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ORIGINAL ARTICLE

Cosmological dynamics of a non-minimally coupled bulk scalar field in DGP setup

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Abstract We consider cosmological dynamics of a canonical bulk scalar field, which is coupled non-minimally to 5-dimensional Ricci scalar in a DGP setup. We show that presence of this non-minimally coupled bulk scalar field affects the jump conditions of the original DGP model significantly. Within a superpotential approach, we perform some numerical analysis of the model parameter space and consider bulk-brane energy exchange in this setup. Also we show that the normal, ghost-free branch of the DGP solutions in this case has the potential to realize a self-consistent phantom-like behavior and therefore explains late time acceleration of the universe in a consistent way.

Keywords Braneworld cosmology · Induced gravity · Bulk scalar field · Superpotentials · Phantom-like behavior

1 Introduction

According to the recent cosmological observations, our universe is undergoing an accelerating phase of expansion and transition to the accelerated phase has been occurred in the recent cosmological past (Riess et al. 2004; Perlmutter et al. 1999; Riess 2004; Astier et al. 2006; Wood-Vasey et al. 2007; Spergel 2007; Hinshaw 2007; Colless et al. 2001; Tegmark et al. 2004; Cole et al. 2005; Springel et al. 2006; Boughn and Crittenden 2004; McEwen et al. 2007; Komatsu et al. 2009). The simplest way to describe the accelerated expansion of the universe is to adopt a cosmological constant. However, huge amount of fine-tuning required for its magnitude and other theoretical problems such as unknown origin and lake of dynamics make it unfavorable for cosmologists (Padmanabhan 2003; Carroll 2001). So, to explain this remarkable behavior of the universe, many theoretical approaches have been proposed in recent years (Copeland et al. 2006; Nojiri and Odintsov 2004a, 2006a; Caldwell 2002; Piazza and Tsujikawa 2002; Wei and Cai 2006; Vikman 2005; Anisimov et al. 2005; Wang et al. 2005; Elizalde et al. 2005; Zhao and Zhang 2006; Alam et al. 2004; Sami 2009a, 2009b; Caldera-Cabral et al. 2009; Sahni 2004a, 2004b; Sahni and Starobinsky 2006; Zhang 2009; Cai et al. 2010; Capozziello et al. 2003; Nojiri and Odintsov 2004b, 2003a, 2003b, 2006b, 2007, 2008, 2009; Sotiriou and Faraoni 2010; Bamba et al. 2008, 2009; Carroll et al. 2004; Amendola et al. 2007; Sawicki and Hu 2007a, 2007b; De Felice and Tsujikawa 2010).

Other alternative approaches to accommodate dark energy are modification of general relativity by considering additional spatial dimensions (Arkani-Hamed et al. 1998, 1999; Antoniadis et al. 1998; Randall and Sundrum 1999a, 1999b; Dvali et al. 2000, 2002; Dvali and Gabadadze 2001; Lue 2006). In the revolutionary braneworld viewpoint, our universe is a 3-brane embedded in an extra dimensional bulk. Standard matter and all interactions are confined on the brane; only graviton and possibly non-standard matter are free to probe the full bulk. One of the various braneworld scenarios, is the model proposed by Dvali, Gabadadze and Porrati (DGP). This setup is based on a modification of the gravitational theory in an induced gravity perspective (Dvali et al. 2000, 2002; Dvali and Gabadadze 2001; Lue 2006). This induced gravity term in the model leads to deviations from the standard 4-dimensional gravity over

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