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ORIGINAL ARTICLE

Shifted cosmological parameter and shifted dust matter in a two-phase tachyonic field universe

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Abstract We propose a model of the evolution of the tachyonic scalar field over two phases in the universe. The field components do not interact in phase I, while in the subsequent phase II, they change flavours due to relative suppression of the radiation contribution. In phase II, we allow them to interact mutually with time-independent perturbation in their equations of state, as Shifted Cosmological Parameter (SCP) and Shifted Dust Matter (SDM). We determine the solutions of their scaling with the cosmic redshift in both phases. We further suggest the normalised Hubble function diagnostic, which, together with the low- and high-redshift $H(z)$ data and the concordance values of the present density parameters from the CMBR, BAO statistics etc., constrain the strength of interaction by imposing the viable conditions to break degeneracy in 3-parameter $(\gamma, \varepsilon, \dot{\phi}^2)$ space. The range of redshifts ($z = 0.1$ to $z = 1.75$) is chosen to highlight the role of interaction during structure formation, and it may lead to a future analysis of power spectrum in this model *vis a vis* Warm Dark Matter (WDM) or ΛCDM models. We further calculate the influence of interaction in determining the age of the universe at the present epoch, within the degeneracy space of model parameters.

Keywords Dark energy · Tachyonic scalar field · Cosmological constant

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1 Introduction

The observed accelerated expansion of the universe (Riess 1998; Perlmutter 1999; Schmidt 1998) is thought to be driven by some exotic field, called dark energy, with an equation of state (EOS) very close to $w_\lambda = -1$ at the present epoch (Komatsu 2011; Percival 2001; Reid 2010). A class of scalar fields is one of the promising candidates of dark energy (Ratra and Peebles 1988; Caldwell et al. 1998; Liddle and Scherrer 1998; Padmanabhan 2003; Copeland et al. 2006; Sahni and Starobinski 2006). Among itself, tachyonic scalar field arising from string theory (Sen 2002) (for different reasons though) appears more relevant than the conventional non-relativistic scalar field in form of quintessence, and it is widely used in literature (Padmanabhan and Roy Choudhury 2002; Bagla et al. 2003; Padmanabhan 2002; Verma and Pathak 2012; Sadeghi et al. 2009; Setare 2007; Setare et al. 2008, 2009). One of its reasons is that the Lagrangian adopted in tachyonic scalar field is relativistic which is more profound and appealing than its non-relativistic counterpart.

In this paper, we propose a model of the evolution of the tachyonic field universe over two phases—namely, non-interacting (phase I) and interacting (phase II)—, respectively. The general evolution, however, may span several such phases with different intervals of time distinguishing each other in terms of their respective interaction strengths. In Sect. 2 of our present work, we investigate phase I, when the tachyonic scalar field has two components—one is radiation while the other is an unknown stuff. This later component has negative pressure and thus mimics the cosmological constant that may have caused the inflation early on during this phase. It is further decomposed into two components—true cosmological constant and matter with negative energy density but zero EOS.