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ORIGINAL ARTICLE

Late time acceleration and role of skewness in anisotropic models

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Abstract We study cosmological models with anisotropy in expansion rates in the context of the recent observations predicting an accelerating universe. In the absence of any anisotropy in the cosmic fluid, it is shown that the role of skewness in directional Hubble rates is crucial in deciding the behavior of the model. We find that incorporation of skewness leads to a more evolving effective equation of state parameter.

Keywords Anisotropic models · Hubble parameter · Accelerated expansion

1 Introduction

Anisotropic cosmological models are studied in recent times with the advent of more precise data from measurements of Cosmic Microwave Background (CMB) temperature anisotropy. The high resolution CMB anisotropy data from Wilkinson Microwave Anisotropy Probe (WMAP) are in good agreement with the prediction of the Λ dominated cold dark matter model (ΛCDM) based upon the spatial isotropy and flatness of the universe (Hinshaw et al. 2009; Nolta et al. 2009). However, ΛCDM encounters some anomalous features at large scale such as (i) observed large scale velocity flows than prediction, (ii) a statistically significant alignment and planarity of the CMB quadrupole and octupole modes and (iii) the observed large scale alignment in the quasar polarization vectors (Antoniou and Perivolaropoulos 2012). More precise measurements of WMAP showed the quadrupole C_2 and octupole C_3 are usually aligned and are concentrated in a plane about 30° to the galactic plane which suggests that an asymmetric expansion with one direction expanding differently form the other two transverse directions at equatorial plane (Buiny et al. 2006) and signals a non-trivial topology of the large scale geometry of the universe (Watanabe et al. 2009; de Oliveira-Costa et al. 2004). The statistically significant and planarity of the quadrupole and octupole modes indicates a preferred direction, dubbed as, axis of evil (Land and Magueijo 2005). However, the large scale anomalies in CMB anisotropy are still debatable (Bunn and Buordon 2008).

The recently released Planck data (Ade et al. 2013a, 2013b, 2013c) shows that the primordial power spectrum of curvature perturbation is slightly red-shifted from the exact scale invariance which seems to be consistent with slow roll inflation mediated by a scalar field. The power spectrum of curvature perturbation ς with broken statistical isotropy can be expressed as (Ohashi et al. 2013; Ackerman et al. 2007)

$$\mathrm{P}_{\varsigma}(\boldsymbol{k}) = \mathrm{P}^0_{\varsigma}(\boldsymbol{k})\left(1 + g_* \cos^2 \Theta_{k,V}\right) \tag{1}$$

where, k is the comoving wave number, $\mathrm{P}^0_{\varsigma}(\boldsymbol{k})$ is the isotropic power spectrum, g_* is the anisotropic parameter characterizing the deviation from isotropy. The power spectrum is isotropic for $g_* = 0$ and anisotropic otherwise. $\boldsymbol{V}$ is a privileged direction close to the ecliptic poles, and $\Theta_{k,V}$ is the angle between $\boldsymbol{k}$ and $\boldsymbol{V}$. The anisotropic parameter g_* is constrained from WMAP data to be $g_* = 0.29 \pm 0.031$ excluding $g_* = 0$ where the CMB multipoles upto $l = 400$ are included (Groeneboom et al. 2010). Planck data constrains this anisotropic parameter as $|g_*| \geq 0.5$ in a two-form anisotropic interaction model leading to the enhancement

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