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ORIGINAL ARTICLE

# Modified dispersion relation and classically forbidden s-wave emission across the horizon

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**Abstract** The classically forbidden s-wave emission of the horizon is studied in this work. The modified dispersion relation was used to obtain the quantum gravity effects. It is shown that the s-wave emission rate across the horizon is modified.

**Keywords** Modified dispersion relation · Space time horizon · Tunneling radiation

## 1 Introduction

Hawking (1975) showed that black holes are not perfectly black, rather they radiate energy continuously. Recently, the semiclassical analysis of this phenomenon carried out by Parikh and Wilczek. Parikh-Wilczek proposal of black hole tunneling radiation is based on the computation of incoming part of action for classically forbidden of s-wave emission across the horizon (Parikh and Wilczek 2000; Parikh 2002, 2004a, 2004b; Kraus and Wilczek 1994, 1995a, 1995b; Kraus and Keski-Vakkuri 1997; Berezin et al. 1999; Calogeracos and Volovik 1999). As a comparison between Hawking original calculation and tunneling method, it is easy to see that the hawking method is a direct method but its complication to generalization to all other space times is failed.

Tunneling model is applied to not only the black hole event horizon, but also to the cosmological horizon (Parikh 2002; Medved 2002; Sekiwa 2008). The black hole tunneling method was studied in different space-times and different frames and the time contribution to the black hole radiation is developed in Chowdhury (2008), Akhmedov et al. (2006a, 2006b, 2007, 2008a, 2008b), Pilling (2008), Zhang et al. (2009), Banerjee and Majhi (2009a, 2009b). In continue, the spectrum form of the tunneling mechanism is analyzed using the density matrix technique (Banerjee and Majhi 2009a, 2009b). However the Parikh-Wilczek method is based on the classical analysis, when it comes into the high-energy regime, for example a small black hole whose size can be compared with Planck scale, the effect of quantum gravity should not be forbidden. In this case, the conventional semiclassical approaches are not proper and the complete quantum gravity analysis is required. To study the quantum gravitational effects on the tunneling mechanism it is interesting to relate the analysis under a minimal length quantum gravity scale (Adler et al. 2001; Han et al. 2008; Farmany et al. 2008; Shu and Shen 2008; Wang et al. 2008; Setare 2004; Nouicer 2007; Zhao and Zhang 2006; Xiang 2006; Dehghani and Farmany 2009; Ashtekar and Krishnan 2003; Maggiore 1994; Yoneya 2000).

However study of the quantum gravity effects on the hawking particle by generalized space-time uncertainty relation is not a direct method because we need to calculate the total uncertainty in the energy. A direct and simple method for this reason is using a generalized form of time energy uncertainty or modified dispersion relation. In this article, using a general form of modified dispersion relation, the classically forbidden s-wave emission rate of the horizon is analyzed carefully.

Tunneling approaches are based on the fact that the WKB approximation of tunneling probability of classical forbidden trajectory from inside to outside of the horizon (Akhme-

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