

HERTZ LECTURE.

DESY Lecture on Physics 2019

Probing the Edges of the Universe:

Black Holes, Horizons and Strings

Prof. Dr. Andrew Strominger
(Harvard University)

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<http://www.desy.de/hertz>



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Microscopic origin of the Bekenstein-Hawking entropy

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Abstract

The visible universe has edges, known as horizons, which surround black holes and other inaccessible spacetime regions. They are governed by a universal but still-mysterious set of laws discovered a half century ago by Stephen Hawking. These laws tell us that black holes are paradoxically both the simplest and most complex objects into the universe. The resolution of this paradox is a central goal of modern physics. Compelling progress in and future prospects for our understanding of black holes, both from string theory and from the recent Event Horizon Telescope image will be described.

1. Introduction

In the early seventies a sharp and beautiful analogy was discovered between the laws of black hole dynamics and the laws of thermodynamics [1–7]. In particular the Bekenstein-Hawking entropy – one quarter the area of the event horizon – behaves in every way like a thermodynamic entropy. A missing link in this line of ideas is a precise statistical mechanical interpretation of black hole entropy. One of the goals of the Bekenstein-Hawking entropy – including the numerical factor – by counting black hole microstates. The laws of black hole dynamics are identified with – and not just be analogous to – the laws of thermodynamics.

$$S_{\text{stat}} = 2\pi\sqrt{Q_H(\frac{1}{2}Q_F^2 + 1)}. \quad (1.1)$$

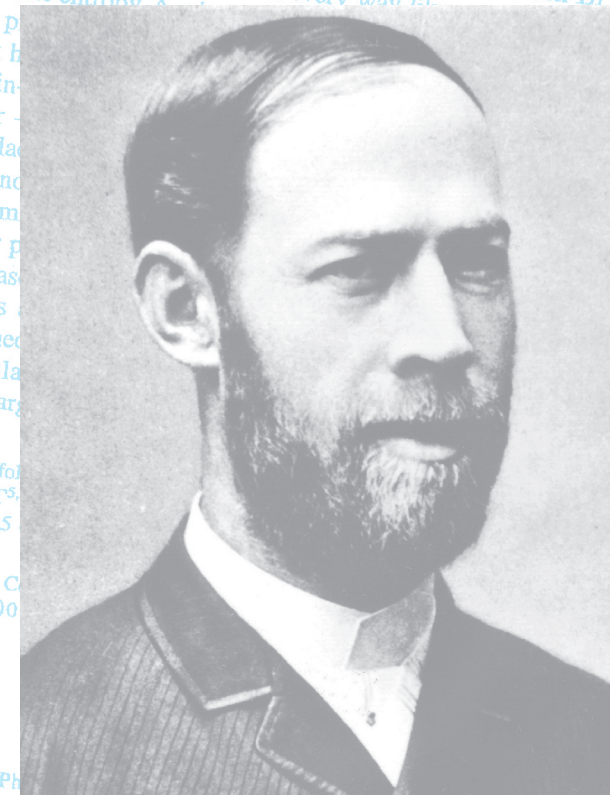
On the other hand we will find that the Bekenstein-Hawking entropy as determined from the low-energy effective action is

$$S_{\text{BH}} = 2\pi\sqrt{\frac{Q_H Q_F^2}{2}}. \quad (1.2)$$

Given the $O(21,5)$ invariance of the theory one expects that the state degeneracy of these BPS solitons be a function

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Extremal black holes with vanishing horizon area (heterotic string states) have degenerate horizons. They look for BPS saturated states – for which both Q_F and Q_H are non-zero. Such BPS states preserve a fraction of the supersymmetry. They may be charged BPS solitons. A function of Q_H and Q_F is determined by counting the bound-state degeneracy. The bound-state degeneracy is given by³



Heinrich Hertz

1857 Hamburg-Karlsruhe-Bonn 1894

BLACK STRINGS AND p-BRANES

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It is shown that low-energy string theory admits a family of solutions with the structure of an extended object surrounded by an event horizon. In particular there is a family of black string solutions, labelled by the mass and axion charge per unit length corresponding to a string in ten dimensions surrounded by an event horizon. The extremal member of this family is the known supersymmetric singular solution corresponding to a macroscopic fundamental string. A similar family of solutions is found describing a fivebrane surrounded by an event horizon, whose extremal member is a previously discovered non-singular supersymmetric fivebrane. Additional charged, extended black hole solutions are presented for each of the antisymmetric tensors that arise in heterotic and type II string theories.



The dS/CFT correspondence

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ABSTRACT: A holographic correspondence (D-dimension) (D-1)