Microstate Counting of (Near-)BPS AdS Black Holes

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Based on 1907.02505 with Larsen, Zeng
and 1907.***** with Pando Zayas

AdS BPS Black Hole Entropy

- AdS_3 BPS black hole entropy ('96 Strominger, Vafa)
- AdS_4 magnetically charged BPS black hole entropy ('15 Benini, Hristov, Zaffaroni, see Zaffaroni's talk)
- AdS_5 BPS black hole entropy:
  - $\mathcal{N} = 4$ SYM Superconformal Index: ('07 Kinney, Maldacena, Minwalla, Raju)

$$\mathcal{I} \sim \mathcal{O}(1)\,, \quad S_{BH} \sim \mathcal{O}(N^2)$$

  - Recent progress:
    - Localization of $\mathcal{N} = 4$ SYM in complex backgrounds ('18 Cabo-Bizet, Cassani, Martelli, Murthy)
    - Free $Z_{\mathcal{N}=4\ SYM}$ with complex fugacities ('18 Choi, Kim, Kim, Nahmgoong, see Seok Kim's talk)
    - $\mathcal{I}_{\mathcal{N}=4\ SYM}$ with complex fugacities ('18 Benini, Milan)

AdS_4 BPS Black Hole Entropy

('19 JN, Pando Zayas)

Metric:

$$ds^2 = d\tau^2 + L^2\left[d\theta^2 + \sin^2\theta\,(d\varphi - i\omega d\tau)^2\right]$$

Find complex background fields A_μ and V_μ ('13 JN):

$$(\nabla_\mu - iA_\mu\gamma_1)\xi = -\frac{1}{2}H\gamma_\mu\xi - iV_\mu\gamma_1\xi + \frac{i}{2}V^\nu\gamma_{\mu\nu}\gamma_1\xi$$

Anti-periodic boundary condition requires

$$\frac{2}{L}(\omega - 4\Delta) = 2\pi i\,(\mathrm{mod}\ 4\pi i)$$

Localization of 3d $\mathcal{N} = 2$ theory:

$$Z = \frac{1}{|\mathcal{W}|}\int d^r\sigma Z_{\text{class}}\, Z_{\text{chiral}}^{1-\text{loop}}\, Z_{\text{vec}}^{1-\text{loop}}$$

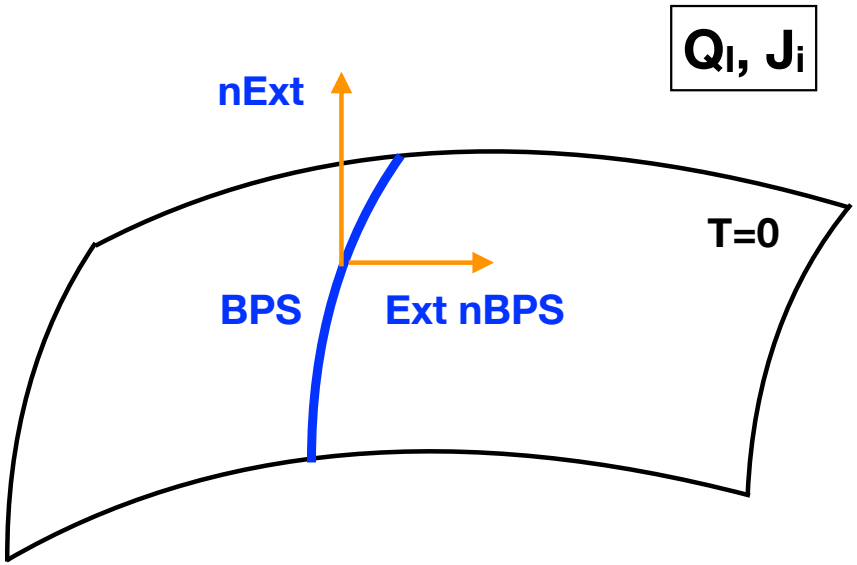
Evaluate Large-N matrix model:

$$F = \mu\frac{k^{\frac{1}{2}}N^{\frac{3}{2}}\sqrt{\Delta_1\Delta_2\Delta_3\Delta_4}}{\omega}$$

$\Rightarrow$ Entropy function $\Rightarrow$ BPS S_{BH} ('18 Choi, Hwang, Kim, Nahmgoong)

AdS_5 nBPS Black Hole Entropy

('19 Larsen, JN, Zeng)



For near-BPS configurations we distinguish:

- Near-Extremal:
  The deviation is characterized by T.
- Extremal near-BPS:
  The deviation is characterized by $\varphi \equiv \Phi - \frac{1}{g}(\Omega_1 + \Omega_2) - 1$

Results on AdS_5 nBPS S_{BH}

- Gravity side ('05 Chong, Cvetic, Lu, Pope; '11 Wu):

$$M, T, S\,(m, q, r_+, a, b)$$

$$Q \leftrightarrow \Phi\,(m, q, r_+, a, b) \quad J_{1,2} \leftrightarrow \Omega_{1,2}\,(m, q, r_+, a, b)$$

- Free $\mathcal{N} = 4$ SYM side ('19 Larsen, JN, Zeng):

$$\log Z(\beta, \Delta_I, \omega_i) = -\frac{N^2}{2T}\frac{(\Phi_1 - \Phi_1^*)(\Phi_2 - \Phi_2^*)(\Phi_3 - \Phi_3^*)}{(\Omega_1 - \Omega_1^*)(\Omega_2 - \Omega_2^*)}$$

$\Rightarrow$ nBPS Entropy function $\Rightarrow$ nBPS S_{BH}

- Relations:

$$\mathrm{Re}\,\Delta_I = \partial_T \Phi_I\,, \quad \mathrm{Re}\,\omega_i = \partial_T \Omega_i$$

- Consistent results on both sides:

$$M - M^* = \frac{1}{2}\frac{C_T}{T}\left[T^2 + \left(\frac{\varphi}{2\pi}\right)^2\right], \quad S - S^* = \frac{C_T}{T}T + \frac{C_E}{T}\frac{\varphi}{2\pi}$$

Possible Future Directions

- AdS_4 near-BPS black hole entropy
- Revisit (near-)BPS AdS_3 (Strominger-Vafa)
- AdS black holes in other dimensions
  (AdS_6 '19 Choi, Kim, AdS_7 '19 Kántor, Papageorgakis, Richmond, $\cdots$)
- Cardy formula in various dimensions ('19 Kim, Kim, Song)

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Thank you!