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ORIGINAL ARTICLE

Hawking radiation from a dielectric black hole

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Abstract Using the new global embedding approach and analytical continuation method of wave function we discuss Hawking radiation of acoustic black holes. Unruh/Hawking temperature of the dielectric black hole is derived. The corresponding relation among these methods that calculate Hawking radiation of dielectric black hole is established. Our result shows that these methods are equivalent.

Keywords Dielectric black hole · Hawking radiation · Global embedding approach · Unruh/Hawking temperature

1 Introduction

The Hawking radiation of black hole is one of the most interesting effects which arise from the combination of quantum mechanics and general relativity. It is a quantum effect of gravity, therefore it is quite important to understand the Hawking radiation of black hole in order to obtain a consistent quantum theory of gravity. So the research on Hawking radiation is very meaningful (Hawking 1975; Damour and Ruffini 1976; Sannan 1988; Parikh and Wilczek 2010; Robinson and Wilczek 2005; Iso et al. 2006a; Zhang and Liu 2007; Liu and Liu 2008; Li et al. 2008; Umetsu 2008; Banerjee and Majhi 2009a; Banerjee and Kulkarni 2009; Banerjee and Modak 2009; Papantonnopoulos and Skamagoulis 2009; Zhao et al. 2009; Banerjee et al. 2010a; Zhao et al. 2010; Zhai and Liu 2010; Ghosh and Sengupta 2011; Saleh et al. 2011; Ibohal and Ibungochouba 2011). Unfortunately, it is quite difficult to observe the Hawking radiation of black hole because the Hawking temperature of black hole is so low that any experiments cannot reach such low temperature. For example, for a Schwarzschild black hole with the same order of magnitude compared with solar mass, its radiation temperature just is 10^{-7} K. Therefore, in the laboratory Hawking effect is investigated by simulated black holes (Unruh 1981; Belgiorno et al. 2010a, 2010b; Faccio et al. 2010; Schutzhold and Unruh 2011; Philbin et al. 2008; Belgiorno et al. 2011).

The quanta of this field will then be excited according to the prediction of Hawking. On these basis, a number of analogue systems have been proposed, for the first time by Unruh (1981) and later by other researchers (see e.g. Barcelo et al. 2005 and references therein), which aim at reproducing some aspects of the kinematics of gravitational systems. Most of these analogies rely on acoustic perturbations and on the realization of so-called dumb holes: a liquid or gas medium is made to flow faster than the acoustic waves in the same medium so that at the transition point between sub and supersonic flow, a trapping horizon is formed that may be traversed by the acoustic quanta, viz. phonons, only in one direction (Unruh 1981). Unfortunately the phonon blackbody spectrum is expected to still have very low temperatures, thus eluding direct detection (see e.g. Macher and Parentani 2009).

Recently, Belgiorno et al. (2010a, 2011) consider a 4D model for photon production induced by a refractive index perturbation (RIP) in a dielectric medium. In a nonlinear Kerr medium, there is a constant velocity v in the x direction and infinitely extended in the transverse y and z directions. In the Eikonal approximation, the model is embodied in a suitable wave for the generic component of the electric field propagating in the nonlinear medium affected by the RIP. Describe this propagation as taking place in an analogue spacetime metric written in the pulse frame, where the metric is static and displays two horizons x_+ and x_- for

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