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ORIGINAL ARTICLE

Non-singular cosmology using tachyon and general non-minimal kinetic coupling

A. Banijamali · B. Fazlpour

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Abstract The bounce with non-minimal coupling is very interesting topic because in the early time, general relativity is likely to be modified, which can give some valuable effects to the evolution of our universe. In this paper we introduce a string-inspired model for bouncing universe, utilizing the tachyon field as well as contributions from general non-minimal kinetic couplings and curvature. It is shown numerically that the bouncing solution appears in the model whereas the equation of state (EoS) parameter crosses the phantom divider.

Keywords Bouncing universe · Non-minimal derivative coupling · Tachyon field

1 Introduction

Inflation is a period of accelerated expansion in the early universe which has been confirmed by cosmological observations (Spergel et al. 2003). It occurs when the energy density of the universe is dominated by the potential energy of some scalar field called inflaton (Guth 1981). Although, inflation has great successes such as solving the flatness, horizon and homogeneity problems (Linde 1990) but it suffers from the crucial problem of the initial singularity (Borde et al. 2003) and hence cannot give complete descriptions of the early universe. The existence of an initial singularity is disturbing, because the space-time description breaks down "there".

A successful solution of the cosmological singularity problem may be provided by non-singular bouncing cosmology which has been proposed a long time ago (Tolman 1931). Bouncing cosmologies can be divided into the following categories: the first consists of models with modifications to Einstein's theory of general relativity (Mukhanov and Brandenberger 1992; Brandenberger et al. 1993), such as the brane world models (Borde and Vilenkin 1994), Pre-Big-Bang (Veneziano 1991; Gasperini and Veneziano 1993) and the Ekpyrotic models (Khoury et al. 2001, 2002), $f(T)$ gravity in which gravity is described by an arbitrary function of the torsion scalar (Cai et al. 2011), higher derivative gravity actions (Brustein and Madden 1998; Biswas et al. 2006), non-relativistic gravitational actions (Brandenberger 2009; Cai and Saridakis 2009; Saridakis 2010) or loop quantum cosmology (Bojowald 2001). The second based on using a kind of matter field that violates the null energy condition (see Novello and Bergliaffa 2008 for review). Bouncing cosmologies can also be inspired by string theory when the string gas cosmology (Brandenberger and Vafa 1989; Brandenberger 2008) embed in a bouncing universe (Biswas et al. 2007).

Furthermore, bouncing cosmology for a homogeneous and isotropic universe can lead to the matter bounce scenario. Non-conventional fluids (Bozza and Veneziano 2005; Peter and Pinto-Neto 2002), non-minimally coupled scalar fields to gravity (Qiu and Yang 2010; Qiu 2010) and ghost condensates (Buchbinder et al. 2007; Creminelli and Senatore 2007; Lin et al. 2011) are belong to this sort of bouncing cosmology and the simplest type of the matter bounce cosmology is the quintom bounce model (Cai et al. 2007, 2008, 2009a, 2009b; Cai and Zhang 2009; Liu et al. 2010).

A. Banijamali
Department of Basic Sciences, Babol University of Technology, Babol, Iran
e-mail: a.banijamali@nit.ac.ir

B. Fazlpour (✉)
Young Researchers Club, Ayatollah Amoli Branch, Islamic Azad University, Amol, Iran
e-mail: b.fazlpour@umz.ac.ir