(Super)Current multiplet correlators and holography

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Based on work with:
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[arXiv:1205.4709]
[arXiv:1208.3615]
[arXiv:1310.6897]
[to appear]

Intro & Motivations

N=2 5d

classical
supergravity

AdS/CFT

N=1 4d
large-N
strongly coupled
gauge theory

SUSY breaking:

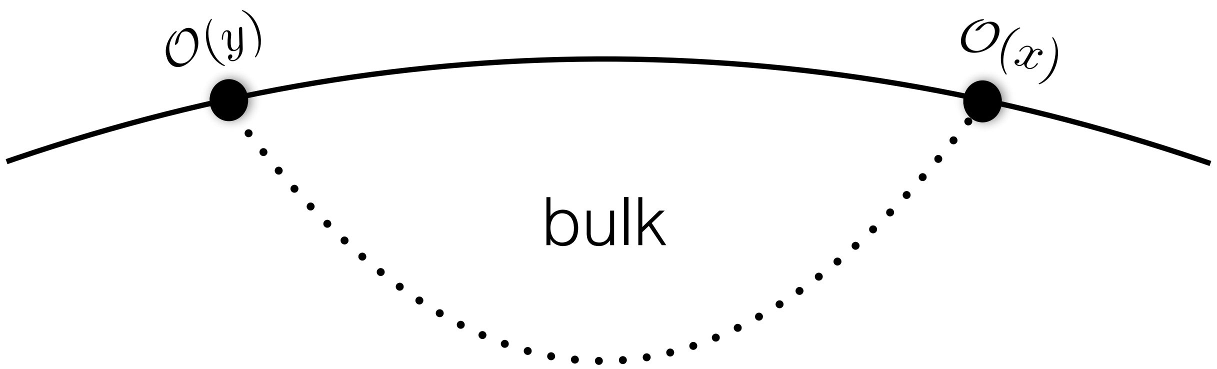
- Always spontaneous on the gravity side
- Sometimes unclear whether spontaneous or explicit in the dual QFT
- Answer can be found in 2-point correlators of gauge invariant operators belonging to the same super multiplet

Strategy

I. Characterization of 2-point correlators inside the chosen super multiplet

$$\left\langle \mathcal{O}(x,\theta,\bar\theta)\,\mathcal{O}(x',\theta',\bar\theta')\right\rangle = \langle O(x)O(x')\rangle + \theta\theta'\langle\psi(x)\psi(x')\rangle + \dots$$

II. Computing strong coupling limit of single correlators using holography



III. Extract info (e.g. about SUSY breaking, spectrum,…) from the behavior of correlators in momentum space

$$\left\langle S_\mu(p)\,\bar S_\nu(-p)\right\rangle = \text{goldstino?}$$
$$\langle j_\mu(p)\,j_\nu(-p)\rangle = \text{goldstone?}$$

Example 1: current multiplet

* Real linear multiplets are associated to conserved currents

$$\mathcal{J} = J + \theta^\alpha j_\alpha + (\theta\bar{\theta})^\mu j_\mu + \dots \quad , \quad \partial^\mu j_\mu = 0$$

I. Characterization of 2-point correlators inside a linear multiplet

$$\begin{aligned}
\langle J(p)\, J(-p)\rangle &= C_0(p^2)\,, \\
\langle j_\alpha(p)\, \bar{j}_{\dot\alpha}(-p)\rangle &= C_{1/2}(p^2)\, \not{p}_{\alpha\dot\alpha}\,, \\
\langle j_\mu(p)\, j_\nu(-p)\rangle &= C_1(p^2)\,(p_\mu p_\nu - \eta_{\mu\nu}p^2)\,, \\
\langle j_\alpha(p)\, j_\beta(-p)\rangle &= B(p^2)\,\epsilon_{\alpha\beta}
\end{aligned}$$

SUSY imposes:

$$C_0 = C_{1/2} = C_1 = C$$
$$B = 0$$

* In a superconformal field theory

$$C(p^2) = \frac{\tau}{(4\pi)^2} \log\left(\frac{\Lambda^2}{p^2}\right)$$

II. Computing linear multiplet correlators in a holographic setup

5d vector multiplet	AdS/CFT	4d linear multiplet
$\mathcal{V} = (D,\, \lambda_\alpha,\, A_\mu)$	$\longleftrightarrow$	$\mathcal{J} = (J,\, j_\alpha,\, j_\mu)$
$m^2 = (-4,\, 1/2,\, 0)$		$\Delta = (2,\, 5/2,\, 3)$

∗ Given some 5d background one can compute 4d linear multiplet correlators letting a 5d vector multiplet fluctuate on this background.

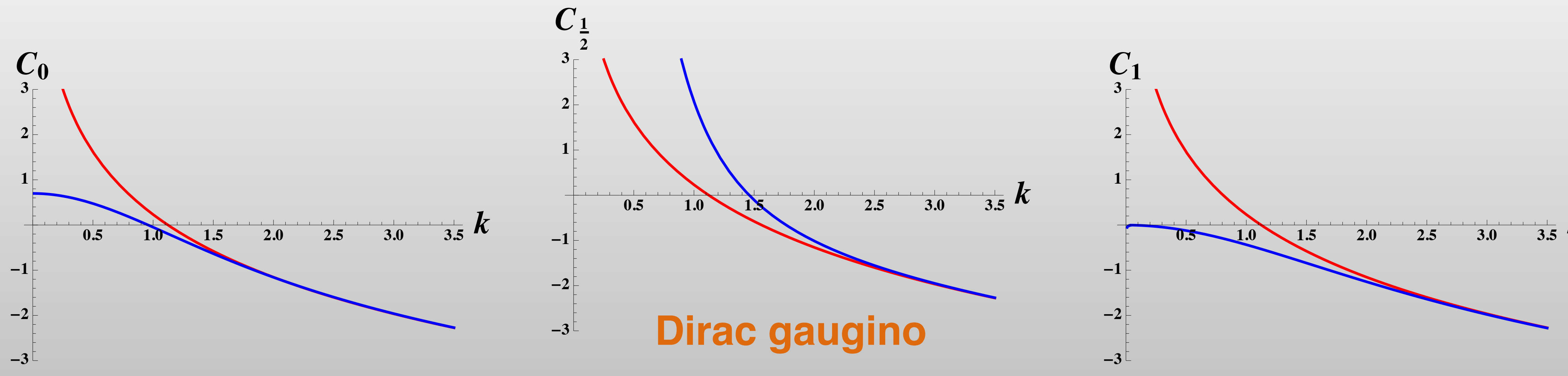
∗ For simplicity we focus on AAdS backgrounds where one can use standard holographic renormalization techniques, e.g.

$$D(p,z) \simeq z^2 \left(\tilde{d}(p) \log(z) + d(p) \right) \quad \text{for } z \to 0$$

$$C_0(p^2) = \frac{\delta d(p)}{\delta \tilde{d}(-p)} + \text{ contact terms}$$

Dilaton domain wall

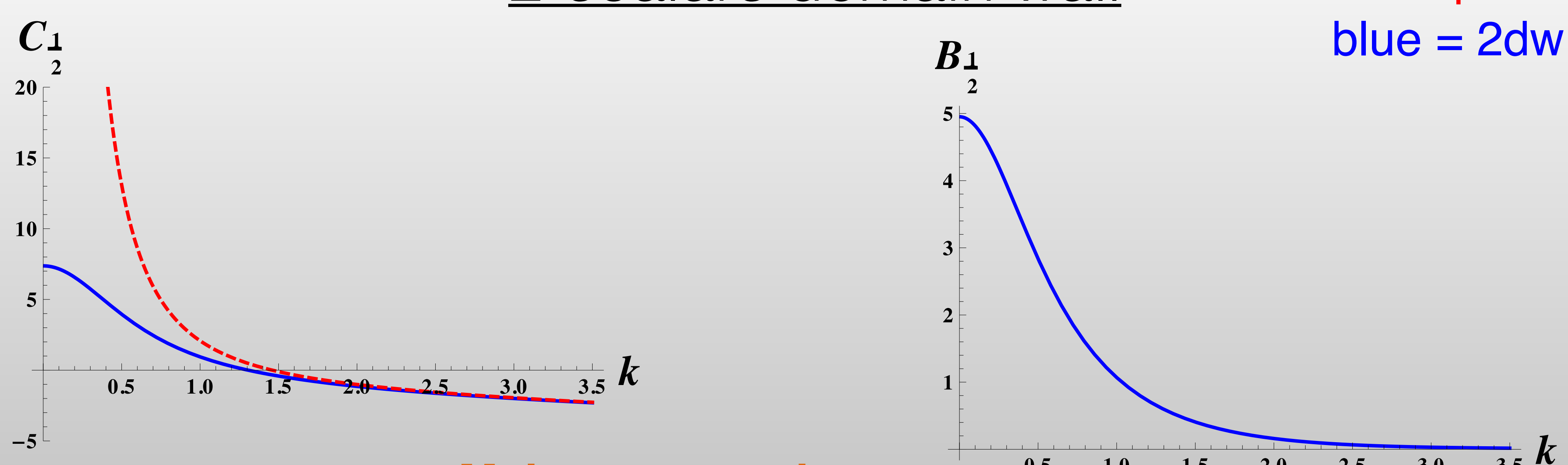
red = pure AdS
blue = ddw



Dirac gaugino

2-scalars domain wall

red = pure AdS
blue = 2dw



Majorana gaugino

Example 2: FZ multiplet

* Ferrrara-Zumino multiplet contains energy-momentum tensor and supercurrent

$$\mathcal{J}_\mu = R_\mu + \theta S_\mu + (\theta\bar{\theta})^\nu T_{\mu\nu} + \dots$$
$$X = x + \theta S + \theta^2\,(T + i\,\partial^\mu R_\mu) + \dots$$

$$\partial^\mu T_{\mu\nu} = \partial^\mu S_\mu = 0$$

I. Characterization of 2-point correlators inside FZ-multiplet

$$\langle x(p)\, x^*(-p)\rangle = \tfrac{2}{3}\, m^2\, F_0(p^2)$$
$$\langle R_\mu(p)\, R_\nu(-p)\rangle = -P_{\mu\nu}\, C_{1R} - \tfrac{1}{3}\, m^2 \eta_{\mu\nu}\, F_1$$
$$\langle T_{\mu\nu}(p)\, T_{\rho\sigma}(-p)\rangle = -\tfrac{1}{8} X_{\mu\nu\rho\sigma}\, C_2 - \tfrac{m^2}{8p^2}\,(\, P_{\mu\nu}P_{\rho\sigma} - P_{\rho(\mu}P_{\nu)\sigma})\, F_2$$
$$\langle S_{\mu\alpha}(p)\, \bar{S}_{\nu\dot{\beta}}(-p)\rangle = -(Y_{\mu\nu})_{\alpha\dot{\beta}}\, C_{3/2} - \tfrac{i}{2}\, m^2\, \varepsilon_{\mu\nu\rho\lambda}\, p^\rho \sigma^\lambda_{\alpha\dot{\beta}}\, F_{3/2} + M^4 (\sigma_\mu \bar{\sigma}^\rho \sigma_\nu)_{\alpha\dot{\beta}}\, \frac{2p_\rho}{p^2}$$

SUSY imposes:

$$C_s = C$$
$$F_s = F$$

Goldstino pole

* In a superconformal field theory

$$C(p^2) = \tfrac{\tau}{(4\pi)^2} \log\left(\tfrac{\Lambda^2}{p^2}\right)$$
$$F(p^2) = 0$$

II. Computing FZ-multiplet correlators in a holographic setup

5d gravity+matter multiplet

$$\mathcal{H}_\mu = \left(g_{\mu\nu},\, \Psi_{\mu\alpha},\, \tilde{A}_\mu\right)$$

$$\Phi = (\phi,\, \psi,\, F)$$

AdS/CFT

4d FZ-multiplet

$$\mathcal{J}_\mu = (T_{\mu\nu},\, S_{\mu\alpha},\, R_\mu)$$

$$X = (x,\, S,\, T + i\partial R)$$

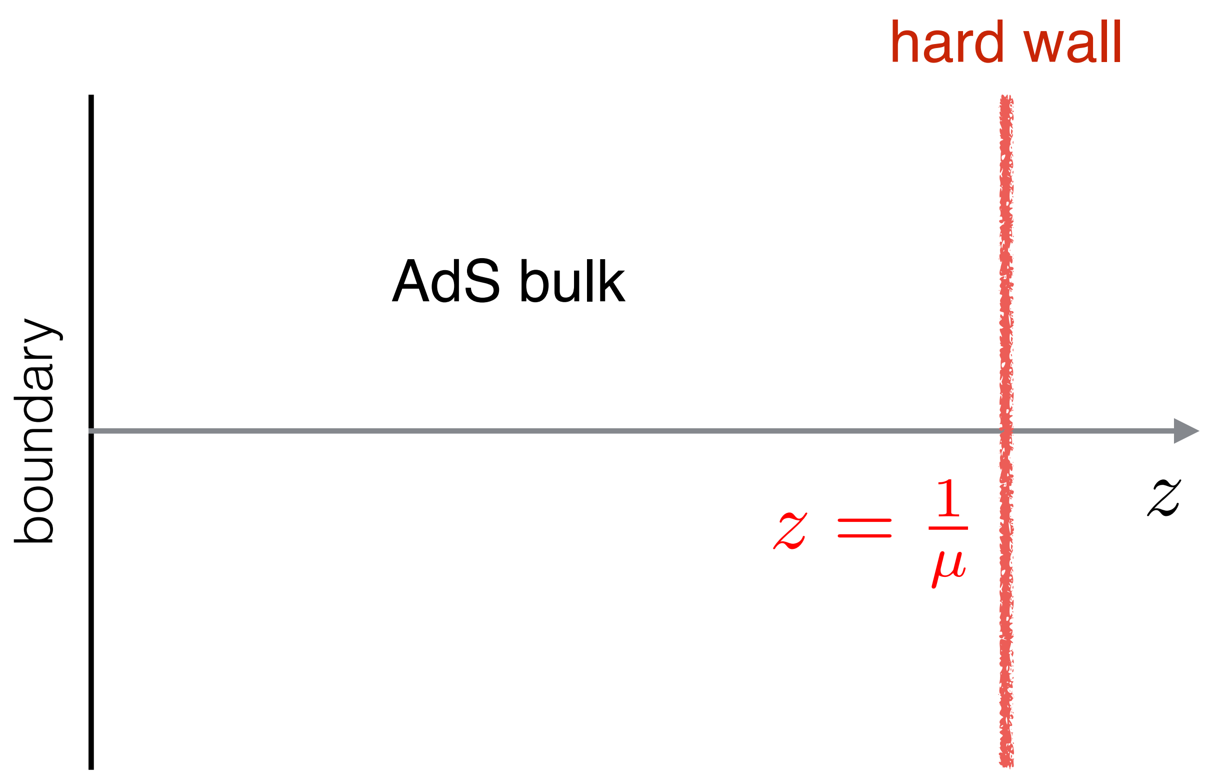
- ✳ Given some 5d background one can compute 4d FZ-multiplet correlators letting the 5d gravity+hyper multiplet fluctuate on this background.
- ✳ Fluctuations of the gravity multiplet are more difficult to deal with.
- ✳ BUT: in computing 2-point of X, back reaction is subleading. This greatly simplifies calculations, e.g.

$$\mathcal{L}_{scft} + m\, F_O$$

$$X = \tfrac{4}{3} m\, O$$

$$\longrightarrow \quad \langle T\, T \rangle_{\mathcal{O}(m^2)} = m^2 \langle \mathrm{Re}(F_O)\, \mathrm{Re}(F_O) \rangle_{m=0}$$

FZ multiplet: simplest set-up



Pure HW

$$C(p^2) \simeq \frac{\mu^2}{p^2} + \mathcal{O}(1)$$

$$F(p^2) = 0$$

HW + mO (w/ SUSY b.c.)

$$F(p^2) \simeq \log\frac{\Lambda^2}{\mu^2} - \frac{p^2}{2\mu^2} + \mathcal{O}\left(\frac{p^4}{\mu^4}, \frac{m^2}{\mu^2}\right)$$

HW + mO (w/ ~~SUSY~~ b.c.)

$$\langle S\,\bar{S}\rangle = 4\not{p}\,\frac{m^2\mu^2}{p^2} + \mathcal{O}\left(\frac{m^2}{\mu^2}\right)$$

Goldstino pole!

Summary & Outlook

- Studied behavior of 2-point functions of operators inside (super)current multiplets, using AdS/CFT.
- Probed different phases and dynamical regimes.
- Worked at supermultiplet level.

Future Prospects

- Repeat the analysis in fully back-reacted solutions (coming soon).
- Investigate dynamical properties of SUSY breaking string-derived backgrounds (typically non-AAdS).