Instituto de Física
Universidade de São Paulo

Geometry and topology of two kinds of extreme Reissner-Nordstrom-anti-de Sitter black holes

Wang, B. [a]; Abdalla, E. [a]; Su, R-K. [c]
[a]*Instituto de Física, Universidade de São Paulo, São Paulo, Brazil*
[b]*department of Physics Shanghai Teacher's University, P. R. China*
[c]*Department of Physics, Fudan University, Shanghai, P. R. China*

Publicação IF - 1423/2000

Geometry and topology of two kinds of extreme Reissner-Nordström-anti-de Sitter black holes

Bin Wang[a,b,1], Elcio Abdalla[a,2] and Ru-Keng Su[c,3]

[a] Instituto De Fisica, Universidade De Sao Paulo, C.P.66.318, CEP 05315-970, Sao Paulo, Brazil

[b] Department of Physics, Shanghai Teachers' University, P. R. China

[c] Department of Physics, Fudan University, Shanghai 200433, P. R. China

Abstract

Different geometrical and topological properties have been shown for two kinds of extreme Reissner-Nordström-anti-de Sitter black holes. The relationship between the geometrical properties and the intrinsic thermodynamical properties has been made explicit.

PACS number(s): 04.70.Dy, 04.20.Gz, 04.62.+v.

[1] e-mail:binwang@fma.if.usp.br

[2] e-mail:eabdalla@fma.if.usp.br

[3] e-mail:rksu@fudan.ac.cn

The study of the extreme black hole (EBH) has been stimulated since the discovery [1,2] that the four-dimensional (4D) Reissner-Nordström (RN) EBH is a different object from its nonextreme counterpart owing to its drastically different topological properties and peculiar zero entropy regardless of its nonzero horizon area. However, these results met some challenges subsequently. Starting with the grand canonical ensemble, it was argued [3-5] that in a finite size cavity a 4D RN non-extreme black hole (NEBH) can approach the extreme state as closely as one likes and the geometrical and topological properies are still of nonextreme sectors. Bekenstein-Hawking formula is believed to hold for RN EBH entropy description, which is also supported by state-counting calculations of certain extreme and near-extreme black holes in string theory, see [6] for a review. These different results indicate that EBHs have a controversial role in black hole thermodynamics and topologies and require special care.

Comparing [1,2] and [3-5], it seems that the clash comes from two different treatments: one refers to Hawking's treatment by starting with the original EBH [1,2] and the other Zaslavskii's treatment by first taking the boundary limit and then the extreme limit to get the EBH from its nonextreme counterpart [3-5]. Applying these two treatments, it was found that two different topological objects represented by different Euler characteristics exist for 4D RN EBH, charged dilaton EBH [7], Kerr EBH [8] as well as two-dimensional (2D) EBHs [7,9]. Drastically different intrinsic thermodynamical properties have also been displayed for 4D Kerr EBH [8] and 2D EBHs [9,10] due to these different treatments. Based upon these results it was suggested that there maybe two kinds of EBHs in nature: the first kind suggested by Hawking et al with the extreme topology and zero entropy, which can only be formed by pair