Astrophys Space Sci (2013) 347:203–208
DOI 10.1007/s10509-013-1506-2

ORIGINAL ARTICLE

Turbulence accelerating cosmology from an inhomogeneous dark fluid

I. Brevik · A.V. Timoshkin · Y. Rabochaya · S. Zerbini

Received: 2 May 2013 / Accepted: 23 May 2013 / Published online: 14 June 2013

Abstract Specific dark energy models with a linear inhomogeneous time-dependent equation of state, within the framework of 4d Friedman-Robertson-Walker (FRW) cosmology, are investigated. It is demonstrated that such 4d inhomogeneous fluid models may lead to a turbulence FRW cosmology. Both one-component and two-component models from 4d inhomogeneous dark fluid models are considered. In the one-component model the universe may develop from a viscous era with, for instance, a constant bulk viscosity, into a turbulent era. In the two-component model the fluid can be decomposed into two components, one non-turbulent (ideal) and another turbulent part, obeying two different equations of state. Conditions for the appearance of the turbulent dark energy universe in terms of the parameters in the equation of state (EoS) without introducing the turbulence concept explicitly are obtained. An equivalent description in terms of an inhomogeneous fluid for the viscous Little Rip (LR) cosmology is also developed.

Keywords Turbulent cosmology · Viscous cosmology · Dark fluid

I. Brevik (✉)
Department of Energy and Process Engineering, Norwegian University of Science and Technology, 7491 Trondheim, Norway
e-mail: iver.h.brevik@ntnu.no

A.V. Timoshkin
Tomsk State Pedagogical University, 634061 Tomsk, Russia

Y. Rabochaya
Eurasian National University, Astana, Kazakhstan

S. Zerbini
Gruppo Collegato di Trento, 38123 Trento, Italy

S. Zerbini
Sezione INFN di Padova, 35131 Padua, Italy

1 Introduction

A variety of complicated problems in cosmology can be explained by the discovery of the accelerated expansion of the universe (Riess et al. 1998; Perlmutter et al. 1999) in terms of dark energy (Bamba et al. 2012a; Li et al. 1999; Nojiri and Odintsov 2011). According to recent observations the dark energy currently accounts for about 69 % of the total mass/energy of the universe (Abe et al. 2013). It possesses a negative pressure and/or negative entropy. The EoS parameter w is still determined up to some uncertainty: it is not clear if w is less than -1, equal to -1, or larger than -1. According to present observations, $w = -1^{+0.09}_{-0.10}$ (Nakamura et al. 2010; Amanullah et al. 2010).

The most interesting case is when the thermodynamic parameter $w = p/\rho < -1$ (phantom dark energy). An essential property of this kind of energy is the Big Rip future singularity (Caldwell 2002; Caldwell et al. 2003; see also Nojiri and Odintsov 2003; Faraoni 2002; Gonzalez-Diaz 2004; Elizalde et al. 2004; Singh et al. 2003; Csaki et al. 2005; Wu and Yu 2005; Nesseris and Perivolaropoulos 2004; Stefancic 2004; Chimento and Lazkoz 2003; Hao and Li 2005; Dabrowski and Stachowiak 2006; Aref'eva et al. 2005; Godlowski and Szydlowski 2005; Sola and Stefancic 2005; Nojiri et al. 2005), where the scale factor becomes infinite at a finite time in the future. In the mild phantom models where w asymptotically tends to -1, the singularity occurs in the infinite future (Frampton et al. 2011a, 2011b, 2012; Frampton and Ludwick 2011; Astashenok et al. 2012a, 2012b, 2012c; Nojiri et al. 2011; Ito et al. 2011; Granda and Loaiza 2011; Xi et al. 2012; Belkacemi et al. 2011; Makarenko et al. 2012; Bamba et al. 2012b; Saitou and Nojiri 2012; Liu and Piao 2012; Elizalde et al. 2012; Stavrinos and Vacaru 2012). Such Rip phenomena take place for mild phantom scenarios like Little Rip or Pseudo Rip.