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ORIGINAL ARTICLE

Holographic dark energy model with linearly varying deceleration parameter and generalised Chaplygin gas dark energy model in Bianchi type-I universe

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Abstract The paper deals with a spatially homogeneous and anisotropic Bianchi type-I universe filled with two minimally interacting fluids; matter and holographic dark energy components. The nature of the holographic dark energy for Bianchi type-I space time is discussed. An exact solution to Einstein's field equations in Bianchi type-I line element is obtained using the assumption of linearly varying deceleration parameter. Under the suitable condition, it is observed that the anisotropy parameter of the universe approaches to zero for large cosmic time and the coincidence parameter increases with increasing time. We established a correspondence between the holographic dark energy models with the generalised Chaplygin gas dark energy model. We also reconstructed the potential and dynamics of the scalar field which describes the Chaplygin cosmology. Solution of the field equations shows that a big rip type future singularity will occur for this model. It has been observed that the solutions are compatible with the results of recent observations.

Keywords Bianchi type-I space time · Linearly varying deceleration parameter · Holographic dark energy · Generalised Chaplygin gas dark energy model and big rip singularity

1 Introduction

Recently, the most remarkable observational discoveries of distant type-Ia supernovae and cosmic microwave background have shown that our universe has entered a phase of accelerated expansion in the recent past (Perlmutter et al. 1998; Riess et al. 1998; Bennett et al. 2003). These observations have made it clear that the current matter-energy density of the universe is close to its critical value of which 30 % is attributed to relativistic matter, including both baryons and dark matter and 70 % to dark energy (Ade et al. 2013). The cause of sudden transition from the earlier deceleration phase to the recent acceleration phase and the source of accelerated expansion are still unknown. According to the Einstein's theory of general relativity, the cause of such acceleration, one needs to introduce a component to the matter distribution of the universe with a large negative pressure and makes up about three quarters of the total cosmic density. This exotic type of unknown repulsive force is termed as dark energy (DE). Recently many radically different models have been proposed to satisfy the present value of DE. The simplest candidate for DE is the cosmological constant (Λ) with equation of state parameter $\omega = -1$ since it fits the observational data well, but it needs to be extremely fine-tuned to satisfy the current value of DE (Copeland et al. 2006). At present Λ with a dynamical character is preferred over a constant Λ to solve cosmological constant problem especially a time dependent Λ which has decreased slowly from its large initial value to reach its present small value (Overduin et al. 1998).

To further investigate the properties of dark energy, many dynamical dark energy models have been proposed such as quintessence with EoS $\omega > -1$ (Barreiro et al. 2000), phantom with EoS $\omega < -1$ (Caldwell 2003), tachyon (Bagla et al. 2003; Sen 2002; Padmanabhan and Choudhury 2002), k-essence (Armendariz et al. 2001), dilatonic ghost condensate (Gasperini et al. 2002), quartessence (Leon et al. 2010) and so forth. The cosmic viscosity is also an effective quantity as caused mainly by the non-perfect cosmic contents interactions and may play a role as dark en-

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