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ORIGINAL ARTICLE

Dynamical stability in scalar-tensor cosmology

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Abstract We study FRW cosmology for a double scalar-tensor theory of gravity where two scalar fields are nonminimally coupled to the geometry. In a framework to study stability and attractor solutions of the model in the phase space, we constrain the model parameters with the observational data. For an accelerating universe, the model behaves like quintom dark energy models and predicts a transition from quintessence era to phantom era.

Keywords Scalar tensor · Stability · Attractor · Distance modulus · Phantom crossing · Quintom

1 Introduction

The acceleration expansion of the universe is supported by observations of high redshift type Ia supernovae, the surveys of clusters of galaxies (Riess et al. 1998, 2004; Pope et al. 2004), Sloan digital sky survey (SDSS) (Abazajian et al. 2005) and Chandra X-ray observatory (Allen et al. 2004). In addition, Cosmic Microwave Background (CMB) anisotropies (Bennett et al. 2003) exhibit the universe flatness (Spergel et al. 2003). The observations determines, with high precisions, the basic cosmological parameters and strongly indicates that the universe is dominated by a smoothly and slowly varying dark energy (DE) component. A dynamical equation of state (EoS) parameter that is connected directly to the evolution of the energy density in the universe and indirectly to the expansion of the Universe can be regarded as a suitable parameter to explain the universe acceleration (Seljak et al. 2005; Setare 2007). In particular, a proposal to explain the recent observations is the quintom dark energy, constructed by two scalar fields, and its EoS parameter crosses the phantom divide line (Cai et al. 2010; Sadeghi et al. 2008; Setare and Saridakis 2008, 2009a, 2009b).

Motivated from string theories, the scalar-tensor models provide the simplest model-independent description of unification theories which predict couplings between scalars and curvature. They have assumed a prominent role since any unification scheme, such as supergravity, in the weak energy limit, or cosmological models of inflation such as chaotic inflation, seem to be supported by them (Capozziello and Lambiase 2000). In addition, they have been employed to study the current acceleration of the universe (Sahoo and Singh 2002; Capozziello et al. 2003; Faraoni 2007; Nojiri and Odintsov 2004; Setare and Jamil 2010; Carroll 1998).

In this paper, we study the detailed dynamics of the double scalar-tensor cosmological models. Since the major difficulty in cosmological models is the nonlinearity of the field equations and thus limitation in obtaining the exact solutions, we investigate the asymptotic behavior of the model, which provides the relevant features to be compared with the current physical data available for the universe. In this context, the perturbation methods, especially linear stability analysis which have been used to study the qualitative analysis of the equations and of the long term behavior of the solutions are being proposed in this work (Farajollahi and Salehi 2010, 2011a, 2011b; Farajollahi et al. 2011a, 2011b; Farajollahi and Milani 2011; Chen and Kao 2001). Section 2 is devoted to a detailed formulation of the model. In Sect. 3, we obtain the autonomous equations of the model and the

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