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ORIGINAL ARTICLE

Quantum gravity effects on the radiation of a stimulated emission from quantum black holes

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Abstract In the recent interest to the quantum black hole spectroscopy, we calculate the quantum gravity effects to Hawking radiation. In the view of our calculation, the quantum black hole radiation is a stimulated emission.

Keywords Quantum black hole · Stimulated emission radiation · Hawking temperature

1 Introduction

In the canonical quantum gravity, the character of the Hawking radiation is modified when quantum gravity effects are properly taking into account, even for non-rotating, neutral and very massive black hole with respect to the Planck scale. To study the quantum gravity effects in a quantum black hole, one can take into account the generalized uncertainty principle. In this article, we concentrate on the quantum gravity effects of a quantum black hole that considered by many of authors: Adler et al. (2001), Setare (2004c, 2006), Nouicer (2007), Myung et al. (2007), Farmany et al. (2008), Dehghani and Farmany (2009) and Farmany and Dehghani (2010). First, we begin with a fundamental frequency from energy spacing between consecutive levels. In Sect. 3 we review the relation between generalized uncertainty principle and the energy-time uncertainty. Finally we show that the Hawking radiation will be emits as stimulated emission in the quantum black holes. Conclusion and suggestions are in the final section.

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2 A fundamental frequency from energy spacing between consecutive levels

In canonical quantum gravity the area of the non-rotating neutral black hole is quantized as (with $G = c = 1$),

$$A = \alpha n \hbar \tag{1}$$

where n is the energy level. The thermal character of the black hole radiation is entirely due to the degeneracy of the levels. Same degeneracy's become manifest as black hole entropy (Bekenstein 2002; Jiang et al. 2010; Majhi 2010; Banerjee et al. 2010; Jadhav and Burko 2009; Drasco 2009; van den Broeck and Sengupta 2007; Dappiaggi and Raschi 2006; Dreyer et al. 2004; Setare 2004a, 2004b; Bekenstein and Mukhanov 1995). With setting $g(n)$ as multiplicity of degeneracy, Bekenstein and Mukhanov (1995) found that in the level $n = 1$, $g(1) = 1$, and in this level ($n = 1$) the black hole entropy is zero. Here the general form of multiplicity degenerate (energy level) is $g(n) = e^{\alpha(n-1)/4}$, where, $\alpha = 4\ln k$, and, $k = 2, 3, 4, \dots$ putting $k = 2$, we can obtain, $\alpha = 4\ln 2$. The energy spacing between consecutive levels for $M \gg \hbar$ corresponds to the fundamental frequency (Bekenstein and Mukhanov 1995)

$$\bar{w} = \frac{\ln 2}{8\pi M} \tag{2}$$

A quantum black hole can decays during interval of observer time Δl by a sequence of integers $\{n_1, n_2, \dots, n_j\}$, of length j. During Δl, the black hole first jumped down to n_1 elementary levels in one ago, then n_2 level, etc. In this process the black hole emit a quantum of some species of energy $n_1\hbar\bar{w}$, then a quantum of energy $n_2\hbar\bar{w}$, etc. Each one of the j quanta carries the energy $2\hbar\bar{w}$. In average, during Δl, the mass of black hole decreases by Bekenstein and Mukhanov (1995)

$$d\langle M\rangle/dt = -2\hbar\bar{w}\Delta t/\tau \tag{3}$$