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ORIGINAL ARTICLE

Correspondence between $f(G)$ gravity and holographic dark energy via power-law solution

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Abstract In this paper, we discuss cosmological application of holographic Dark Energy (HDE) in the framework of $f(G)$ modified gravity. For this purpose, we construct $f(G)$ model with the inclusion of HDE and a well-known power law form of the scale factor $a(t)$. The reconstructed $f(G)$ is found to satisfy a sufficient condition for a realistic modified gravity model. We find quintessence behavior of effective equation of state (EoS) parameter ω_{DE} through energy conditions in this context. Moreover, we observe that the squared speed of sound v_s^2 remains negative, which indicates the instability of HDE $f(G)$ model.

Keywords $f(G)$ gravity · Holographic dark energy · Correspondence · Stability

1 Introduction

Accelerated expansion of the universe is now well established thanks to many observations (Spergel et al. 2003; Perlmutter et al. 1999). It is suggested in the studies that the universe exhibits spatially flat scenario and contains dark energy (DE) with negative pressure as a major component and of dust matter consisting of cold dark matter (CDM) plus baryons. The contribution of radiation can be considered practically negligible. In order to understand the DE nature, it is required to clarify if it produced by a cosmological constant (Λ) or by a form of dynamical model. The dynamical DE models can be differentiated from the cosmological constant through the tool of EoS parameter $w_{DE} = p_{DE}/\rho_{DE}$, where the numerator and denominator indicate, respectively, the pressure and the energy density of DE.

Several candidates of DE have been proposed (see for example Copeland et al. 2006). It was shown through the data analysis of SNeIa that these dynamical models provide more consistency with present scenario of the universe as compare to Λ. A detailed analysis of DE can be found in Li et al. (2011). The development in the study of black hole theory and string theory results the holographic principle which states that *the number of degrees of freedom of a physical system should be finite, it should scale with its bounding area rather than with its volume and it should be constrained by an infrared cut-off.*

The Holographic DE (HDE) is one of the most interesting dynamical model and it is based on the holographic principle proposed by Fischler and Susskind (1998). HDE has been constrained and tested by various astronomical schemes and with the help of the anthropic principle (Huang and Li 2005). By the inclusion of holographic principle into cosmology, it can be found the upper bound of the entropy contained in the universe. Through this bound, Li (2004) proposed the following constraint on the DE density:

$$\rho_{DE} = 3c^2 M_p^2 L^{-2}, \tag{1}$$

where c^2, L and $M_p = (8\pi G)^{-1/2} = 10^{18}$ GeV (with G being the gravitational constant) indicates a numerical con-

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