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ORIGINAL ARTICLE

Functional form of $f(R)$ with power-law expansion in anisotropic model

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Abstract In this paper, we study an anisotropic Bianchi-I space-time model in $f(R)$ theory of gravity in the presence of perfect fluid as a matter contains. The aim of this paper is to find the functional form of $f(R)$ from the field equations and hence the solution of various cosmological parameters. We assume that the deceleration parameter to be a constant, and the shear scalar proportional to the expansion scalar to obtain the power-law form of the scale factors. We find that the model describes the decelerated phases of the universe under the choice of certain constraints on the parameters. The model does not show the acceleration expansion and also transition from past deceleration to present accelerating epoch. We discuss the stability of the functional form of $f(R)$ and find that it is completely stable for describing the decelerating phase of the universe.

Keywords $f(R)$ gravity · Anisotropic models

1 Introduction

The recent developments in cosmology with the observations such as Ia supernova (Riess et al. 1998, 1999; Perlmutter et al. 1999; Tonry et al. 2003), cosmic microwave background anisotropy (Spergel et al. 2003), large scale structure (Tegmark et al. 2004; Seljak et al. 2005; Percival et al. 2007; Kamatsu et al. 2009), baryon oscillation (Eisenstein et al. 2005) and weak lens (Jain and Taylor 2003) have led to the conclusion that the universe is accelerating in the current epoch. It has been observed that a fluid known as dark energy (DE) with large negative pressure is responsible for this acceleration. Many DE models have been proposed to explain the cosmic accelerated expansion (Copeland et al. 2006). A cosmological constant Λ responsible for acceleration is the simplest candidate of DE (Sahni and Starobinsky 2000; Padmanabhan 2003), which so far best fits with the observational data. However, the observed value of the cosmological constant is much smaller (10^{120} orders of smaller magnitude) than any other energy (vacuum energy) predicted by quantum physics (Peebles and Ratra 2003; Carroll 2001). This problem is known as fine-tuning problem in cosmology. Therefore, there is no guiding principle for construction of a promising model of cosmological constant.

The second alternative of cosmological constant, which is not stable, is a minimally coupled scalar field ϕ, usually called quintessence. These scalar fields may be responsible for a stage of accelerated expansion (Steinhardt et al. 1999; Zlatev et al. 1999). A further interesting possibility is provided by non-minimally coupled scalar field (Amendola 1999; Chiba 2003a). It is also mentioned that energy conditions are violated in all these kind of scalar fields. Also, these models end with a finite future singularity known as Big Rip. Modification of the gravity theory is an alternative approach, for example, $f(R)$ model (Capozziello et al. 2003; Nojiri and Odintsov 2003; Carroll et al. 2004). The $f(R)$ model is a modified gravity model, constructed by replacing the gravitational Lagrangian with a general function of the Ricci scalar R.

The $f(R)$ gravity provides a very natural unification of the early-time inflation and late-time acceleration. It describes the transition from deceleration to acceleration in the evolution of the universe (Nojiri and Odintsov 2007a,

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