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Exact solutions in nonlinear superstring models and black holes without singularities

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Abstract. We deal with the classical black hole dynamics, general properties of supersymmetric black holes, a new statistical explanation of the black hole entropy in the context of superstring theory, and consider the relationship between their thermodynamics at different scales. We argue that superstring theory is able to give an explanation of black hole thermodynamics in an arbitrary spacetime dimension. A purely geometric method for constructing exact solutions of nonlinear superstring models is introduced. It is then possible to obtain nice relations between superstring and black hole geometries in multidimensional gravity and give a perfect explanation of black hole thermodynamics in terms of superstring theory. We also find a useful relation between the geometric parameters of black holes and some topological invariants which are analogous to instanton charges for self-dual Yang-Mills solutions in four-dimension.

Keywords: superstrings, black holes, exact solutions, complex supermanifolds

MSC numbers: 83C55, 83C57

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1. Introduction

Nowadays 'supertheories' deal with the construction of a quantum theory of gravity that would be compatible with the idea of unifying all the fundamental interactions of nature: gravitation, strong interaction, weak interaction, and electromagnetism...

In Section 2.1 we explain how to refer to articles, books, proceedings... In Section 3 we insert graphics into the document and ...

2. Second section

2.1 Definition, proposition, lemma, theorem, corollary

A connection between superstrings states and black holes can be made in a different fashion. In the following pictures the internal causal structure[1] of a spherically symmetric open superstring is shown. The conformal structure...

Definition 1. *This is a definition. In in-line equations within a paragraph write a/b instead of $\frac{a}{b}$, and in a separate line write*

$$\frac{1+a/b}{a+b} \quad \textit{or} \quad \frac{1+\dfrac{a}{b}}{a+b} \ \textit{(acceptable)} \quad \textit{instead of} \quad \frac{1+\frac{a}{b}}{a+b}.$$

Proposition 1. *This is a proposition.*

Lemma 1. *This is a lemma.*

Theorem 1. *This is a theorem.*

Corollary 1. *This is a corollary.*

Proof. This is a proof of the corollary.

2.2 How to refer to articles, books, proceedings etc

This is a reference (to an article) with one author [1].
This is a reference (to a book) with two authors [2].
This is a reference (to an article) with three authors [3].
This is a reference (to an arXiv preprint) with more than three authors [4].
This is a reference to materials of a conference [5].
This is a reference to a conference report [6].

2.3 Bold Greek letters

To insert a bold Greek letter into your text, you need to use the \bm command in math mode: for example, $\boldsymbol{\alpha}$ differs from α.

[1] See our previous works for details

3. Third section

It would be also interesting to explore the possible application of our solutions to cosmological models. Whether our general solutions have interesting applications to these problems remains to be seen. The spectrum of quantum black holes predicted by superstring theory immediately provides predictions for the spectrum of emitted massless particles, for the entropy, and for the evaporation rate. One of the most important results in string theory is the discovery of close relations between black hole thermodynamics and...

3.1 An example of inserting plots in the text

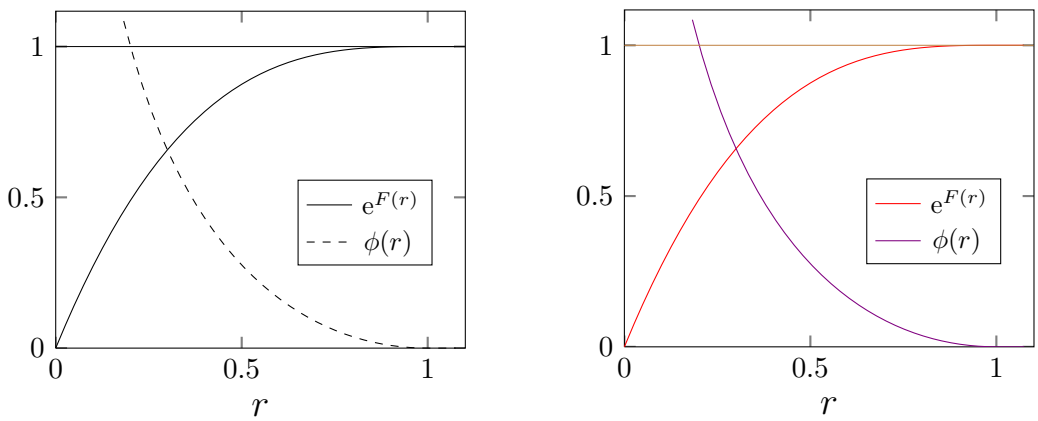

Figure 1: We strongly recommend to take advantages of electronic publications. Particulary, colour figures are greeted.

See Figure1 and Theorem1. Note that in the *figure* environment the \label{ } command, if any, should *follow* the \caption{ } command[1].

3.2 Two examples of long formulas

It is needed to use the *align* and *multline* environments:

$$
\begin{aligned}
R = & \left(\frac{B_{(0)(0)}}{B} - \frac{A_{(1)(1)}}{A}\right) \alpha^1 \otimes \alpha^1 + \left(\frac{C_{(0)(0)}}{C} - \frac{A_{(1)}C_{(1)}}{AC}\right)\left(\alpha^2 \otimes \alpha^2 + \alpha^3 \otimes \alpha^3\right) \\
& + \frac{C_{(1)}^2 - C_{(0)}^2 - 1}{C^2} *\alpha^1 \otimes *\alpha^1 + \left(\frac{C_{(1)(1)}}{C} - \frac{B_{(0)}C_{(0)}}{BC}\right)\left(*\alpha^2 \otimes *\alpha^2 + *\alpha^3 \otimes *\alpha^3\right) \\
& + \left(\frac{C_{(1)(0)}}{C} - \frac{A_{(1)}C_{(0)}}{AC}\right)\left(\alpha^3 \otimes *\alpha^2 + *\alpha^2 \otimes \alpha^3 - \alpha^2 \otimes *\alpha^3 - *\alpha^3 \otimes \alpha^2\right),
\end{aligned}
$$

[1]See Esse-2013-01-01.tex

$$
\begin{aligned}
S = {} & 2\left(\frac{A_{(1)(1)}}{A} - \frac{B_{(0)(0)}}{B}\right) \\
& - 4\left(\frac{C_{(0)(0)}}{C} - \frac{A_{(1)}C_{(1)}}{AC}\right) + 4\left(\frac{C_{(1)(1)}}{C} - \frac{B_{(0)}C_{(0)}}{BC}\right) \\
& + 2\frac{C_{(1)}^2 - C_{(0)}^2 - 1}{C^2}\,.
\end{aligned}
$$

3.3 Once more example of inserting plots in the text

Figures can also be produced directly in the main *.tex* file with using, e.g., *pgfplots* package. In this case files with graphics data (if any) should be uploaded online together with the other files.

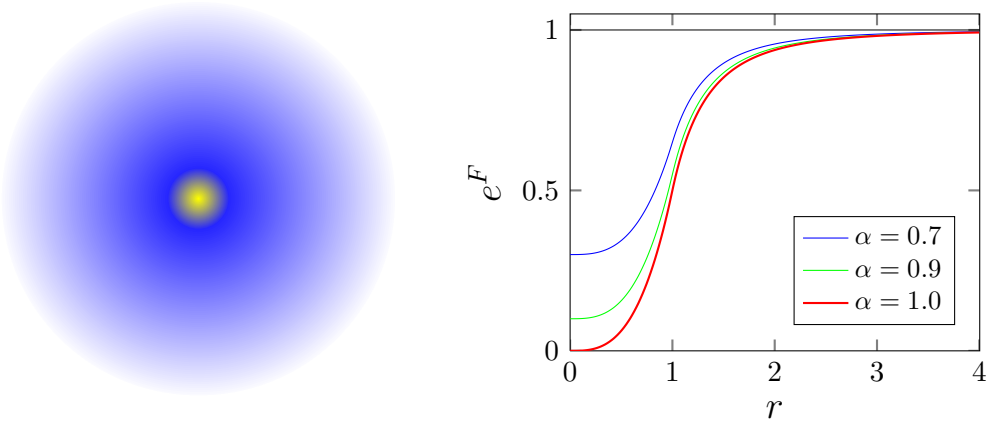

Figure 2: On the right panel the curves are plotted by data from the files *figure2b–1.dat*, *figure2b–2.dat*, and *figure2b–3.dat*.

The *figure* environment is very useful.

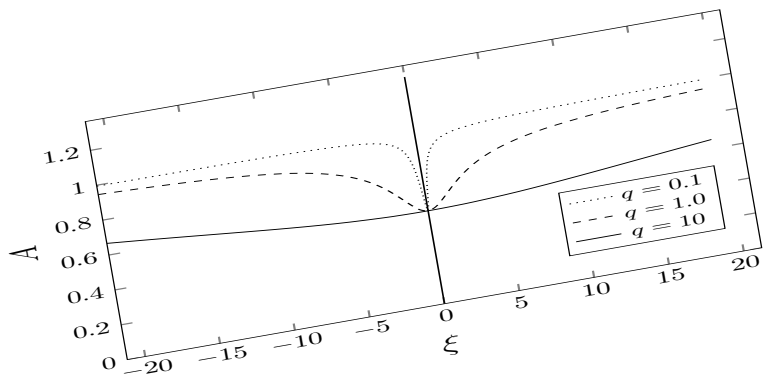

Figure 3: This is Figure 3. Parameters *width*, *height* and *angle* are specified.

One more figure...

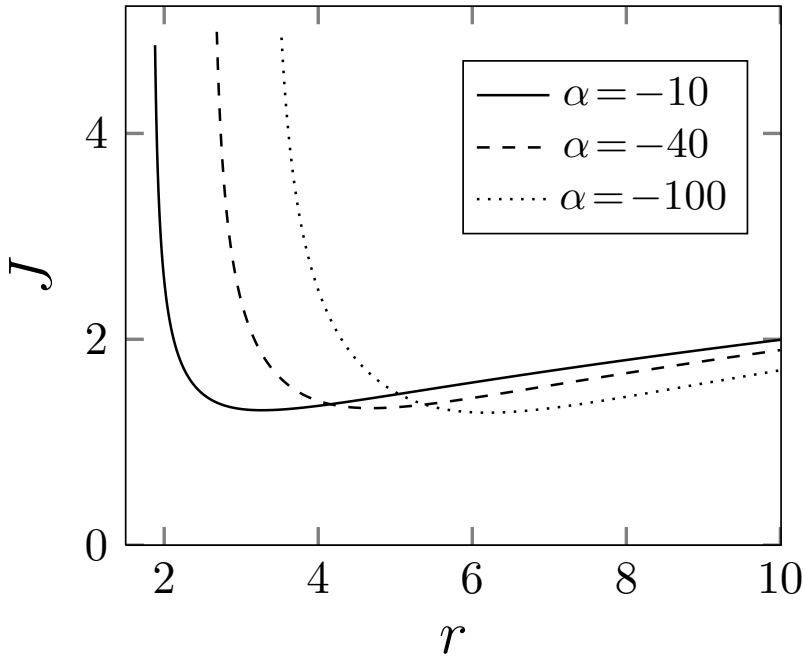

Figure 4: This is Figure 4. Value 1.6 is used for the *scale* parameter.

Figure 1 (the left panel) illustrates... This should be clearer from Figure 2... More subtle examples are shown in Figure 3... In Figure 4...

4. Conclusions (Discussion, Summary, Final Remarks etc)

The found relations between geometrical properties of BH event horizons and some thermodynamic quantities provides...

5. Appendix

Include this section only in a case of necessity.

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