Astrophys Space Sci (2013) 345:421–425
DOI 10.1007/s10509-013-1404-7

ORIGINAL ARTICLE

The phase space of quintom cosmology

A. Nikjou · R. Baghbani · M.T. Darvishi · F. Khani

Received: 30 December 2012 / Accepted: 23 February 2013 / Published online: 5 March 2013

Abstract The properties of quintom model are investigated in the isotropic and homogeneous universe as a dynamical system dominated by dark energy including the phantom and quintessence fields. A general discussion about the phase space of spatially non-flat universe is presented. We study the results for the later times without assuming the specific form of the potential. Then, we exhibit an obvious structure for the dynamics of the system.

Keywords Phantom field · Scalar field · Kinetic term · Exponential potential · Quintom field

1 Introduction

One of the most important problems of cosmology, is the problem of so-called dark energy (DE). The type Ia supernova observations suggests that the universe is dominated by dark energy with negative pressure which provides the dynamical mechanism of the accelerating expansion of the universe (Perlmutter et al. 1999; Garnavich et al. 1998; Riess et al. 1998). The strength of this acceleration is presently matter of debate, mainly because it depends on the theoretical model implied when interpreting the data. Most of these models are based on dynamics of a scalar or multi-scalar fields (e.g quintessence (Ratra and Peebles 1988; Wetterich 1988; Zlatev et al. 1999; Steinhardt et al. 1999) and quintom model of dark energy, respectively). Primary scalar field candidate for dark energy was quintessence scenario, a fluid with the parameter of the equation of state lying in the range, $-1 < w < -1/3$. While the most model independent analysis suggest that the acceleration of the universe to be below the de Sitter value (Daly and Djorgovsky 2003; John 2004; Nesserisand and Perivolaroupolos 2004; Wang and Tegmark 2005), it is certainly true that the body of observational data allows for a wide parameter space compatible with an acceleration larger than the de Sitter's (Caldwell et al. 2003; Hannestad and Mörtsell 2004; Xia et al. 2006). If eventually this proves to be the case, the fluid driving the expansion would violate not only the strong energy condition $\rho + 3P > 0$, but the dominate energy condition $\rho + P > 0$, as well. Fluids of such characteristic dubbed phantom fluid (Caldwell 2002). In spite of the fact that the field theory of phantom fields encounter the problem of stability which one could try to bypass by assuming them to be effective fields (Carroll et al. 2003; Gibbons 2003; Schulz and White 2001; Caldwell et al. 2003; Dabrowski et al. 2003; Singh et al. 2003; Nojiri and Odintsov 2003a, 2003b; Nojiri et al. 2006; Guo et al. 2004), it is nevertheless interesting to study their cosmological implication. Recently there are many relevant studies on phantom energy (Meng and Wang 2003; Johri 2003; Sami and Toporensky 2003; Szydlowski 2004; Lima and Alcaniz 2004; Bouhmadi-Lopez and Madrid 2004; Chimento and Lazkoz 2004; Wei and Tian 2004; Onemli and Woodard 2004; Gonzalez-Diaz and Siguenza 2004; Gonzalez-Diaz 2004; Wei 2004; Nojiri and Odintsov 2005a, 2005b; Capozziello et al. 2006). The analysis of the properties of dark energy from recent observations mildly favor models with w crossing -1 in the near past. But, neither quintessence nor phantom can fulfill this transition. In the quintessence model, the equation of state $w = p/\rho$ is always in the range $-1 \leq w \leq 1$ for

A. Nikjou · R. Baghbani
Department of Physics, Payam Noor University,
P.O. BOX 19395-4697, Tehran, Iran

M.T. Darvishi · F. Khani (✉)
Department of Mathematics, Razi University, Kermanshah 67149, Iran
e-mail: farzad_khani59@yahoo.com