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ORIGINAL ARTICLE

Tunneling of massive and charged particles from noncommutative Reissner-Nordström black hole

Kourosh Nozari · Sara Islamzadeh

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Abstract Massive charged and uncharged particles tunneling from commutative Reissner-Nordström black hole horizon has been studied with details in literature. Here, by adopting the coherent state picture of spacetime noncommutativity, we study tunneling of massive and charged particles from a *noncommutative* inspired Reissner-Nordström black hole horizon. We show that Hawking radiation in this case is not purely thermal and there are correlations between emitted modes. These correlations may provide a solution to the information loss problem. We also study thermodynamics of noncommutative horizon in this setup.

Keywords Black hole · Noncommutative geometry · Quantum tunneling

1 Introduction

After the discovery of Hawking radiation (Hawking 1974), a lot of attempts have been made to explore different aspects of this revolutionary achievement. There are some important questions in this regard: Is black hole radiation purely thermal? Are unitary and Lorentz invariance symmetries preserved at the quantum gravity level? What happens in the final stages of black hole evaporation? Are the information that were entered horizon at the time of star formation missing? Although, there is no perfect theory by now to answer these questions properly, various methods are presented to address such questions in recent years. One of these attempts is the strategy provided by Parikh and Wilczek (2000). In this approach, particle and antiparticle pairs are created and the particle tunnels through event horizon. Due to emission of this particle, total energy of black hole reduces. Conservation of energy requires that the event horizon radius reduces too. To deduce the black hole event horizon thermodynamics, Parikh and Wilczek utilized the WKB approximation. This approximation is actually justified since there is an infinite blue shift in the vicinity of the horizon. Indeed, the barrier through which tunneling occurs is induced by the emitted particle itself. They have considered the tunneling particle as a spherically symmetric shell that is ejected from black hole surface. This approach was the basis of a lot of research programs then after. Tunneling of massless (Arzano et al. 2005; Nozari and Mehdipour 2008a) and massive (Zhang and Zhao 2005) particles from Schwarzschild black hole and also noncommutative inspired Schwarzschild black hole (Nozari and Mehdipour 2008b; Miao et al. 2012) are studied. Recently, tunneling of massive and charged particles from Reissner-Nordström black hole horizon is reported too (Miao et al. 2011). Also extensions to higher dimensional spacetime models are considered by some authors (Rizzo 2006; Nozari and Mehdipour 2009, 2010).

In recent years noncommutative quantum field theory has been attracted much attentions (Snyder 1974; Seiberg and Witten 1999; Douglas and Nekrasov 2001; Szabo 2003; Chaichian et al. 2003; Micu and Sheikh-Jabbari 2001). Noncommutativity is an intrinsic characteristic of manifold that implies the existence of a natural ultra-violet cutoff (or equivalently a minimal measurable length) in quantum field theory. Spacetime noncommutativity can be achieved natu-

K. Nozari (✉)
Research Institute for Astronomy and Astrophysics of Maragha (RIAAM), P.O. Box 55134-441, Maragha, Iran
e-mail: knozari@umz.ac.ir

S. Islamzadeh
Department of Physics, Faculty of Basic Sciences, University of Mazandaran, P.O. Box 47416-95447, Babolsar, Iran
e-mail: s.islamzadeh@stu.umz.ac.ir