Configuration entropy in the ΛCDM and the dynamical dark energy models: Can we distinguish one from the other?

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19 October 2018

ABSTRACT

The evolution of the configuration entropy of the mass distribution in the Universe is known to be governed by the growth rate of density perturbations and the expansion rate of the Universe. We consider the ΛCDM model and a set of dynamical dark energy models with different parametrization of the equation of state and explore the evolution of the configuration entropy in these models. We find that the nature of evolution of the configuration entropy depends on the adopted parametrization which may allow us to discern them from each other. The configuration entropy initially decreases with time but nearly plateaus out at present in the ΛCDM model. The models where dark energy becomes less dominant at late times exhibit a larger decrease in the configuration entropy compared to the ΛCDM model after redshift $z \sim 1$. We find that the configuration entropy remains nearly unchanged in the models where dark energy becomes more dominant at late times. Our results suggest that the method presented here may be also used to constrain the initial value of the configuration entropy of the Universe.

Key words: methods: analytical - cosmology: theory - large scale structure of the Universe.

1 INTRODUCTION

Understanding the observed accelerated expansion of the Universe remains one of most interesting and challenging problems in cosmology. The fact that we live in an expanding Universe is quite well known since Edwin Hubble’s milestone discovery of the Hubble’s law (Hubble 1929).

The observational evidence of accelerating expansion of the Universe was confirmed much later by two independent groups (Riess et al. 1998; Perlmutter et al. 1999a) in 1998. This proved to be a landmark discovery in cosmology which revolutionized our current understanding of the Universe. The accelerated expansion of the Universe demands an explanation given the attractive nature of gravity and presence of matter in the Universe. The most common hypothetical explanation at present is that there exists something called dark energy which has negative pressure and whose energy density remains constant despite the expansion of the Universe. This hypothetical entity is very often identified with the cosmological constant of Einstein’s field equation but the question of the physical origin of this component is far from being settled. Different physically motivated ideas such as the backreaction mechanism (Buchert 2000), effect of a large local void (Tomita 2001; Hunt & Sarkar 2010), entropic force (Easson et al. 2011), information storage in the spacetime (Padmanabhan 2017; Padmanabhan & Padmanabhan 2017) have been proposed to explain the accelerated expansion of the Universe. A number of various other alternative models such as quintessence (Ratra & Peebles 1988; Caldwell et al. 1998), k-essence (Armendariz-Picon et al. 2001), extra-dimensional models (Milton 2003), and modified gravity (Tsujikawa 2010) have been also proposed to understand the physical origin and the nature of dark energy. A thorough discussion on these models and the possible ways to constrain them can be found in Copeland et al. (2006) and Amendola & Tsujikawa (2010).

The time-independent cosmological constant is regarded as the simplest dark energy candidate and the corresponding model is the ΛCDM model which has been proved to be the most successful model in explaining a wide range of cosmological observations. Despite its great success in explaining many cosmological observations, the ΛCDM model is still plagued by the cosmological constant problem and coincidence problem in the context of dark energy. In an
attempt to construct more natural models, a particular class of models known as the dynamical dark energy models with time-dependent equation of state have been proposed (Caldwell et al. 1998). If the equation of state of dark energy varies with time, it is argued that the signature of that variation would be found in the expansion history and the growth of the large scale structures in the Universe.

A number of other studies (Radicella & Pavón 2012; Pavón & Radicella 2013; Mimoso & Pavón 2013; Pavón 2014; Ferreira & Pavón 2016) suggest that the accelerated expansion of the Universe may be related to the second law of thermodynamics. It has been shown that the entropy of the Universe tends to some maximum value in the $\Lambda$CDM model (Pavón 2014) whereas different other models such as the modified gravity theories, nonsingular bouncing Universes and the Universes dominated by matter or phantom fields do not tend to a state of maximum entropy (Radicella & Pavón 2012; Mimoso & Pavón 2013; Ferreira & Pavón 2016).

The entropy of the relativistic particles remains unchanged during the expansion of the Universe. The growth of the Stellar Black Holes (SBH) and the Supermassive Black Holes (SMBH) increases the entropy of the Universe (Bekenstein 1973; Hawking 1976; Penrose 2004; Frampton 2009; Egan & Lineweaver 2010). Gibbons & Hawking (1977) show that besides other sources, an entropy is associated with the Cosmic Event Horizon (CEH) which is the most dominant source of entropy in the Universe (Egan & Lineweaver 2010).

In a recent work, Pandey (2017) proposed that the transition of the Universe from a nearly smooth to a highly clumpy state due to the growth of structures by the gravitational instability is associated with a large decrease in the configuration entropy of the Universe. It has been argued that the present acceleration of the Universe may arise to counterbalance this dissipation of the configuration entropy. It is well known that a static Universe with gravity and matter is unstable. The growth of structure at small scales would force the configuration entropy to decrease. If we treat the Universe as a thermodynamic system, then the second law of thermodynamics should hold for the Universe as a whole. Since none of the known entropy generation processes are efficient enough to counter the loss of configuration entropy, the Universe must expand to prevent the further growth of structures. The configuration entropy continues to dissipate in a matter dominated Universe. Interestingly, this dissipation is damped out in a $\Lambda$ dominated Universe where the entropy rate becomes zero and the configuration entropy tends to some maximum value.

In the present work, we explore the behaviour of the configuration entropy in the $\Lambda$CDM model and a set of dynamical dark energy models to test if they can be distinguished from each other based on the configuration entropy. The Universe in the radiation dominated era was very smooth and hence possessed very high configuration entropy on all scales. The relative inhomogeneities observed in the CMBR is of the order of $10^{-5}$ at the time of recombination. These inhomogeneities were amplified further by the gravitational instability leading to the growth of large scale structures in the Universe. As the structures form, the universe becomes more clumpy or inhomogeneous leading to a larger dissipation of the configuration entropy. The configuration entropy rate is known to depend on the growth rate of structures and the expansion rate of the Universe both of which in turn depend on the cosmological model under consideration. We study the consequences of the dynamical nature of the equation of state on the growth rate and the expansion rate and subsequently on the configuration entropy of the Universe. Configuration entropy in the present Universe can be easily measured from the large redshift surveys like SDSS (York et al. 2000). In future, combining measurements from future galaxy surveys like DESI and Euclid and observations from the different future 21 cm experiments would enable us to measure the configuration entropy of the Universe at different redshifts. This would then allow us to constrain the various cosmological parameters by measuring the configuration entropy of the Universe and its evolution.

2 THEORY

2.1 Evolution of configuration entropy

We consider a significantly large comoving volume $V$ of the Universe over which the Universe can be treated as homogeneous and isotropic. This large volume is further subdivided into smaller sub-volumes $dV$. Let $\rho(\bar{x},t)$ be the density measured inside the different subvolumes. Here $\bar{x}$ denote the comoving coordinate assigned to each sub-volumes.

Pandey (2017) defines the configuration entropy following the definition of information entropy (Shannon 1948) as

$$S_c(t) = - \int \rho \log \rho \, dV.$$  (1)

The continuity equation for a fluid in an expanding universe in comoving coordinate can be expressed as,

$$\frac{\partial \rho}{\partial t} + \frac{\dot{a}}{a} \rho + \nabla \cdot (\rho \vec{v}) = 0.$$  (2)

where $a$ is the scale factor and $\vec{v}$ is the peculiar velocity of the fluid element contained in a subvolume $dV$.

Multiplying Equation 2 by $(1 + \log \rho)$ and integrating over the entire volume $V$, we get (Pandey 2017),

$$\frac{dS_c(t)}{dt} + \frac{3}{a} \dot{S}_c(t) = \frac{1}{a} \int \rho(3\dot{a} + \nabla \cdot \vec{v})dV = 0.$$  (3)

Redefining $F(t) = \frac{1}{2} \int \rho(3\dot{a} + \nabla \cdot \vec{v})dV$ and changing the variable from $t$ to $a$, the Equation 3 becomes

$$\frac{dS_c(a)}{da} = \dot{a} + 3S_c(a) - F(a) = 0.$$  (4)

where $F(a)$ can be expressed as,

$$F(a) = 3MH(a) + \frac{1}{a} \int \rho(\bar{x},a)\nabla \cdot \vec{v}dV.$$  (5)

Here $M = \int \rho(\bar{x},a)dV = \int \rho(1+\delta(\bar{x},a))dV$ is the total mass contained inside the comoving volume $V$, $\delta(\bar{x},a) = \frac{\bar{x}(\bar{x},a)}{\bar{x}(\bar{x},a)} - 1$ is the density contrast and $\bar{x}$ is the mean density of matter within the comoving volume under consideration.

In linear perturbation theory, the density perturbations evolve as $\delta(\bar{x},a) = D(a)\delta(\bar{x})$ where $D(a)$ is the growing mode of density perturbations. The divergence of the peculiar velocity $\vec{v}$ can be expressed as,

$$\nabla \cdot \vec{v} = -\frac{\partial \delta(\bar{x},t)}{\partial t} = -\frac{\partial \delta(\bar{x},a)}{\partial a} \frac{\dot{a}}{a} = -a \frac{dD(a)}{da} \delta(\bar{x}).$$  (6)

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Writing $\rho(\delta, a)$ as $\bar{\rho}(1 + \delta(\delta, a))$ and inserting the expression for $\nabla \cdot \vec{\tau}$ in Equation 4 we get,
\[
\frac{dS_c(a)}{da} = \bar{\rho} - \frac{2}{a}\left\{ S_c(a) - M \right\} + \frac{1}{2a^3} \frac{dD(a)}{da} \int \delta(\delta, a) dV + D(a) \int \delta^2(\delta, a) dV = 0.
\]
(7)

The first term in the square bracket is zero by definition. So we finally have an ordinary first-order differential equation,
\[
\frac{dS_c(a)}{da} + \frac{3}{a} S_c(a) - M + f \frac{D''(a)}{a} + \int \delta^2(\delta, a) dV = 0.
\]
(8)

where, $f = \frac{\delta \rho}{\rho_{\text{tot}}}$ is the dimensionless linear growth rate.

We have to solve Equation 8 to determine the evolution of the configuration entropy in different cosmological models. We set the time independent quantities in the third term of Equation 8 to be 1 for the present analysis. We then calculate $D(a)$ and $f$ for different cosmological models considered in this work and numerically solve Equation 8 using the 4th order Runge-Kutta method.

It is interesting to note that the evolution of the configuration entropy is governed by the initial condition at the beginning when the contribution of the third term is negligible as compared to the second term in Equation 8. The cosmology dependence of $S_c(a)$ purely arises from the third term which involves the growth rate and its derivative. An analytical solution of Equation 8 ignoring the third term in it is given by,
\[
S_c(a) = \frac{M}{S_c(a_0)} + \left(1 - \frac{M}{S_c(a_0)} \right) \left( \frac{a_i}{a} \right)^3.
\]
(9)

where, $a_i$ is the initial scale factor which we have chosen to be $10^{-3}$ throughout the analysis.

### 2.2 Growing mode and the dimensionless linear growth rate of density perturbation

Any primordial density perturbations present in the early Universe will be amplified by the gravitational instability. Initially the density of matter was slightly higher than the average in some regions whereas it was a little lower in some other regions. The overdense regions would turn into even denser regions and the underdense regions would be more underdense with time. The growth of the density perturbations can be studied reliably with the linear perturbation theory when the density perturbations $\delta << 1$. If we consider only the perturbations to the matter then the growth equation becomes,
\[
\delta'(t) + 2H\delta(t) - (3/2)H^2\Omega_m \delta(t) = 0.
\]
(10)

Changing the variable of differentiation from $t$ to $a$ the Equation 10 becomes (Linder & Jenkins 2003)
\[
\delta''(a) + \left(\frac{2 - q}{a} - \frac{3}{2a^2} \right) \delta'(a) - \frac{3 \Omega_m}{2a^3} \delta(a) = 0.
\]
(11)

where a prime over $\delta$ means derivative with respect to $a$, $\Omega_m$ is the density parameter and $q = \frac{\dot{a}}{a}$ is the deceleration parameter.

If we assume that the universe has only two components such as matter (baryonic matter and dark matter) and dark energy whose equation of state is parametrized with some function $\omega(a)$ then we can write,
\[
\frac{H^2(a)}{H_0^2} = \Omega_m a^{-3} + (1 - \Omega_m) e^{\int_0^a \left(3/2 + \omega(a')\right) dlna'}.
\]
(12)

Here $H_0$ is the present value of the Hubble parameter. The time varying nature of the dark energy is encoded in the parametrization of $\omega(a)$. This may appear as ad-hoc and phenomenological but it is more generic approach (Linder & Jenkins 2003). We rewrite Equation 11 as (Linder & Jenkins 2003)
\[
D'' + \frac{3}{2} \left[ 1 - \frac{\omega(a)}{1 + X(a)} \right] \frac{D'}{a} - \frac{3}{2} \frac{X(a)}{1 + X(a)} D = 0.
\]
(13)

where $D = \frac{\omega(a)}{\Omega_m}$ and $\delta(a)$ is density contrast at some initial scale factor $a_i$ and
\[
X(a) = \frac{\Omega_m}{1 - \Omega_m} e^{-\int_0^a \omega(a') dlna'}.
\]
(14)

Equation 13 explicitly shows that the growth rate depends on the functional form of $\omega(a)$ and will give different result when a different $\omega(a)$ is chosen. We numerically solve the Equation 13 using the 4th order Runge-Kutta method. We normalize the solution $D(a)$ so that $D(a_0) = 1$ in the LCDM model where $a_0$ is the present scale factor.

We can write the matter density history as,
\[
\Omega_m(a) = \frac{\Omega_m a^{-3}}{E^2(a)}.
\]
(15)

and the dimensionless linear growth rate as
\[
f = [\Omega_m(a)]^\gamma,
\]
(16)

where $\gamma$ is the growth index which can be obtained by using the fitting formula provided by Linder (2005) as,
\[
\gamma = 0.55 + 0.05[1 + \omega(z = 1)].
\]
(17)

We estimate the dimensionless linear growth rate $f$ by combining Equation 15, Equation 16 and Equation 17.

### 2.3 Different parametrization of dynamical dark energy models

A number of two-parameter descriptions of $\omega$ have been explored in the literature. In the present work, we consider a number of different parametrization of dynamical dark energy. For each of these models we calculate the growing mode of density perturbation $D(a)$ and the dimensionless linear growth rate $f$ using the equations outlined in the subsection 2.2. We then solve Equation 8 to study the evolution of the configuration entropy in these models.

#### 2.3.1 Chevallier-Polarski-Linder (CPL) Parametrization

In CPL parametrization (Chevallier & Polarski 2001; Linder 2003), the equation of state is parametrized as,
\[
\omega(a) = \omega_0 + \omega_1 (1 - a).
\]
(18)

The main advantage offered by this parametrization is its bounded behaviour at infinite redshift. The slope of the equation of state $\frac{\omega'(a)}{\omega(a)} = -\omega_1$ is constant and the sign of the
constant determines whether the energy density increases or decreases with scale factor.

In the present work, we choose the values of the two constants $\omega_0$ and $\omega_1$ from Gong (2005) and Johri & Rath (2006) who claim that $\omega_0 = -1.6$, $\omega_1 = 3.3$ to be the best fit values to SN Ia 'gold set' data. We also consider the case for $\omega_1 = -3.3$ following Mamon et al. (2018) who suggest that the model with negative $\omega_1$ is thermodynamically stable.

2.3.2 Jassal-Bagla-Padmanabhan (JBP) Parametrization

Jassal et al. (2005) parametrized the equation of state as,

$$\omega(a) = \omega_0 + \omega_1 a (1-a) = \omega_0 + \omega_1 a - \omega_1 a^2. \tag{19}$$

The slope of the equation of state $\frac{d\omega(a)}{da} = \omega_1 (1 - 2a)$ is not a constant in this case. We use the best fit values to the SN Ia 'gold set' data provided in Gong (2005) and Johri & Rath (2006) as $\omega_0 = -1.9$, $\omega_1 = 6.6$. We also consider the case for $\omega_1 = -6.6$ as before.

We also consider some models where $\omega(a)$ does not deviate much from $-1$ throughout the entire range of evolution. We again consider the CPL and JBP parametrizations albeit with some different choice of parameters. We use $(\omega_0 = -1.0, \omega_1 = -0.26)$ for the CPL and $(\omega_0 = -1.0, \omega_1 = -0.38)$ for the JBP parametrization which are constrained by Tripathi et al. (2017) using SNIa+BAO+H(z) data. Two other parametrizations (Barboza & Alcaniz 2008; Liu et al. 2008) for which $\omega(a)$ remains close to $-1$ for the entire redshift range are also considered.

2.3.3 Barboza-Alcaniz (BA) Parametrization

The equation of state proposed in Barboza & Alcaniz (2008) is given by,

$$\omega(a) = \omega_0 + \omega_1 \frac{(1-a)}{(2a^2 - 2a + 1)} \tag{20}$$

This parametrization also exhibit a bounded behaviour at infinite redshift. We use the parameters $(\omega_0 = -1.11, \omega_1 = 0.43)$ as constrained by Barboza & Alcaniz (2008) using SNIa, BAO, CMB and H(z) data.

2.3.4 Liu-Li-Hao-Jin (LLHJ) Parametrization

Liu et al. (2008) propose a family of parametrizations. Family I is given by

$$\omega(a) = \omega_0 + \omega_1 (1-a)^n \tag{21}$$

Family II is given by

$$\omega(a) = \omega_0 + \omega_1 a^{n-1} (1-a) \tag{22}$$

Both family I and family II reduce to CPL parametrization for $n = 1$. For $n = 2$, family II reduces to JBP parametrization. We consider the parametrization of family I with $n = 2$ in this work. This parametrization starts with $\omega > -1$ but quickly slides below $-1$. The values of the parameters $(\omega_0 = -1.113, \omega_1 = 0.136)$ are constrained by Liu et al. (2008) using SNIa data.
The equation of state \( \omega(a) \) comes into play while evaluating \( E^2(a) \) in Equation 12 and \( X(a) \) in Equation 14. We show the evolution of \( E^2(a), D^2(a), \) the dimensionless growth rate \( f \) and the equation of state parameter \( \omega(a) \) for different cosmological models considered in the present work in the different panels of Figure 1 and Figure 2.

### 3 RESULTS AND CONCLUSIONS

We study the evolution of the configuration entropy in different cosmological models by solving Equation 13 and Equation 8. The results are shown in different panels of Figure 3. We consider three different combinations of the initial configuration entropy \( S_i(a_i) \) and the mass \( M \). In the top left panel of Figure 3, we show the configuration entropy as a function of the scale factor \( a \) in the dynamical dark energy models and the \( \Lambda \)CDM model for \( S_i(a_i) = 1 \) and \( M = 2 \).

We note that initially there is a sharp increase in the configuration entropy in all the models which soon stabilizes to a constant value. The configuration entropy then starts decreasing with increasing scale factor in both the \( \Lambda \)CDM model and the dynamical dark energy models with \( \omega < 0 \). We find that the decrease of the configuration entropy with increasing scale factor is very similar in the two models with CPL and JBP parameterization of dark energy equation of state with \( \omega < 0 \). We observe that these models with negative \( \omega_1 \) exhibit a larger decrease in the configuration entropy as compared to the \( \Lambda \)CDM model which leads to a larger dissipation of the configuration entropy in these models. These models are the ones in which the dark energy domination starts early but it becomes less dominant at late times. On the other hand, the dynamical dark energy models with \( \omega > 0 \) in both the CPL and JBP parametrization do not show a decrease in the configuration entropy after the initial increase in its value. These are the models in which the dark energy domination starts at a later stage suppressing the growth of structures which can be clearly seen in the significantly smaller values of the growth rate in these models in Figure 1.

The top right panel of Figure 3 shows the evolution of the configuration entropy in different cosmological models for \( S_i(a_i) = 2 \) and \( M = 2 \). The bottom panel shows the same but for the combination \( S_i(a_i) = 3 \) and \( M = 2 \). The choice of these parameters are somewhat arbitrary here and we consider three representative examples each for \( S_i(a_i) < M, S_i(a_i) = M \) and \( S_i(a_i) > M \). It may be noted here that in this work, \( S_i(a_i) \) and \( M \) have the same dimension as we do not normalize the density \( \rho \) by the total mass \( M \) in Equation 1.

The top right and the bottom panels of Figure 3 show the same trends in the evolution of configuration entropy in different cosmological models as observed in the top left panel of Figure 3 but with one remarkable difference. In the top left panel, we observe a sharp increase in the configuration entropy near the initial value of the scale factor. Contrary to this, the configuration entropy shows a sharp decrease near the initial value of the scale factor when \( S_i(a_i) > M \). This can be clearly seen in the bottom panel of Figure 3. No such sharp increase or decrease can be seen in
Figure 3. Different panels show the evolution of the ratio of the configuration entropy $S_c(a)$ to its initial value $S_c(a_i)$ for CPL and JBP parametrization of dark energy along with the $\Lambda$CDM model for different initial entropy $S_c(a_i)$ and mass $M$ enclosed within comoving volume $V$ as indicated in each panel.

Figure 4. Same as Figure 3 but for BA and LLHJ parametrization along with CPL and JBP parametrization with different choice of parameters.
the configuration entropy near the initial scale factor when we choose $S_c(a_i) = M$. The corresponding results are shown in the top right panel of Figure 3. Initially the evolution of the configuration entropy is determined by the second term in Equation 8 as the cosmology dependent third term remains negligible at an early stage of evolution. We expect that this particular behaviour of the configuration entropy may be exploited to constrain its initial value from future observations.

We have also considered a set of models in which the equation of state parameter $\omega(a)$ does not deviate much from $-1$ in the entire range of evolution. We show the evolution of the configuration entropy for different combinations of $S_c(a_i)$ and $M$ in these models in Figure 4. The Figure 4 shows that the nature of evolution at the initial stage is primarily decided by the values of $S_c(a_i)$ and $M$, as noticed earlier for the other models in Figure 3. The CPL and JBP parametrizations with a different choice of parameters in this case are nearly indistinguishable from the ΛCDM model. The differences between the ΛCDM model and these models are noticeable after $z > 1$ only when $S_c(a_i) = M$ in the top right panel of Figure 4. On the other hand, the BA and LLHJ parametrizations show a quite discernible behaviour compared to the ΛCDM model or the CPL and JBP parametrizations throughout the entire range of evolution. Interestingly, the configuration entropy in these models decreases with time and then start increasing again after redshift $\sim 0.5$.

Finally, we explore the transients observed in the numerical values of $\frac{S_c(a)}{S_c(a_i)}$ near the initial scale factor $a_i$ when $S_c(a_i) < M$ and $S_c(a_i) > M$ respectively. The bottom two panels show the same but for BA and LLHJ parametrization along with CPL and JBP parametrization with different choice of parameters. The approximate analytical solution (Equation 9) of Equation 8 are also plotted in each case for a comparison.

**Figure 5.** The top left and right panels show the initial transient in $\frac{S_c(a)}{S_c(a_i)}$ near the initial scale factor $a_i$ for CPL and JBP parametrization along with the ΛCDM model for $S_c(a_i) < M$ and $S_c(a_i) > M$ respectively. The bottom two panels show the same but for BA and LLHJ parametrization along with CPL and JBP parametrization with different choice of parameters. The approximate analytical solution (Equation 9) of Equation 8 are also plotted in each case for a comparison.
with CPL and JBP parametrization with different choice of parameters. It is interesting to note that both the LLHJ and BA parametrizations show noticeable deviation from the approximate analytical results starting from the very small value of scale factor \((a \sim 0.002)\). This indicates that the cosmology dependent term in Equation 8 becomes relevant even at an early stage of evolution in these two models. Earlier, we notice in Figure 4 that \(\Sigma_{\text{config}}\) show a qualitatively similar behaviour in the LLHJ and BA parametrizations despite their different equation of states and growth rates. However it may be noted that it is the product of \(f\) and \(D^2(a)\) in the third term of Equation 8 which determines the behaviour of entropy in a particular model.

The present analysis deals with the evolution of the configuration entropy in the linear regime. It would be also interesting to study its behaviour in the non-linear regime. The anisotropic gravitational collapse of the overdense regions leads to different types of non-linear structures such as sheets, filaments and clusters. The evolution of the density field and the velocity field become quite diverse in these environments. Consequently, it becomes difficult to capture the evolution with a simple analytic framework. However, one can track the evolution of the configuration entropy in the non-linear regime using N-body simulations.

In the present work, we have considered a set of different models for dark energy and explore the evolution of the configuration entropy in these models. The evolution of the configuration entropy is primarily governed by the growth rate of structures and the expansion rate of the Universe. The differences in the configuration entropy as shown in Figure 3 and Figure 4 arise due to the different expansion history and growth rate in different models. Our results suggest that the models with \(\omega_i > 0\) and \(\omega_j < 0\) can be easily distinguished from their distinct behaviour with respect to each other. It is interesting to note that the nature of evolution of the configuration entropy also depends on the adopted parametrization. So one may also discern the dynamical dark energy models with different parametrizations by studying the evolution of the configuration entropy. We hope that an analysis of the configuration entropy from future observations may enable us to constrain these models in an efficient manner.

4 ACKNOWLEDGEMENT

We sincerely thank an anonymous referee for useful comments and suggestions which helped us to improve the draft. The authors would like to thank Eric V. Linder, Sudipta Das and Suman Sarkar for useful discussions. The authors would also like to acknowledge financial support from the SERB, DST, Government of India through the project EMR/2015/001037. BP would also like to acknowledge IUCAA, Pune and CTS, IIT, Kharagpur for providing support through associateship and visitors programme respectively.

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