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ORIGINAL ARTICLE

Quantum corrections for ABGB black hole

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Abstract In this paper, we study quantum corrections to the temperature and entropy of a regular Ayón-Beato-García-Bronnikov black hole solution by using tunneling approach beyond semiclassical approximation. We use the first law of black hole thermodynamics as a differential of entropy with two parameters, mass and charge. It is found that the leading order correction to the entropy is of logarithmic form. In the absence of the charge, i.e., $e = 0$, these corrections approximate the corresponding corrections for the Schwarzschild black hole.

Keywords Black holes · Semiclassical entropy · Quantum tunneling

1 Introduction

General Relativity describes that black hole (BH) absorbs all the light that hits the horizon, reflecting nothing, just like a perfect black body in thermodynamics. Hawking (1974) suggested that BH like a black body with a finite temperature, emits radiation from the event horizon by using quantum field theory in curved spacetime, named as Hawking radiation. Several attempts (Hartle and Hawking 1976; Gibbons and Hawking 1977) have been made to visualize the Hawking radiation spectrum by using quantum mechanics of a scalar particle. However, tunneling (Parikh 2004; Parikh and Wilczek 2000; Srinivasan and Padmanabhan 1999) provides the best way to visualize the source of radiation. The essential idea of the tunneling mechanism is that a particle-antiparticle pair is formed close to the horizon inside a BH. According to this phenomenon, in the presence of electric field, particles have the ability to penetrate energy barriers by following trajectories (not allowed classically).

When a particle with positive energy crosses the horizon, it appears as Hawking radiation. When a particle with negative energy tunnels inwards, it is absorbed by the BH, hence its mass decreases and ultimately vanishes. Similarly, motion of the particle may be in the form of outgoing or ingoing radial null geodesics. For outgoing and ingoing motion, the corresponding action becomes complex and real respectively, whereas classically a particle can fall behind the horizon. The emission rate of the tunneling particle from the BH is associated with the imaginary part of the action which, in turn, is related to the Boltzmann factor for the emission at the Hawking temperature.

Cognola et al. (1995) investigated the first quantum correction to the entropy for an eternal $4D$ extremal Reissner-Nordström (RN) BH by using the conformal transformation techniques. Bytsenko et al. (1998a) suggested that the Schwarzschild-de Sitter BH could be generated due to back-reaction of dilaton coupled matter in the early universe, which is the solution of quantum corrected equations of motion. Bytsenko et al. (1998b) evaluated the first quantum correction to the Bekenstein-Hawking entropy by using Chern-Simmons representation of the $3D$ gravity. Bytsenko et al. (2001) calculated the first quantum correction to the finite temperature partition function for a self-interacting massless scalar field by using dimensional regularization zeta-function techniques.

Elizalde et al. (1999) investigated the existence of a quantum process (anti-evaporation) opposite to the Hawking radiation (evaporation) as an evidence for supersym-

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