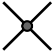
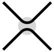
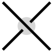
 $\sim \frac{\lambda}{N}\Big($  $+$  $+$  $\Big)$

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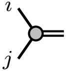
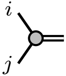
 $\equiv -\lambda\mathbb{1}$ 

$\equiv \frac{2}{\sqrt{N}}\,\delta^{ij}$

Exact σ-propagator

 $\equiv -\lambda \mathbb{1}$ 

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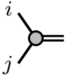

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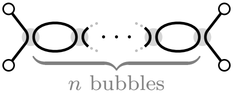
$\sum_{n=0}^{\infty}$ 

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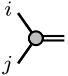
 $\equiv -\lambda\mathbb{1}$ 

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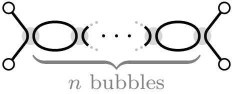
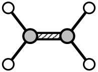
$\sum_{n=0}^{\infty}$ 

$=$  $\sim \dfrac{1}{N}$

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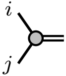
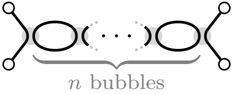
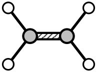
 $\equiv -\lambda \mathbb{1}$  $\equiv \frac{2}{\sqrt{N}}\, \delta^{ij}$

$\sum_{n=0}^{\infty}$  $=$  $\sim \frac{1}{N}$

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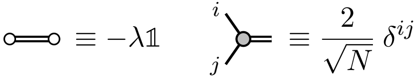

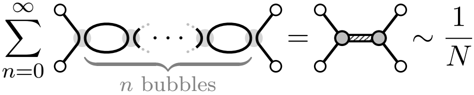

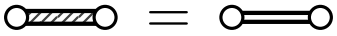

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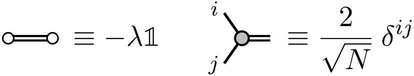

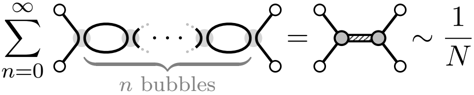

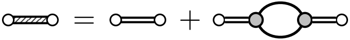

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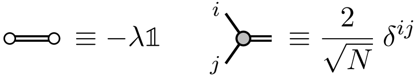

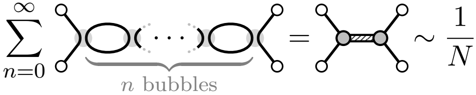

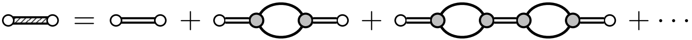

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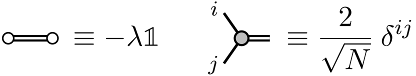

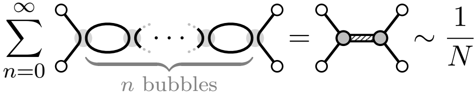

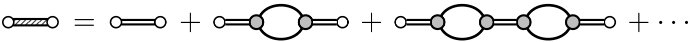

$$= (-\lambda\mathbb{1}) + (-\lambda\mathbb{1}) \circ 2B \circ (-\lambda\mathbb{1}) + \dots$$

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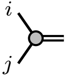
 $\equiv -\lambda \mathbb{1}$ 

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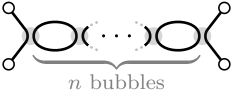
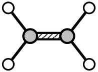
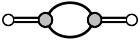
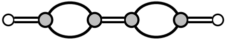
$\sum_{n=0}^{\infty}$ 

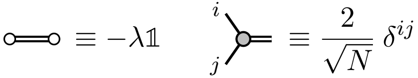
$=$  $\sim \dfrac{1}{N}$

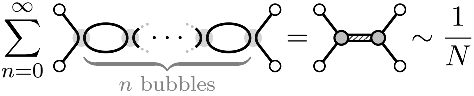
 $=$  $+$  $+$  $+\cdots$

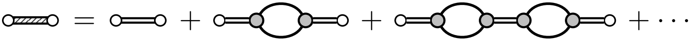
$$= (-\lambda\mathbb{1}) + (-\lambda\mathbb{1}) \circ 2B \circ (-\lambda\mathbb{1}) + \dots$$

$$= -\lambda \sum_{n=0}^{\infty} (-2\lambda B)^n$$

Exact $\boldsymbol{\sigma}$-propagator







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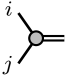
 $\equiv -\lambda\mathbb{1}$ 

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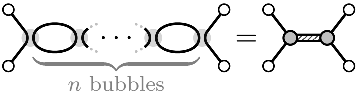
$\sum_{n=0}^{\infty}$ 

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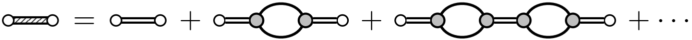

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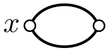
$B(x,y) \equiv \frac{1}{2}$ 

$\equiv \left[\frac{1}{(-\Box + m_\phi^2)\mathbb{1}}\,(x,y)\right]^2$

O(N) model in AdS

fixed AdS background

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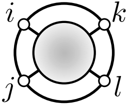
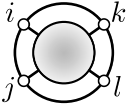
fixed AdS background



O(N) model in AdS

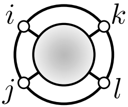
fixed AdS background



$$= \left\langle \mathcal{O}^i \mathcal{O}^j \mathcal{O}^k \mathcal{O}^l \right\rangle$$

$\mathsf{O}(N)$ model in AdS

fixed AdS background

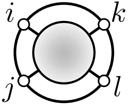


$$= \left\langle \mathcal{O}^i \mathcal{O}^j \mathcal{O}^k \mathcal{O}^l \right\rangle$$

$$\mathcal{O}^i(P) \sim \lim_{s\to\infty} s^{\Delta_\phi} \phi^i\Big(X \equiv sP + \dots\Big)$$

O(N) model in AdS

fixed AdS background



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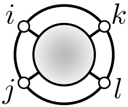
CFT

O(N) model in AdS

fixed AdS background



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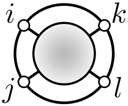
QFT in AdS $\longleftrightarrow$ CFT

$\mathsf{O}(N)$ model in AdS

fixed AdS background



$$= \left\langle \mathcal{O}^i \mathcal{O}^j \mathcal{O}^k \mathcal{O}^l \right\rangle$$

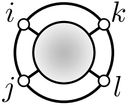
$$\mathcal{O}^i(P) \sim \lim_{s\to\infty} s^{\Delta_\phi} \phi^i\Big(X \equiv sP + \dots\Big)$$

QFT in AdS $\longleftrightarrow$ CFT

CFT in AdS$_{d+1}$

$\mathsf{O}(N)$ model in AdS

fixed AdS background



$$= \left\langle \mathcal{O}^i \mathcal{O}^j \mathcal{O}^k \mathcal{O}^l \right\rangle$$

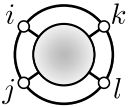
$$\mathcal{O}^i(P) \sim \lim_{s\to\infty} s^{\Delta_\phi} \phi^i\Big(X \equiv sP + \dots\Big)$$

$$\text{QFT in AdS} \longleftrightarrow \text{CFT}$$

$$\text{CFT in AdS}_{d+1} \xleftrightarrow{\text{Weyl transformation}}$$

$\mathsf{O}(N)$ model in AdS

fixed AdS background



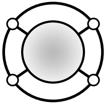
$$= \left\langle \mathcal{O}^i \mathcal{O}^j \mathcal{O}^k \mathcal{O}^l \right\rangle$$

$$\mathcal{O}^i(P) \sim \lim_{s \to \infty} s^{\Delta_\phi} \phi^i\Big(X \equiv sP + \dots\Big)$$

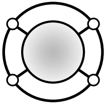
$$\text{QFT in AdS} \longleftrightarrow \text{CFT}$$

$$\text{CFT in AdS}_{d+1} \xleftrightarrow{\text{Weyl transformation}} \text{BCFT in } \mathbb{R}^d \times \mathbb{R}_{\geq}$$

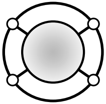
Conformal Block/Partial Wave Decomposition



Conformal Block/Partial Wave Decomposition

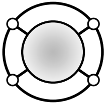
 $\equiv \langle (\mathcal{O}\mathcal{O})(\mathcal{O}\mathcal{O}) \rangle$

Conformal Block/Partial Wave Decomposition

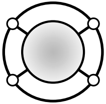


$$\equiv \langle (\mathcal{O}\mathcal{O})(\mathcal{O}\mathcal{O})\rangle = \sum_{\substack{\text{primary } \mathcal{O}_\star \\ \text{with } \Delta_\star, J_\star}} \mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star] \left| G^{(s)}_{\Delta_\star, J_\star} \right\rangle$$

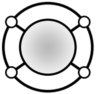
Conformal Block/Partial Wave Decomposition



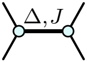
$$\equiv \langle (\mathcal{O}\mathcal{O})(\mathcal{O}\mathcal{O}) \rangle = \sum_{\substack{\text{primary } \mathcal{O}_\star \\ \text{with } \Delta_\star, J_\star}} \mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star] \Big| G^{(s)}_{\Delta_\star, J_\star} \Big\rangle$$



$$= \sum_{J=0}^{\infty} \int_{\frac{d}{2}+i\mathbb{R}_\geq} \frac{\mathrm{d}\Delta}{2\pi i} \, \mathsf{Spec}_s \left[\begin{array}{c} \Delta \\ J \end{array} \right|$$

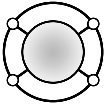


$$\Big] \Big|$$

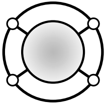


$$\Big\rangle$$

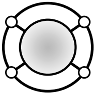
Conformal Block/Partial Wave Decomposition



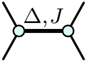
$$\equiv \langle (\mathcal{O}\mathcal{O})(\mathcal{O}\mathcal{O}) \rangle = \sum_{\substack{\text{primary } \mathcal{O}_\star \\ \text{with } \Delta_\star, J_\star}} \mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star] \Big| G^{(s)}_{\Delta_\star, J_\star} \Big\rangle$$



$$= \sum_{J=0}^{\infty} \int_{\frac{d}{2}+i\mathbb{R}_\geq} \frac{\mathrm{d}\Delta}{2\pi i} \, \mathsf{Spec}_s \left[\begin{matrix} \Delta \\ J \end{matrix} \right|$$



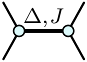
$$\Bigg] \Bigg|$$



Δ, J

$$\Bigg\rangle$$

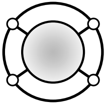
$$\Bigg|$$



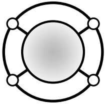
Δ, J

$$\Bigg\rangle = K_{\widetilde{\Delta}, J} \Big| G^{(s)}_{\Delta, J} \Big\rangle + K_{\Delta, J} \Big| G^{(s)}_{\widetilde{\Delta}, J} \Big\rangle$$

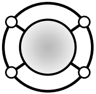
Conformal Block/Partial Wave Decomposition



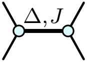
$$\equiv \langle (\mathcal{O}\mathcal{O})(\mathcal{O}\mathcal{O})\rangle = \sum_{\substack{\text{primary } \mathcal{O}_\star \\ \text{with } \Delta_\star, J_\star}} \mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star] \left| G^{(s)}_{\Delta_\star, J_\star} \right\rangle$$



$$= \sum_{J=0}^{\infty} \int_{\frac{d}{2}+i\mathbb{R}_\geq} \frac{\mathrm{d}\Delta}{2\pi i} \, \mathsf{Spec}_s \left[\begin{matrix} \Delta \\ J \end{matrix} \middle| \right.$$

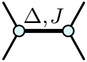


$$\left. \vphantom{\begin{matrix} \Delta \\ J \end{matrix}} \right] \Big|$$



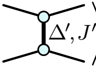
$$\Big\rangle$$

$$\Big|$$



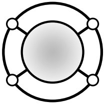
$$\Big\rangle = K_{\widetilde{\Delta}, J} \left| G^{(s)}_{\Delta, J} \right\rangle + K_{\Delta, J} \left| G^{(s)}_{\widetilde{\Delta}, J} \right\rangle$$

$$\Big|$$

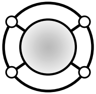


$$\Big\rangle = K_{\widetilde{\Delta}', J'} \left| G^{(t)}_{\Delta', J'} \right\rangle + K_{\Delta', J'} \left| G^{(t)}_{\widetilde{\Delta}', J'} \right\rangle$$

Conformal Block/Partial Wave Decomposition

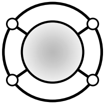


$$= \sum_J \int_{\frac{d}{2}+i\mathbb{R}} \frac{\mathrm{d}\Delta}{2\pi i}\, \mathsf{Spec}_s\left[\begin{matrix}\Delta \\ J\end{matrix}\,\middle|\right.$$

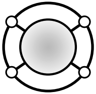


$$\left.\vphantom{\begin{matrix}\Delta \\ J\end{matrix}}\right]\, K_{\widetilde{\Delta},J}\middle| G^{(s)}_{\Delta,J}\right\rangle$$

Conformal Block/Partial Wave Decomposition



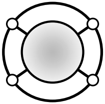
$$= \sum_J \int_{\frac{d}{2}+i\mathbb{R}} \frac{\mathrm{d}\Delta}{2\pi i}\, \mathsf{Spec}_s\left[\begin{array}{c}\Delta \\ J\end{array}\right|$$



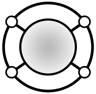
$$\left.\vphantom{\begin{array}{c}\Delta \\ J\end{array}}\right] K_{\widetilde{\Delta},J}\left|G^{(s)}_{\Delta,J}\right\rangle$$

$$= \sum_{\substack{\text{primary } \mathcal{O}_\star \\ \text{with } \Delta_\star, J_\star}} \mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star]\left|G^{(s)}_{\Delta_\star,J_\star}\right\rangle$$

Conformal Block/Partial Wave Decomposition



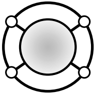
$$= \sum_J \int_{\frac{d}{2}+i\mathbb{R}} \frac{\mathrm{d}\Delta}{2\pi i}\, \mathsf{Spec}_s \left[\begin{array}{c} \Delta \\ J \end{array} \right|$$



$$\Big] \; K_{\widetilde{\Delta},J} \Big| G^{(s)}_{\Delta,J} \Big\rangle$$

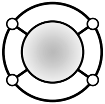
$$= \sum_{\substack{\text{primary } \mathcal{O}_\star \\ \text{with } \Delta_\star, J_\star}} \mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star] \Big| G^{(s)}_{\Delta_\star, J_\star} \Big\rangle$$

$$\frac{-C_\star}{\Delta - \Delta_\star}\, \delta_{J,J_\star} \in K_{\widetilde{\Delta},J}\, \mathsf{Spec}_s \left[\begin{array}{c} \Delta \\ J \end{array} \right|$$

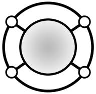


$$\Big]$$

Conformal Block/Partial Wave Decomposition



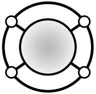
$$= \sum_J \int_{\frac{d}{2}+i\mathbb{R}} \frac{\mathrm{d}\Delta}{2\pi i}\, \mathsf{Spec}_s\Bigg[\begin{array}{c}\Delta \\ J\end{array} \Bigg|$$



$$\Bigg]\, K_{\widetilde{\Delta},J} \Big| G^{(s)}_{\Delta,J} \Big\rangle$$

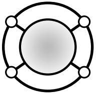
$$= \sum_{\substack{\text{primary } \mathcal{O}_\star \\ \text{with } \Delta_\star, J_\star}} \mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star] \Big| G^{(s)}_{\Delta_\star,J_\star} \Big\rangle$$

$$\frac{-C_\star}{\Delta-\Delta_\star}\, \delta_{J,J_\star} \in K_{\widetilde{\Delta},J}\, \mathsf{Spec}_s\Bigg[\begin{array}{c}\Delta \\ J\end{array} \Bigg|$$



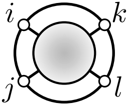
$$\Bigg]$$

$$\mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star] \equiv C_\star = -\operatorname{Res}_{\Delta=\Delta_\star} \Bigg(K_{\widetilde{\Delta},J_\star}\, \mathsf{Spec}_s\Bigg[\begin{array}{c}\Delta \\ J_\star\end{array} \Bigg|$$

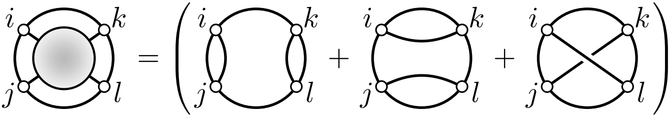


$$\Bigg]\Bigg)$$

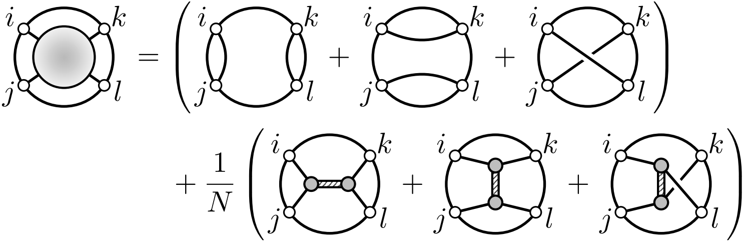
Boundary 4-point correlator in AdS



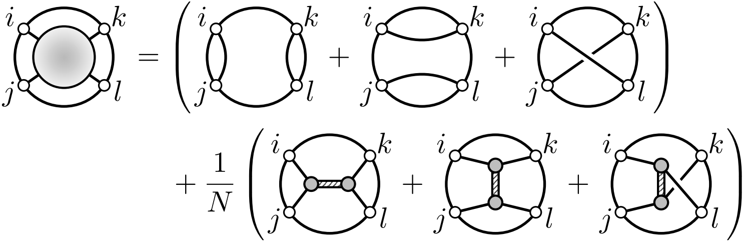
Boundary 4-point correlator in **AdS**

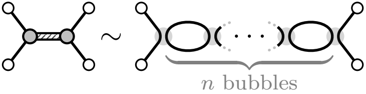


Boundary 4-point correlator in **AdS**

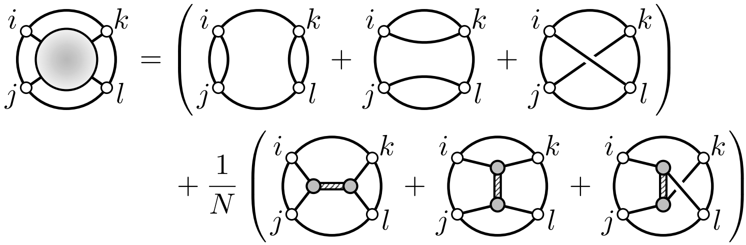


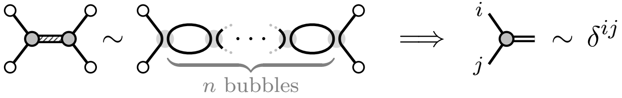
Boundary 4-point correlator in **AdS**



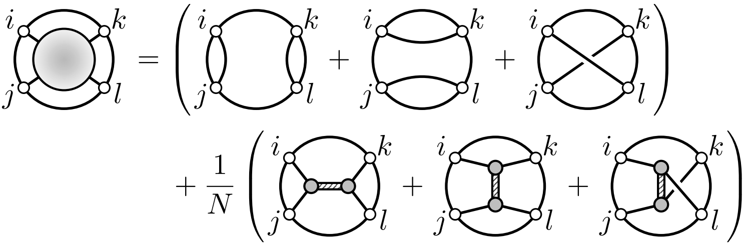


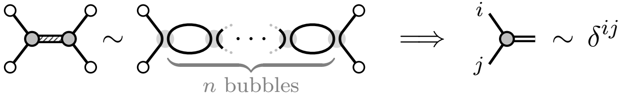
Boundary 4-point correlator in AdS

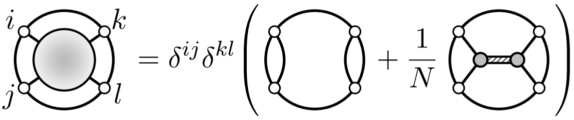




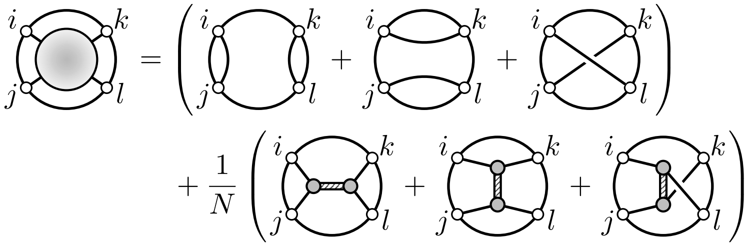
Boundary 4-point correlator in **AdS**

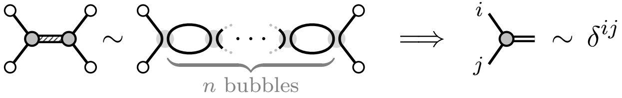


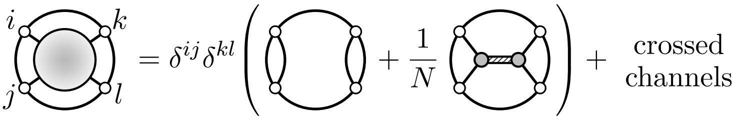




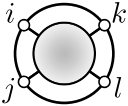
Boundary 4-point correlator in **AdS**



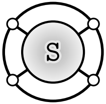




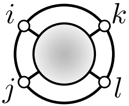
Decomposition into $\mathbf{O}(N)$ irreps



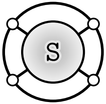
$$= \overbrace{N\mathcal{P}^{ijkl}_{(\mathtt{S})}}^{\delta^{ij}\delta^{kl}}$$



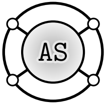
Decomposition into $\mathbf{O}(N)$ irreps



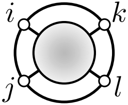
$$= \overbrace{N\mathcal{P}^{ijkl}_{(\mathtt{S})}}^{\delta^{ij}\delta^{kl}}$$

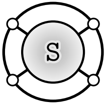


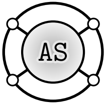
$$+ \overbrace{\mathcal{P}^{ijkl}_{(\mathtt{AS})}}^{\delta^{[i}_{[k}\delta^{j]}_{l]}}$$

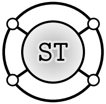


Decomposition into $\mathsf{O}(N)$ irreps

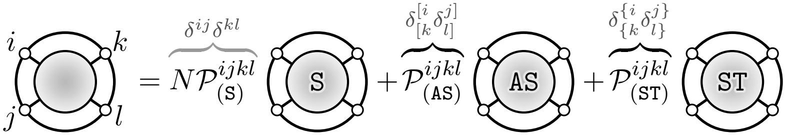


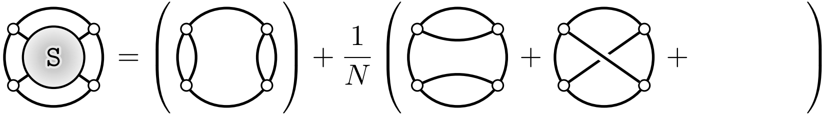
$= \overbrace{N\mathcal{P}^{ijkl}_{(\texttt{S})}}^{\delta^{ij}\delta^{kl}}$


$+ \overbrace{\mathcal{P}^{ijkl}_{(\texttt{AS})}}^{\delta^{[i}_{[k}\delta^{j]}_{l]}}$


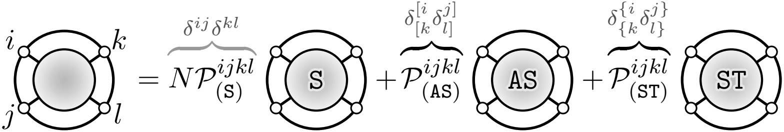
$+ \overbrace{\mathcal{P}^{ijkl}_{(\texttt{ST})}}^{\delta^{\{i}_{\{k}\delta^{j\}}_{l\}}}$


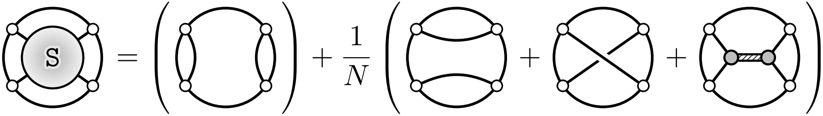
Decomposition into O(N) irreps



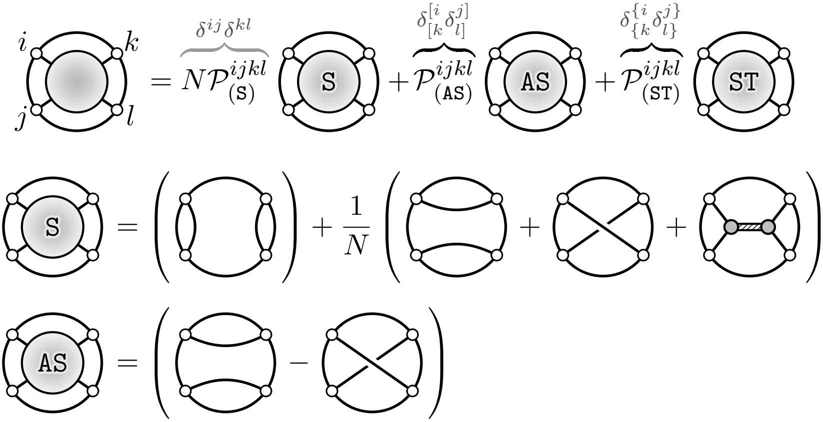


Decomposition into $\mathsf{O}(N)$ irreps

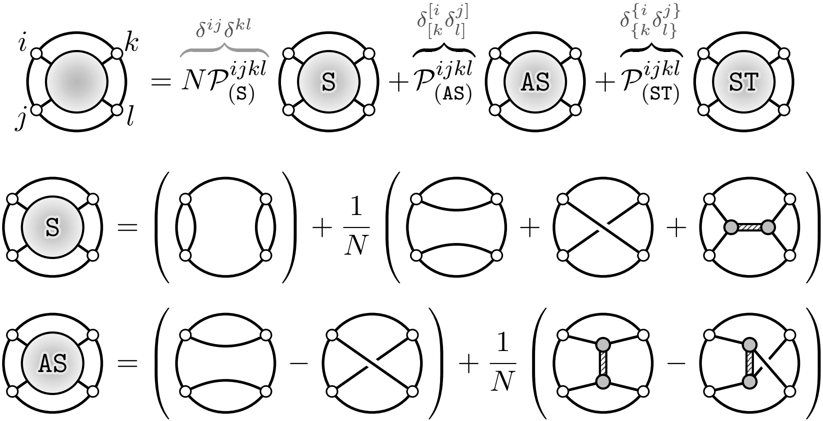




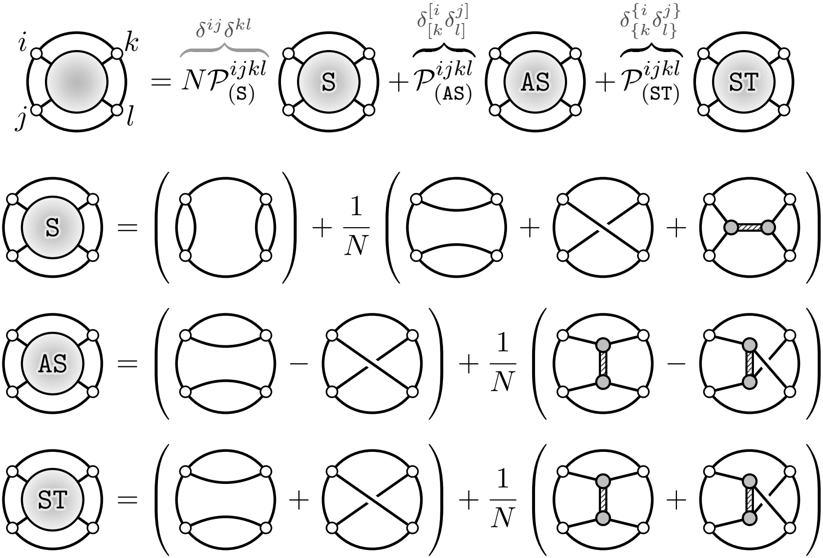
Decomposition into $\mathbf{O}(N)$ irreps



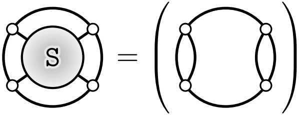
Decomposition into $\mathbf{O}(N)$ irreps



Decomposition into $\mathbf{O}(N)$ irreps



Singlet sector (MFT)



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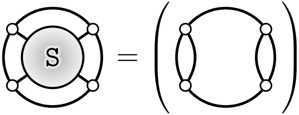
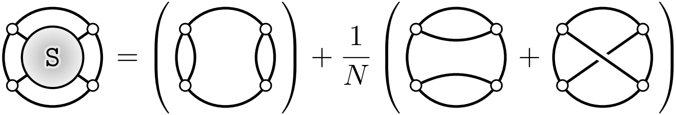


$$[\mathcal{O}^i \times \mathcal{O}^j]^{(\mathrm{S})} \overset{N=\infty}{\sim} \mathbb{1}^{(\mathrm{S})}$$

Singlet sector (MFT)



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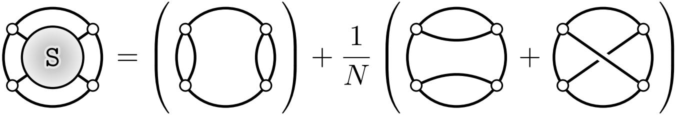

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$$[\mathcal{O}^i \times \mathcal{O}^j]^{(\mathrm{S})} \overset{\lambda=0}{\sim} \mathbb{1}^{(\mathrm{S})} \oplus \frac{1}{\sqrt{N}} \left[\mathcal{O}^{\bullet} \Box^n \partial^J_{\text{even}} \mathcal{O}^{\bullet}\right]^{(\mathrm{S})}$$

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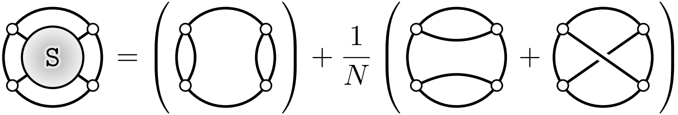

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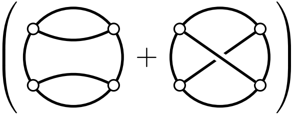
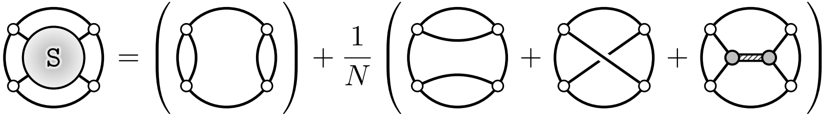


$$= \sum_{n=0}^{\infty} \sum_{\substack{J=0 \\ J \text{ even}}}^{\infty} 2C^{(\mathrm{MFT})}_{n,J} \left| G^{(s)}_{2\Delta_\phi+2n+J,J} \right\rangle$$

Singlet sector (interacting)



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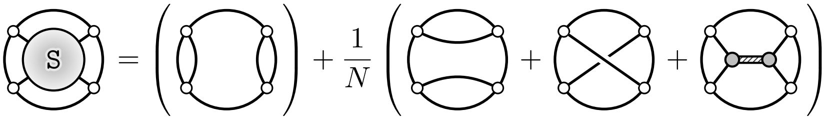

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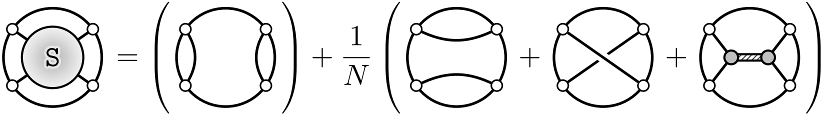
$$[\mathcal{O}^i \times \mathcal{O}^j]^{(\mathtt{S})} \sim \mathbb{1}^{(\mathtt{S})}$$

Singlet sector (interacting)



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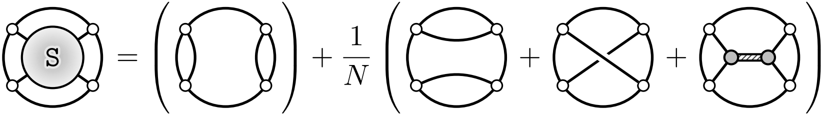
Singlet sector (interacting)



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$$[\mathcal{O}^i \times \mathcal{O}^j]^{(\mathrm{S})} \sim \mathbb{1}^{(\mathrm{S})} \oplus \frac{1}{\sqrt{N}} [\text{“}\mathcal{O}^{\bullet} \Box^n \mathcal{O}^{\bullet}\text{”}]^{(\mathrm{S})}_{O(1) \text{ finite shifts}} \oplus \frac{1}{\sqrt{N}} \left[\mathcal{O}^{\bullet} \Box^n \partial^{J>0}_{\text{even}} \mathcal{O}^{\bullet}\right]^{(\mathrm{S})}_{\text{MFT}}$$

Utilizing the spectral representation

$$B(x,y) = \int_{\mathbb{R}} \mathrm{d}\nu \, \widetilde{B}(\Delta)\Omega_\Delta(x,y) \qquad \left(\Delta \equiv \frac{d}{2} + \mathring{i}\nu\right)$$

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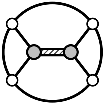

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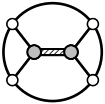

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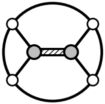
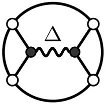


$$= 4\int_{\mathbb{R}} \mathrm{d}\nu \left(\frac{-1}{\lambda^{-1} + 2\widetilde{B}(\Delta)}\right)$$



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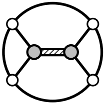

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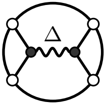
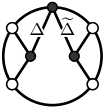


$$= 4\int_{\mathbb{R}} \mathrm{d}\nu \left(-\frac{1}{\lambda^{-1} + 2\widetilde{B}(\Delta)}\right)\sqrt{\mathfrak{C}_\Delta \mathfrak{C}_{\widetilde{\Delta}}}\;\frac{\nu^2}{\pi}$$



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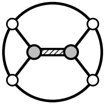

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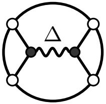

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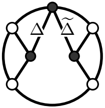
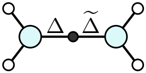


$$= \int_{\frac{d}{2} + i\mathbb{R}_{\geq 0}} \frac{\mathrm{d}\Delta}{2\pi i} \left(-\frac{1}{\lambda^{-1} + 2\widetilde{B}(\Delta)}\right)\left(\frac{\Gamma^2_{\dots} \cdots \Gamma_{\dots}}{\cdots \Gamma^2_{\dots} \cdots \Gamma_{\dots}}\right)$$



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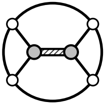

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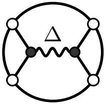

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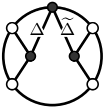

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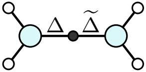
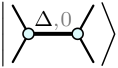
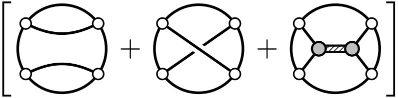


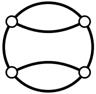
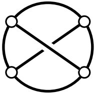
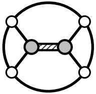
$$\equiv \int_{\frac{d}{2}+i\mathbb{R}_{\geq 0}} \frac{\mathrm{d}\Delta}{2\pi i}\left(-\frac{1}{\lambda^{-1} + 2\widetilde{B}(\Delta)}\right)\left(\frac{\Gamma^2_{\dots}\cdots\Gamma_{\dots}}{\cdots\Gamma^2_{\dots}\cdots\Gamma_{\dots}}\right)$$

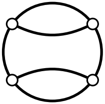
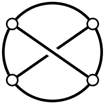


Singlet sector — spectral functions

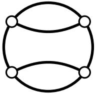
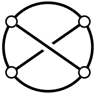
$\frac{1}{N}\,\mathsf{Spec}_s$ 

Singlet sector — spectral functions

$\frac{1}{N}\,\mathsf{Spec}_s\Big[$  $+$  $+$  $\Big]$

$\Big($  $+$  $\Big) = \sum_{n=0}^{\infty} \sum_{\substack{J=0 \\ J\text{ even}}}^{\infty} 2C^{(\mathrm{MFT})}_{n,J} \left| G^{(s)}_{2\Delta_\phi+2n+J,J} \right\rangle$

Singlet sector — spectral functions

$$\frac{1}{N}\,\mathsf{Spec}_s\Bigg[$$

$$+$$

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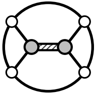
$$\Bigg]$$

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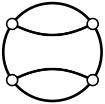
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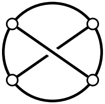
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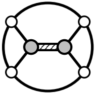
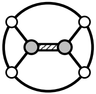
$$\mathsf{Spec}_s\Bigg[\begin{matrix}\Delta\\ J\end{matrix}\Bigg|$$

$$\Bigg] = -\delta_{J,0}\,\frac{1}{\lambda^{-1}+2\widetilde{B}(\Delta)}\times$$

$$\times\,\frac{\Gamma^2_{\Delta_\phi-\frac{\Delta}{2}}\,\Gamma^2_{\Delta_\phi-\frac{\widetilde{\Delta}}{2}}\,\Gamma^2_{\frac{\Delta}{2}}\,\Gamma^2_{\frac{\widetilde{\Delta}}{2}}}{4\pi^d\,\Gamma^2_{\Delta_\phi}\,\Gamma^2_{1-\frac{d}{2}+\Delta_\phi}\,\Gamma_{\Delta-\frac{d}{2}}\,\Gamma_{\widetilde{\Delta}-\frac{d}{2}}}$$

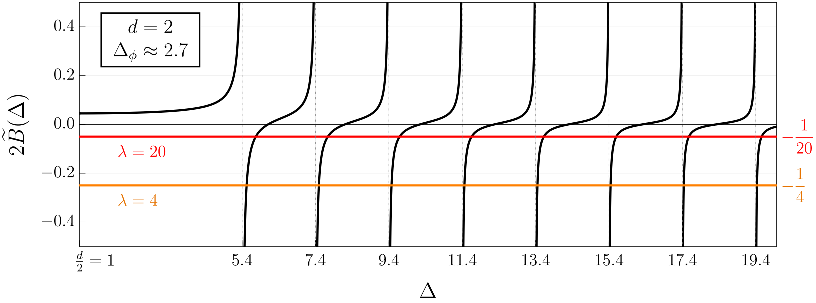
Singlet sector — scalar non-MFT operators

$$\mathsf{Spec}_s\left[\begin{array}{c}\Delta\\ J\end{array}\right|$$



$$\left.\vphantom{\begin{array}{c}\Delta\\ J\end{array}}\right] \propto \frac{1}{\lambda^{-1}+2\widetilde{B}(\Delta)}$$

$$\implies \lambda^{-1}+2\widetilde{B}\left(\Delta^{(\mathsf{S})}_{\bullet,0}\right)=0$$



Singlet sector — scalar non-MFT operators

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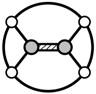

$$\left.\vphantom{\begin{array}{c}\Delta\\ J\end{array}}\right] \propto \frac{1}{\lambda^{-1} + 2\widetilde{B}(\Delta)}$$

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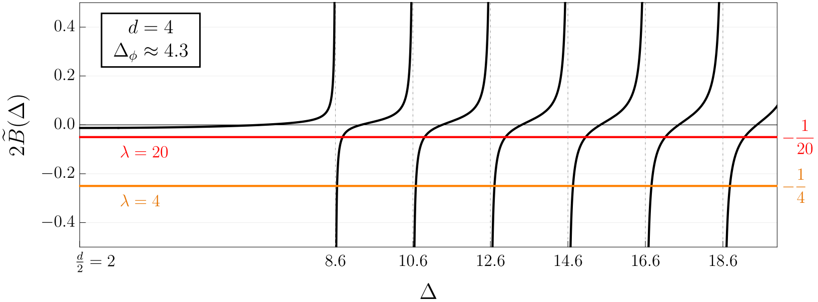
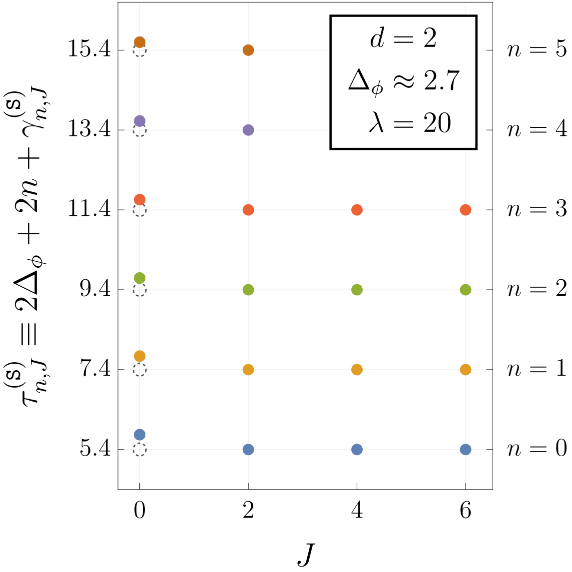
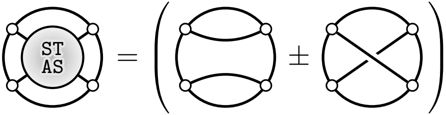


Singlet sector — twist–spin plot



Non-singlet sector (MFT)



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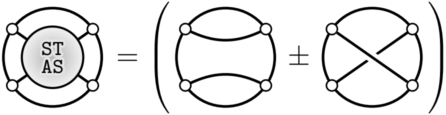

$$\left[\mathcal{O}^i \times \mathcal{O}^j\right]^{(\mathtt{ST})} \overset{N=\infty}{\sim} \left[\mathcal{O}^{\{i}\Box^n \partial^J_{\text{even}} \mathcal{O}^{j\}}\right]^{(\mathtt{ST})}$$

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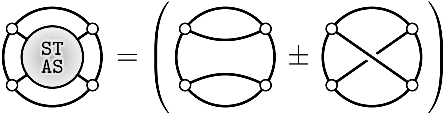

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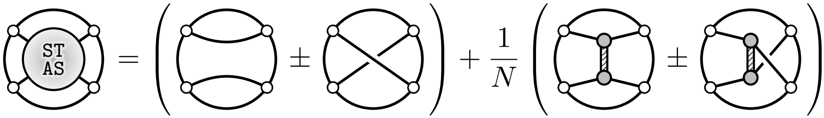
Non-singlet sector (interacting)



$$\left[\mathcal{O}^i \times \mathcal{O}^j\right]^{(\texttt{ST})} \overset{N=\infty}{\sim} \left[\mathcal{O}^{\{i}\Box^n\partial^J_{\text{even}}\mathcal{O}^{j\}}\right]^{(\texttt{ST})}$$

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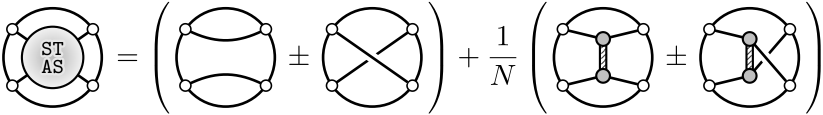

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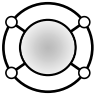
Anomalous dimensions as double poles

$$\frac{-C_\star}{\Delta-\Delta_\star}\,\delta_{J,J_\star} \in K_{\widetilde{\Delta},J}\,\mathsf{Spec}_s\left[\begin{array}{c}\Delta\\ J\end{array}\right|$$



$$\Big]$$

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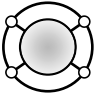

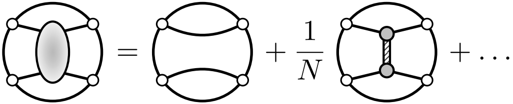

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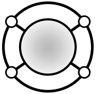
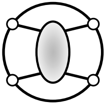
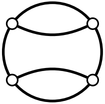
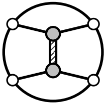
$$\frac{-C_\star}{\Delta - \Delta_\star}\,\delta_{J,J_\star} \in K_{\widetilde{\Delta},J}\,\mathsf{Spec}_s\left[\begin{array}{c|c}\Delta & \\ J & \end{array}\right.$$  $$\Big]$$

 $=$  $+\,\frac{1}{N}$  $+\dots$

$$\mathsf{ope}^2[\mathcal{O}\mathcal{O}\mathcal{O}_\star] \equiv C_\star\left(\frac{1}{N}\right) = C_\star^{(\mathrm{MFT})} + \frac{1}{N}\,C_\star^{(1)} + O\left(\frac{1}{N^2}\right)$$

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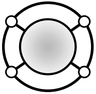
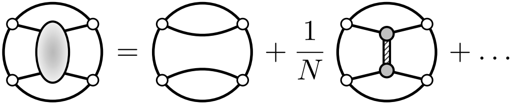
$$\frac{-C_\star}{\Delta - \Delta_\star}\,\delta_{J,J_\star} \in K_{\widetilde{\Delta},J}\,\mathsf{Spec}_s\left[\begin{array}{c}\Delta\\ J\end{array}\right|$$  $$\Big]$$



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Anomalous dimensions as (double) poles

$$\frac{-C_\star\left(\frac{1}{N}\right)}{\Delta - \Delta_\star\left(\frac{1}{N}\right)}$$

Anomalous dimensions as (double) poles

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Anomalous dimensions as (double) poles

$$\frac{-C_\star\left(\frac{1}{N}\right)}{\Delta - \Delta_\star\left(\frac{1}{N}\right)} = \frac{-C_\star^{(\mathrm{MFT})}}{\Delta - \Delta_\star^{(\mathrm{MFT})}} + \frac{1}{N}\left[\frac{-C_\star^{(1)}}{\Delta - \Delta_\star^{(\mathrm{MFT})}} \qquad\qquad\qquad\qquad \right]$$

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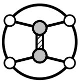
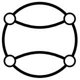
$$\gamma^{(1)}_{n,J} = \mathrm{Res}_{\Delta=2\Delta_\phi+2n+J}\left(\frac{\mathsf{Spec}_s\left[\begin{matrix}\Delta\\ J\end{matrix}\,\middle|\,\cdots\right]}{\mathsf{Spec}_s\left[\begin{matrix}\Delta\\ J\end{matrix}\,\middle|\,\cdots\right]}\right)$$





Crossed channel contributions

Suppose we resolved the "direct" s-channel spectrum.

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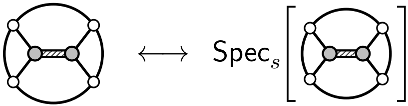

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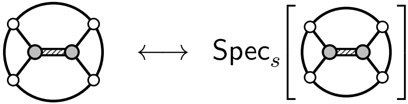

What is the contribution of the crossed-channel diagrams?

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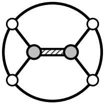
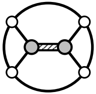
 $\longleftrightarrow$ $\mathsf{Spec}_s\Big[$  $\Big]$

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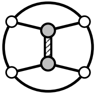
$\mathsf{Spec}_s\Big[$  $\Big]$

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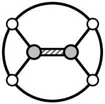
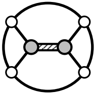


$\longleftrightarrow$ $\mathsf{Spec}_s\Big[$  $\Big]$

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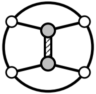
$\mathsf{Spec}_s\Big[$  $\Big] = \sum_{\mathcal{O}^{(\mathrm{s})}_{\bullet,0}}$

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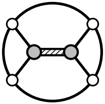
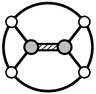
 $\longleftrightarrow$ Spec_s []

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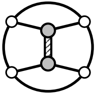
Spec_s [] $= \sum_{\mathcal{O}^{(\mathrm{S})}_{\bullet,0}} \mathsf{ope}^2\left[\mathcal{O}\mathcal{O}\mathcal{O}^{(\mathrm{S})}_{\bullet,0}\right]$

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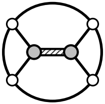
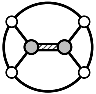
 $\longleftrightarrow$ $\mathsf{Spec}_s\Big[$  $\Big]$

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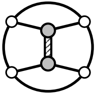
$\mathsf{Spec}_s\Big[$  $\Big] = \sum_{\mathcal{O}^{(\mathrm{s})}_{\bullet,0}} \mathsf{ope}^2\Big[\mathcal{O}\mathcal{O}\mathcal{O}^{(\mathrm{s})}_{\bullet,0}\Big]\, \mathsf{CrK}^{\,s\longleftarrow t}_{\left\langle \Delta,J \middle| \Delta^{(\mathrm{s})}_{\bullet,0},0\right\rangle}$

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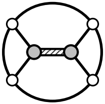
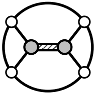


$\longleftrightarrow$ Spec_s []

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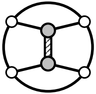
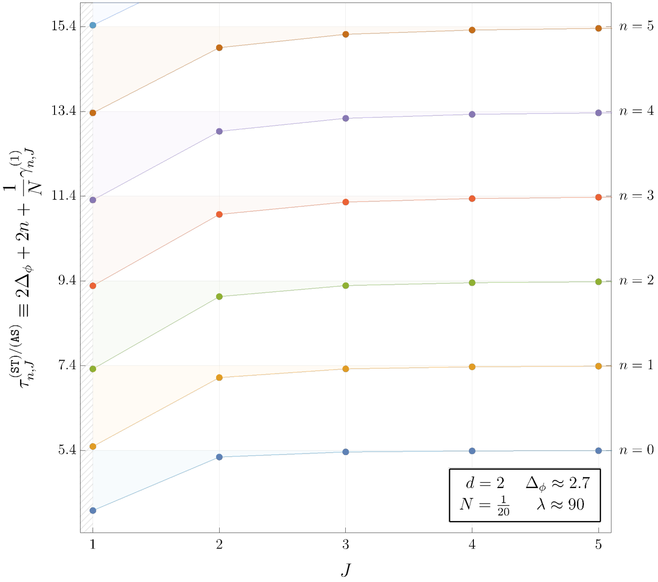
Spec_s []

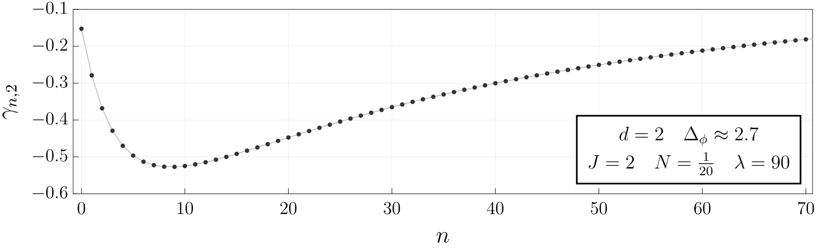
$$= \sum_{\mathcal{O}^{(\mathtt{S})}_{\bullet,0}} \mathsf{ope}^2\left[\mathcal{O}\mathcal{O}\mathcal{O}^{(\mathtt{S})}_{\bullet,0}\right] \mathsf{CrK}^{\,s\longleftarrow t}_{\left\langle \Delta,J \middle| \Delta^{(\mathtt{S})}_{\bullet,0},0\right\rangle}$$

$$\gamma^{(\mathtt{ST})/(\mathtt{AS})}_{n,J} = \sum_{\mathcal{O}^{(\mathtt{S})}_{\bullet,0}} \mathsf{ope}^2\left[\mathcal{O}\mathcal{O}\mathcal{O}^{(\mathtt{S})}_{\bullet,0}\right] \gamma^{(1)}_{n,J}\Big|_{\substack{t\text{-channel} \\ \text{exchange of } \mathcal{O}^{(\mathtt{S})}_{\bullet,0}}}$$

Non-singlet sector — twist–spin plot



Non-singlet sector — dependence on n



Non-singlet sector — large J asymptotics

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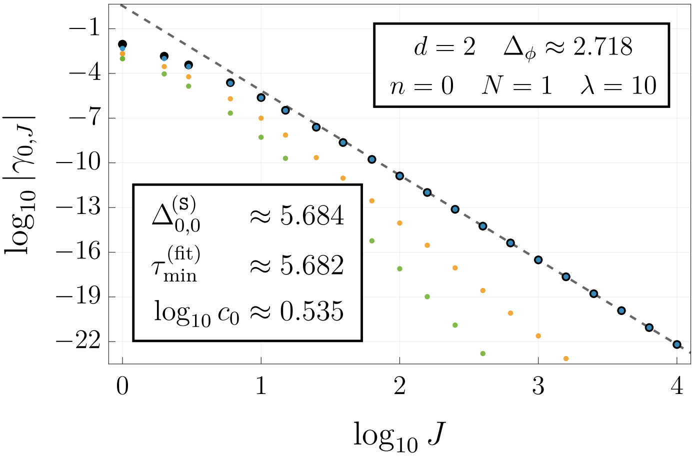

Summary and outlook

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t-chanel conformal block $\overset{\text{contribution}}{\rightsquigarrow}$ anomalous dimensions of s-channel double-twist operators

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  $\rightsquigarrow$ complete picture of $\frac{1}{N}$ corrections to the CFT data

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Future directions:

Summary and outlook

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  ⇝ complete picture of $\frac{1}{N}$ corrections to the CFT data

Future directions:

- Resolve some technical details — calculation of OPE coefficients, $J = 0$ (ST) operators

Summary and outlook

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- Analyzed non-singlet sector of boundary CFT corresponding to the $\mathsf{O}(N)$ model in EAdS

  $\rightsquigarrow$ complete picture of $\frac{1}{N}$ corrections to the CFT data

Future directions:

- Resolve some technical details — calculation of OPE coefficients, $J = 0$ (ST) operators
- Applications to BCFT or DCFT setting, or other models

Summary and outlook

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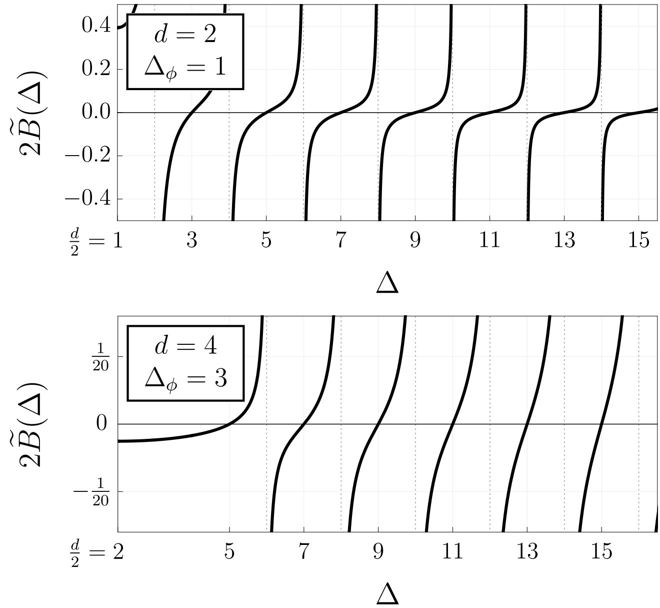
More details in 2503.16345 [hep-th]

Extra slides

Some extra slides.

Criticality in the bulk



Criticality in the bulk