email: jbz701@alumni.ku.dk Link to: github-page

Research Statement

Rasmus Steen Kofoed Nielsen

Past research experience

2019-2020 My prior research work, which became the topic of my master thesis, was focused on studying defect versions of the standard AdS/CFT setup from type II.b super string theory. These modified AdS/CFT setups completly (*or partially*) break super symmetry, thus providing prehabs more realistic frameworks for the study of holography. The defect setups in question are obtained by the insertion of probe branes, with various geometries, into the stack of N D3-branes.

In ealier works [4, 6], interesting checks of these defect AdS/CFT dualities were carried out by computing the next to leading order corrections to certain one-point functions on the field theory sides, along with the dual gravity correlation functions.

My contributions to this story has focused on progressing towards a check using protected two-point functions and their gravity duals. Expressions for protected two-point functions in the case of $AdS_4 \times S^2 \times S^2$ probe geometry was identified. Progress towards expressions for two-point functions in the case of $AdS_4 \times S^4$ probe geometry was made. The dual gravity objects in both cases have yet to be identified.

In addition to my work on protected two-point functions in these defect setups, I have also obtained expressions for non-protected two-point functions, building on the ideas pressented in [9]. The machinary used in this context has applications in statistical physics, as well as condensed matter theory [2].

Motivations for past research

- Performing a very **non-trivial check of AdS/CFT** (*holographic dualities*), in a framework with comepletely broken super symmetry.
- Developing applications to the study of **strongly coupled fermions**, and the fractional quantum Hall effect in $2+1$ dimensions (*condensed matter theory*).
- Developing applications to the study of **Quantum Quenche Dynamics** in non-equilibrium systems (*condensed matter theory / statistical physics*).

Future research directions

2021- There are several future research directions, which I would like to pursue:

- Completing the checks of AdS/CFT in the setups with completely broken super symmetry, by computing both the two-point functions on the field theory side, as well as the (*still unidentified*) dual gravity objects. This will, among other things, require study of trace relations between $SO(5)$ fuzzy spherical harmonic matrices and $SO(5)$ generators.
- Studying *entangelment entropy* and *black hole solutions* in these defect versions of AdS/CFT. This could potentially help further our understanding of black hole microstates, as well as the connection between gravity and quantum entangelment.
- Alternatively, it could be very interesting to study *entangelment entropy* and *black hole solutions* for the case of a 3D bulk theory. In this case, the gravitational theory is much simpler due to the absence of propagating modes. valuable inside could be gained in such a simplified toy model.
- Employing *Lattice Gauge Theory* to study different aspects of $\mathcal{N}=4$ super Yang Mills theory and QCD, as well as the non-linear σ-model of super string theory on an AdS background, in the strong coupling regimes of the respective theories.

References

[1] J. Maldacena, "The Large N Limit of Superconformal field theories and supergravity", *Int. J. Theor. Phys.* **38** (1999) 1113-1133, *Adv. Theor. Math. Phys.* **2** (1998) 231-252, arXiv:hep-th/9711200

[2] M. de Leeuw, T. Gombor, C. Kristjansen, G. Linardopoulos and B. Pozsgay, "Spin Chain Overlaps and the Twisted Yangian", *JHEP* **01** (2020) 176, arXiv:1912.09338 [hep-th]

[3] V. A. Mitsou, "Experimental status of particle and astroparticle searches for supersymmetry", 2013 *J. Phys.: Conf. Sereffectively.* **447** 012019, arXiv:1304.1414 [hep-ph]

[4] I. Buhl-Mortensen, M. de Leeuw, A. C. Ipsen, C. Kristjansen and M. Wilhelm, "A Quantum Check of AdS/dCFT", *JHEP* **1701** (2017) 098, arXiv:1611.04603 [hep-th]

[5] M. de Leeuw, A. C. Ipsen, C. Kristjansen, K. E. Vardinghus and M. Wilhelm, "Two-point functions in AdS/dCFT and the boundary conformal bootstrap equations", *JHEP* **1708** (2017) 020, arXiv:1705.03898 [hep-th]

[6] A. G. Grau, C. Kristjansen, M. Volk and M. Wilhelm, "A Quantum Check of Non-Supersymmetric AdS/dCFT", *JHEP* **1901** (2019) 007, arXiv:1810.11463 [hep-th]

[7] A. G. Grau, C. Kristjansen, M. Volk and M. Wilhelm, "A Quantum Framework for AdS/dCFT through Fuzzy Spherical Harmonics on S^4", DESY-19-220, arXiv:1912.02468 [hep-th]

[8] I. Buhl-Mortensen, M. de Leeuw, C. Kristjansen and K. Zarembo, "One-point Functions in AdS/dCFT from Matrix Product States", *JHEP* **1602** (2016) 052, arXiv:1512.02532 [hep-th], NORDITA-2015-132, UUITP-26-15

[9] E. Widen, "Two-point functions of SU(2)-subsector and length-two operators in dCFT", *Phys. Lett.* **B773** (2017) 435-439, arXiv:1705.08679 [hep-th]