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ORIGINAL ARTICLE

Interacting modified holographic dark energy in Kaluza-Klein universe

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Abstract The interaction of modified holographic dark energy and dark matter with varying G in flat Kaluza Klein universe is considered. Further, we take infrared cutoff scale L as future event horizon. In this scenario, equations of state parameter as well as evolution are explored. We also check the validity of the generalized second law of thermodynamics. It is interesting to mention here that our results show consistency with the present observations.

Keywords Kaluza-Klein cosmology · Modified holographic dark energy · Dark matter · Generalized second law of thermodynamics

1 Introduction

It is believed that our universe has entered in an accelerated expansion phase and experienced a large negative pressure (Riess et al. 1998; Perlmutter et al. 1999; Fedeli et al. 2009; Caldwell and Doran 2004). The force responsible for driving the universe apart is some cosmological antigravity substance known as the mysterious dark energy (DE). Although 75 percent of the mass-energy content of our universe contains this type of DE but its nature is still speculative. One usually characterizes the DE phenomena with equation of state (EoS) parameter ω (the ratio of pressure to energy density): ω lying in the range $(-1, -1/3)$ describes quintessence DE era, $\omega = -1$ represents DE due to cosmological constant consistent with current observations (Davis et al. 2007), while it may be $\omega < -1$, the phantom case (which can lead to a future unavoidable singularity of space-time).

The simplest candidate of DE is the cosmological constant but it faces some serious problems (Weinberg 1989, 2000) like 'fine tuning problem' (unusual small value) and 'coincidence problem' (why DE and DM are of the same order today even though universe is expanding?). The dynamical DE scenario is an alternative way to alleviate or even solve these problems. So far, a plethora of dynamical DE models has been proposed by physicist which are classified into two categories: scalar field models containing quintessence (Ratra and Peebles 1988), phantom (Caldwell 2002; Carroll et al. 2003), k-essence (Armendariz-Picon et al. 1999, 2001; Chiba et al. 2000), tachyon (Padmanabhan 2002; Bagla et al. 2003), quintom (Feng et al. 2005) and the interacting DE models (interaction of DE with DM) including family of Chaplygin gas (Kamenshchik et al. 2001; Bento et al. 2002; Zhang et al. 2006), braneworld (Deffayet et al. 2002; Sahni and Shtanov 2003), holographic DE (HDE) (Hsu 2004; Li 2004), new agegraphic DE models (Cai 2007), etc. These possibilities reflect the indisputable fact that the true nature and origin of DE has not been convincingly explained yet.

In the aforementioned candidates of DE, holographic dark energy is one of the marvelous attempts to examine the nature of DE in the framework of quantum gravity. It is based on holographic principle (Susskind 1995) which states that *all the information relevant to a physical system inside a spatial region can be observed on its boundary instead of its volume*. The main feature of this DE is that it links DE density to the cosmic horizon (a global property of the universe). Cohen et al. (1999) argued that the quantum zero-point en-

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