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ORIGINAL ARTICLE

Hawking temperature and entropy of Kerr-Sen black hole as a series with dependence on Plank constant

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Abstract By assumption of a low-energy string theory in addition to the necessity of the semi-classic expansion on action, we study Hawking temperature and entropy of Kerr-Sen black hole. These subjects, recently have introduced in the literature and consist of the new terms of temperature and entropy as the expansion form with powers of $\hbar$. Comparing the results with the high energy black hole demonstrates how the semi-classic approximation affects the thermodynamics of the Kerr-Sen black hole, corrected terms classical action and the entropy.

Keywords Hawking temperature · Plank constant · Corrected entropy · Action

1 Introduction

Black holes are remarkably simple gravitational systems for distant observers so long as one neglects quantum effects. However, for $\hbar = 0$ their physical behavior remains an open question whose complete answer requires a full-fledged quantum gravity theory (Banerjee and Modak 2009). In 1974, Hawking proved that black holes are not so black as their name pronounces. Rather, they radiate energy continuously like a black body with temperature given by $T_H = \hbar\kappa/2\pi$, where κ is the surface gravity of black holes. He made his calculation based on quantum field theory in curved spacetimes, which was so technically involved that some other different methods appeared subsequently for the study of black hole radiation called Hawking radiation now. The quantum gravity effects are also felt by observers outside the event horizon; as clearly indicated by Hawkings semiclassical calculations which show that a generic black hole radiates as a perfect black body at Hawking temperature T_H (Khani et al. 2013). In classical gravity, the solutions of the Schwarzschild, Reissner-Nordström and Kerr-Newman black holes on noncommutative spacetimes have been given (Adler 1999; Adler et al. 2001). One other class of rotating charged black hole solutions in four dimensions is Kerr-Sen geometry. The solution includes three non gravitational fields: an antisymmetric tensor field, a vector field and a dilaton. The Kerr-Sen black hole is a solution of the low-energy string theory effective action, that this solution can be obtained by applying the Hassan-Sen transformation to the Kerr geometry (Sen 1992). Its geometry is the subject of the study of many papers.

One of the intriguing properties of a black hole is that it carries entropy. Understanding this entropy is an enormous challenge in modern physics (Bekenstein 1973). Inspired by black hole thermodynamics, it was realized that there is a profound connection between gravity and thermodynamics. It is shown that the Einstein equation can be derived from the proportionality of entropy to the horizon area, together with the Clausius relation $\delta Q = T\,ds$ (Jacobson 1995; Pesci 2007). In this paper, we discuss the semi-classic state of thermodynamically properties for a low energy Kerr black hole. Our main purpose is to investigate how the semi-classic approximation affect the thermodynamics of the Kerr-Sen black hole and corrected terms classical action and entropy.

One way to generalize the ordinary black hole is to allow it to carry gauge charge and angular momentum. In this paper we will describe the main facts about charged

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