Astrophys Space Sci (2013) 348:437–440
DOI 10.1007/s10509-013-1571-6

ORIGINAL ARTICLE

Corrected Hawking temperature of (2 + 1) dimensional BTZ (Banados-Teitelboim-Zanelli) rotating Black Hole by using tunneling method

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Received: 5 May 2013 / Accepted: 16 July 2013 / Published online: 13 August 2013

Abstract We study the $(2+1)$ dimensional BTZ (Banados-Teitelboim-Zanelli) rotating Black Hole. Along with the scalar field it obeys the Klein-Gordon equation of motion. We use the dragging coordinate system to isolate the r–t sector from the metric. By considering the massless particle and scalar field, we calculate the corrected Hawking temperature with the help of tunneling method.

Keywords Black Hole · Classical theories of gravity · Hawking temperature

1 Introduction

Bekenstein (1973) was the first to conjecture that there is a fundamental relationship between the properties of Black Holes and the laws of thermodynamics. Hawking strengthened this conjecture by showing that Black Holes can radiate when quantum effects are taken into account (Hawking 1975; Gibbons and Hawking 1977a, 1977b). Black Holes can emit any kind of particles via thermal radiation, known as Hawking radiation. The emitted particles that have tunneled across the event horizon with a temperature is proportional to its surface gravity and its entropy is proportional to its horizon area. Recently, a semi-classical method of controlling Hawking radiation as a tunneling effect has been developed (Shankaranarayanan et al. 2001; Parikh and Wilezek 2000; Kerner and Mann 2006; Mirza and Sherkatghanad 2011). This method is a particularly interesting method for calculating Black Hole temperature since it provides a dynamical model of the Black Hole radiation. In the tunneling approach, the particles are allowed to follow classically forbidden trajectories in a co-ordinate system which is well-behaved at the horizon. The tunneling probability for the classically forbidden trajectory from inside to outside the event horizon is related to the Boltzmann factor for emission at the Hawking temperature T_H i.e. $\Gamma \propto e^{-2I_m I} = e^{-E/T_{H,}}$ (Parikh 2004), where E is the energy of the tunneling particles and I is the action for the trajectory. To calculate the imaginary part I_m of the action for the emitted particles, the complex path method or Hamilton-Jacobi method is used frequently.

Recently Mirza and Sherkatghanad (2011) studied the AdS rotating Black Hole solution for the BHT (Bergshoeff-Hohm-Townsend) massive gravity in three dimensions. They have calculated the corrected entropy of the rotating Black Hole solution of the new massive gravity using tunneling method and Cardy formula. Tunneling method was also used by Banerjee and Modak (2009) to evaluate the corrected entropy for Lovelock Black Holes. Misra and Mahanta (2013) have calculated the corrected Hawking temperature for the Warped AdS_3 rotating Black Hole by tunneling method. Shankaranarayanan et al. (2002) obtained the corrected temperature associated with the Hawking radiation in different coordinate systems by applying the Hamilton-Jacobi method for the Schwarzschild space-time. Robinson and Wilczek (2005) proposed a new derivation of Hawking radiation via gravitational anomaly at the horizon of a Schwarzschild type Black Hole. Motivated by Robinson and Wilczek's view point that Hawking radiation can be treated as a compensating energy-momentum flux required to cancel gravitational anomaly at the horizon of

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