3d SCFTs and holography

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June 2023

Why 3d SCFTs and holography?

- Question

> Path integral of string/M-theory
> beyond the 2-derivative supergravity approximation?

- Step I. AdS/CFT correspondence provides a stage:

$$Z_{\text{CFT}} = Z_{\text{string/M-theory}}\big|_{\text{AdS solution}} .$$

- Step II. Supersymmetry (localization) allows for the exact calculation of

$$Z_{\text{SCFT}} = Z_{\text{string/M-theory}}\big|_{\text{susy AdS solution}} .$$

- Tackle this question for SCFT$_3$...!

SCFT_3 on various manifolds

$$Z_{\mathsf{SCFT}} = \int \mathcal{D}X\, e^{-S_{\mathsf{SCFT}}[X]} \xrightarrow{\text{localization}} \text{Matrix Model}$$

Localization for $\mathcal{N} = 2$ SCFT_3 on various compact manifolds

- S^3 partition function (Ptn Fct) & susy Wilson loops
  [Kapustin-Willett-Yaakov 09] [Jafferis 10] [Hama-Hosomichi-Lee 10]
- $L(p, q)$ lens space Ptn Fct & susy Wilson loops [Gang 09]
- S^3_b Ptn Fct [Hama-Hosomichi-Lee 11] [Imamura-Yokoyama 11]
- 3d Riemannian manifold Ptn Fct [Festuccia-Seiberg 11] [Dumitrescu-Festuccia-Seiberg 12]
  [Closset-Dumitrescu-Festuccia-Komargodski-Seiberg 12] [Klare-Tomasiello-Zaffaroni 12] $\cdots$
- $S^1 \times S^2$ superconformal index (SCI) [Kim 09] [Imamura-Yokoyama 11] [Kapustin-Willett 11]
- $S^1 \times \Sigma_{\mathfrak{g}}$ topologically twisted index (TTI) [Benini-Zaffaroni 15] [Closset-Willett-Kim 17]
- Seifert manifold Ptn Fct [Closset-Willett-Kim 17,18]
- $S^1 \times D^2$ (w/ bdry) Ptn Fct [Beem-Dimofte-Pasquetti 12] [Hwang-Kim-Park 12]

SCFT_3 of different types $\rightarrow$ holography

$$Z_{\text{SCFT}} \xrightarrow{\text{localization}} \text{Matrix Model} = Z_{\text{string/M-theory}}\Big|_{\text{susy AdS}} \simeq e^{-S_{\text{sugra}}}$$

SCFT_3 from M2 branes [Aharony-Bergman-Jafferis-Maldacena 08] $\cdots$

- Holographic matching [Drukker-Mariño-Putrov 10] [Herzog-Klebanov-Pufu-Tesileanu 10] [Liu-P.Zayas-Rathee-Zhao 17] [Bobev-Charles-Hristov-Reys 20] $\cdots$

SCFT_3 from M5 branes wrapping 3-manifold [Dimofte-Gaiotto-Gukov 11] $\cdots$

- Holographic matching [Gang-Kim-Lee 14] [Gang-Kim 18] [Gang-Kim-P.Zayas 19] [Benini-Gang-P.Zayas 19] [Bobev-Crichigno 19] [Bobev-Charles-Gang-Hristov-Reys 20] $\cdots$

SCFT_3 from D2 branes in massive IIA [Gaiotto-Tomasiello 09] $\cdots$

- Holographic matching [Mariño-Putrov 11] [Jafferis-Klebanov-Pufu-Safdi 11] [Suyama 13] [Guarino-Jafferis-Varela 15] [Fluder-Sparks 15] [Liu-P.Zayas-Zhou 18] [Liu-JH 21] $\cdots$

SCFT_3 from D4 branes wrapping $\Sigma_{\mathfrak{g}}$ in massive IIA D8/O8 background

[Seiberg 96] [Intriligator-Morrison-Seiberg 97] [Aharony-Hanany-Kol 97] [Bah-Passias-Weck 18] $\cdots$

- Holographic matching [Bergman-RodriguezGomez 12] [Jafferis-Pufu 12] [Bobev-Crichigno 17] [Crichigno-Jain-Willett 18] [Hosseini-Yaakov-Zaffaroni 18] $\cdots$

SCFT_3 and holography: open questions

$$Z_{\text{SCFT}} \xrightarrow{\text{localization}} \text{Matrix Model} = Z_{\text{string/M-theory}}\Big|_{\text{susy AdS}} = e^{-S_{\text{sugra}}} + \cdots ?$$

Exact SCFT_3 results from string/M-theory path integral?

- Exact ($1/N$-expansion) results $\to Z_{\text{string/M-theory}}$ beyond the semi-classical limit!

  e.g. ABJM S^3 Ptn Fct [Fuji-Hirano-Moriyama 11] and $S^1 \times \Sigma_{\mathfrak{g}}$ TTI [Bobev-JH-Reys 22]

New exact SCFT_3 results?

- Exact results for SCFT_3 *not* from M2 branes?
- Exact results for SCFT_3 on different 3d manifolds?

  e.g. SCI with a compact $1/N$-expansion beyond Cardy limit? [Bobev-Choi-JH-Reys 22]

$$\log[\text{ABJM SCI}] = -\frac{2}{\omega}\left[\frac{\pi\sqrt{2k}}{12}\left(N - \frac{k}{24} + \frac{2}{3k}\right)^{\frac{3}{2}} + \hat{g}_0(k)\right] + \log[\text{ABJM TTI}] + \mathcal{O}(\omega, e^{-\sqrt{N}})$$