AdS Black Holes and Their Microstates

Seyed Morteza Hosseini*

Department of Physics, Imperial College London, London, SW7 2AZ, UK

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Abstract: We will review some recent progresses in deriving the Bekenstein-Hawking entropy of supersymmetric anti de Sitter (AdS) black holes in dimensions equal or greater than four. The counting of the number of microstates is based on three basic tools: holography, localization and matrix model techniques. We cover in details the case of four-dimensional static AdS black holes, focusing on the topologically twisted index of ABJM theory. We also summarise some of the results obtained for other AdS black holes.

Content of the lectures

The lectures consist of three parts and the duration will depend on the pace of covering the topics, which could range from 6 to 8 hours.

I AdS black holes in 4d $\mathcal{N}=2$ **gauged supergravity** — We cover the aspects of gauged supergravity that are relevant for these lectures and describe the supersymmetric *magnetic, static* $\mathrm{AdS}_4\times S^7$ black holes. The lectures also explain how to calculate their entropy using field theory techniques and introduce the notions of attractor mechanism and entropy functional that are useful for comparing gravity and field theory.

II Localization meets holography — We sketch the technique of supersymmetric localization and discuss the topologically twisted index for three-dimensional supersymmetric theories. We then perform the large N limit of the ABJM matrix model, which serves as an example for many similar calculations, and compare with gravity.

III Results for other AdS black holes — We survey the state of the art for other AdS black holes. In particular, we explain the microscopic origin of the entropy of rotating, electrically charged $\mathrm{AdS}_5\times S^5$ black holes.

The lectures presuppose some background knowledge of the main instances of holographic dualities in different dimensions. We expect that the reader knows that $\mathcal{N}=4$ SYM in four dimensions is dual to $\mathrm{AdS}_5\times S^5$, the ABJM theory to $\mathrm{AdS}_4\times S^7$, the enigmatic 6d $\mathcal{N}=(2,0)$ theory to $\mathrm{AdS}_7\times S^4$, and the $\mathrm{USp}(2N)$ Seiberg theories in five dimensions to $\mathrm{AdS}_6\times S^4$. Some prior acquaintance with supersymmetry would be also helpful but not essential.

Further readings — A. Zaffaroni, Living Rev. Rel. **23** (2020) no.1, 2 [arXiv:1902.07176 [hep-th]].

*Electronic address: s.hosseini@imperial.ac.uk