File ID	169964
Filename	Summary

SOURCE (OR PART OF THE FOLLOWING SOURCE):

Type	Dissertation
Title	Supersymmetric black holes as probes of quantum gravity
Author	X.D. Arsiwalla
Faculty	Faculty of Science
Year	2010
Pages	iv, 158

FULL BIBLIOGRAPHIC DETAILS:
http://dare.uva.nl/record/336449

Summary

Our greatest glory is not in never failing, but in rising up every time we do

- adapted from Confucius

Supersymmetric Black Holes as Probes of Quantum Gravity

The research presented in this thesis features a specific class of black holes arising in string theory that offer a rare window towards probing quantum gravity. The driving force behind much of this research in black hole physics lies in the idea of holography which is a duality between a gravitational theory in a bulk space-time and a quantum theory (without gravity) living on the boundary of that space-time. In string theory this duality is famously manifest as the AdS/CFT correspondence. Macroscopic observables refer to gravitational quantities in the bulk; whereas, microscopics corresponds to the theory living on a bound state of higher dimensional objects in string theory called branes. The black holes that we work with in this thesis are analogs of zero temperature black holes (also known as extremal) in Einstein's gravitational theory with electromagnetic charge; and are obtained through compactification of a type of closed string theory in ten dimensions, where the compactified six dimensions are endowed with 4, 2 and 0 dimensional (spatially) branes, thus giving a black hole solution in four non-compact dimensions. Lifting this set-up to eleven dimensions by opening a circular spatial dimension gives a five dimensional black string in M-theory, where the branes now lift to 5 & 2 dimensional membranes and respectively angular momentum along the M-theory circle. Subsequent fragmentation of this system leads to interesting multi-center configurations in 4 as well as 5 dimensions. Investigating this specific system and its various manifestations, sheds new insights into the quantum

field theory(gauge theory)/gravity paradigm.

An interesting recent development that initiated the research in this thesis is the Ooguri-Strominger-Vafa (OSV) conjecture, which is a correspondence relating a class of supersymmetric black holes to topological string theory - a lower dimensional string theory living on a six dimensional compactification space. This conjecture has raised several questions as well as opened up novel possibilities. Firstly, one had to verify that it indeed held true for a range of interesting gravitational systems. Of specific interest for this thesis was the D0-D2-D4 black hole solution from Type II A string theory compactified on a specific Calabi-Yau background. The dual gauge theory, in this case, turned out to be a quantum deformed version of two dimensional Yang-Mills on a closed surface. Since the latter lends itself to non-perturbative analysis, it opens up the interesting possibility to extract non-perturbative information from the gauge theory and thus determine corresponding corrections to the black hole system. Of course, as an independent check, it is still be useful to compute the black hole's entropy and observed charges with the inclusion of higher order corrections. To sum it up, both microscopic as well as macroscopic computations are necessary for furthering this research.

Besides the OSV conjecture, other developments in the direction of black holes with non-trivial topology and their respective entropy counting issues also began to gain momentum around the same time. At first sight, many of these apparently diverse developments appeared seemingly unrelated. As a case in point, we list those developments here: solutions for multi-center supersymmetric black holes; the discovery of black rings in five dimensions; the 4D/5D connection relating black holes in four dimensions to those in five dimensions, and subsequently a multi-center extension of this connection along with the inclusion of extended black objects; the formulation of an entropy function technique that is well suited for computations involving higher order corrections due to the remarkable feature that within this formalism, all equations of motion straightforwardly reduce to algebraic equations; quiver[3] gauge theories dual

[3]Literally speaking, a quiver is a case for holding arrows. In mathematics, a quiver is a directed graph, with loops and links between vertices. For our purposes here, the vertices represent gauge groups.

to multi-center black hole configurations, necessary for a holographic understanding of microstates. Our take in this work is that a lot of these themes in fact compliment each other and thus a parallel rather than serial approach to research in this field can in fact lead to integration of ideas and emergence of new insights therein. Nevertheless, the underlying theme behind all of this is still the gravity/gauge duality connecting the macroscopic to the microscopic. Therefore in order to modestly achieve some of these objectives, a large emphasis of the work in this thesis has been placed on developing methodology and interpreting underlying mechanisms.

Here we briefly summarize our results. In chapter 3, we began our investigations with macroscopic gravity calculations. We developed an entropy formalism suited for 5D black objects. This is then applied to both 5D black holes as well as black rings. In chapter 4, we turned our attention to the 4D/5D conjecture and carefully investigated subtle charge shifts that result in the process for black holes and black rings. These are issues that have stirred considerable debate in the literature. For single center configurations, the new tools developed in chapter 3 provide us with a geometric interpretation of the above shifts via spectral flow. We then moved on to understand this picture for multi-center geometries and interpret these results via the corresponding split-spectral flows. To do so, insights from AdS fragmentation were found to be extremely beneficial. In chapter 5, we investigated continuum multi-center black hole configurations, thus finding solutions to integrability equations for large n centers. We have subsequently used these solutions for generating interesting electro-magneto-gravitational backgrounds. As an interesting application we then discussed this in the context of a black hole levitron. On the microscopic side, we have studied the dual gauge theory of the aforementioned black hole, constructed as a bound state of D-branes. In this rare case, the microscopic theory turns out to be fully non-perturbative and thus lends itself as a very interesting tool for instanton analysis. In order to do this, we considered topological strings over a non-compact Calabi-Yau background, over which we sought to test the validity of the OSV conjecture and in the process discovered a remarkable phase transition in the theory. We analyzed this transition and commented on its implications for black hole physics.