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Formation of Large Structures in the Acceleration Universe with a Hybrid Expansion Law

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Abstract. In the current paper, we have studied the effect of dark energy on formation where dark energy exists in the background. For this purpose, we used both WMAP9 and Planck data to study how the radius changes with redshift in these models. We used different data sets to fix the cosmological parameters to obtain a solution for a spherical region under collapse. The mechanism of structure formation for dark and baryonic matter is different. When processed by gravitational instability, density perturbations have given rise to collapsed dark matter structures, called halos. These dark matter halos offer the backdrop for the subsequent formation of all collapsed baryonic structures, including stars, galaxies, and galaxy clusters. In Planck Data forΛCDM, with the presence of dark energy in the background, the formation of baryonic matter is delayed. Therefore, it is a factor for the largening of the baryonic matter radius. Accompanying dark energy is entailing an increment of dark matter virial radius. For WACDM Data, dark energy alongside time-dependent parameter of state and baryon acoustic oscillations are the reasons for the delay of dark matter formation and the radius reduction. Due to the lack of data without baryonic acoustic waves in the background, we are left unable to delineate its impact on the structures. In $WCDM(BAO+H_0)$ and $WCDM(H_0)$, the lack of BAO shows a critical role in the delaying of baryonic matter structure formation. Respectively, it causes growing virial radius of dark matter. BAO, without taking dark energy into accounts, is the reason for the increasing and decresing of radius of dark and baryonic matter. It also delays baryonic matter formation. In $\Lambda CDM(BAO+H_0)$ and $\Lambda CDM(H_0)$, We have studied ΛCDM data for standard model under two circumstances: (a) $\Lambda CDM(BAO+H_0)$, (b) $\Lambda CDM(H_0)$ data. Dark energy in this data delays formation and intensifies virial radius of baryonic matter. Our studies show WCDM andΛCDM have the same effect on formation if we do not consider dark energy in BG. Planck data, in comparing with WMAP, has important role in describing standard model.

Keywords: Dark Energy – Scalar Fields – Baryonic Acoustic Waves – Standard Model

1 Introduction

In 1998, two teams studying distant Type Ia supernovae presented independent evidence that our universe is currently accelerating [1, 2]. The physical origin of cosmic acceleration remains a deep mystery. The accelerated expansion of the Universe,discovered in 1998, has raised fascinating questions for cosmology and physics as a whole. Two different approaches are proposed for this problem: (i) Dark Energy models that modify the stress-energy content of the Universe, adding an additional component with equation of state w=-1. That is, we modify the right-hand side of the Einstein equations. (ii) The Modified Gravity category corresponds to modifying the left-hand side. For example General Relativity (GR) by modifying the Einstein-Hilbert action [3, 4, 5].

The candidates of dark energy include cosmological constant and a variety of scalar field models. The models based upon modified theories of gravity are faced with the challenges posed by the local physics. Large scale modification of gravity essentially implicates extra degrees of freedom which might influence local physics where the Einstein theory of gravity is approving with observations. By giving a priori a cosmic history, specifying either the equation of state (EoS) or the scale factor $''a''$, we can always construct a scalar field potential which would imitate the desired result. Similar reconstruction can be executed in scalar tensor theories [6, 7].

The dynamics of realistic Universe are illustrated by an EoS parameter which behaves differently at different epochs. For instance, in general relativistic description of the dynamics of the spatially flat RW space-time, the fluids with constant EoS parameter $w > -1$ give rise to a power-law expansion ($a \propto t^{\frac{2}{3(1+w)}}$) of the Universe and for an exponential expansion $a \propto e^{kt}$, where $k > 0$ is a constant; it is required that $w = -1$. The solution of the Einstein's field equation in the presence of a single fluid with a constant EoS parameter gives a relation for the EoS parameter of a fluid. The discovery of cosmic acceleration is debatably one of the most important developments in modern cosmology [8, 9].

Most dark energy modelling using scalar fields has followed the Quintessence pattern of a slowly rolling canonical scalar field. However, there has been increasing interest in loosening the assumption of a canonical kinetic term. In its most general form, this idea is known as k-essence [10].

Tachyon dark energy has been explored by many authors, e.g.[6, 11, 12]. Bagla et al (2003) focused on two specific choices of Tachyon potential, and carried out numerical analysis of the cosmological evolution in order to constrain them against supernova data and the growth rate of large-scale structure [6]. Copeland et al (2005) studied a wider range of potentials, concentrating mainly on analytical inspection of attractor behavior and the critical point structure without making comparison to specific observations [12]. By studying a wide range of potentials and testing them directly against current observational constraints, they aim to combine some of the positive features of each analysis [13].

Parsons and Barrow studied the behavior of the scale factor in the context of inflation in the early Universe [14]. They pointed out that Einstein's field equations in the presence of self-interacting scalar field are invariant under the constant rescaling of the scalar field, and then they generated the HEL (Hybrid Expansion Law) behavior from power-law expansion. They also showed that such an expansion of the Universe can be represented as a Friedmann Universe in the presence of imperfect fluid. Akarsu et al (2014) study HEL expansion in the context of the history of the Universe after the inflation took place, and mainly investigate whether this law could be used for explaining the evolution of the Universe starting from the radiation- or matter-dominated Universe to the currently accelerating Universe. They also carried out the effective fluid and the single scalar field reconstruction using Quintessence, Tachyon and Phantom fields, which can capture HEL in the framework of general relativity [15].

In cosmology, baryon acoustic oscillations (BAO) refers to regular, periodic fluctuations in the density of the visible baryonic matter (BM) of the Universe. BAO matter clustering provides a $''standardruler''$for length scale in cosmology in the same way that supernova experiments provide a $''standardcandle''$ for astronomical observations. BAO measurements help cosmologists understand the nature of dark energy better by constraining cosmological existing BAO in the background [15].

The effect of the dynamics of dark energy on the growth rate of the large scale structures in the framework of LCDM and MOND is investigated. For variable dark energy model, increasing the bending parameter b causes the structure viralizes at lower redshift with larger radius. Therefore, the variable dark energy model put off the spherical collapse to the later times. The case of the low-density model has an intermediate behavior such that the virialization redshift in this model corresponds with b = 0.4 in variable dark energy model. Finally, we compared the virialization of structures under the variable dark energy model with the recent results of MONDian N-body simulations. We showed that the various models of simulation are consistent with the variable dark energy model with different bending parameter [16, 17].

The process of the structure formation in the presence of dark energy models must be studied linear theory in order to address the growth of structures in linear regime and the effect of dark energy on matte power spectrum and variance, which is then, must be used in Press- Schechter kind of study of the nonlinear structures [18]. There is ample evidence that galaxies reside in extended halos of dark matter(DM) which forms through gravitational instability. Density perturbations grow linearly until they reach a critical density, after which they turn around from the expansion of the Universe and collapse to form virialized dark matter halos. These halos continue to grow in mass and size, either by accreting material from their neighborhood or by merging with other halos. Some of these halos may survinve as bound entities after merging into a bigger halo, thus giving rise to a population of subhalos. The illustrated process shows the formation of a dark matter halo in a numerical simulation of structure formation in a CDM cosmology. It also shows how a small volume with small perturbations initially expands with the Universe. As time proceeds, small-scale perturbations grow and collapse to form small halos. At a later stage, these small halos merge together to form a single virialized DM halo with an ellipsoidal shape, which reveals some substructure in the form of DM subhalos[19].

Within this paper, we intend to investigate whether a simple scale factor obtained by multiplying power-law and exponential law, which we will call hybrid expansion law, could triumph in explaining the observed Universe. We have used scalar fields for investigating structures formation and the effect dark energy has on it.

Here follows the outline: In Sec. 2, we will inspect the potential and EoS in scalar fields such as Quintessence, Tachyon and Phantom. In Sec. 3, we will exhibit how the presence of dark energy affects structure formation by using Planck, WACDM, and WCDM data. We will finalize the paper summarizing the results in the conclusion section.

2 Scalar fields

Scalar field models have played a vital role in cosmological studies for nearly half a century. Those assumed scalar fields have appeared in different cosmological research aspects to resolve various cosmological problems [21], such as driving inflation, time variable cosmological constant explaination, and so on. The scalar fields have played one other essential role for the past fifteen years as a candidate for dark energy proceeding the discovery of the accelerating expansion of universe. There are so many phenomenological dark energy models of scalar fields, such as Quintessence, Phantom, quintom and the scalar fields with non-canonical kinetic energy term [22, 23].

To study the dynamical evolution of those scalar field models and their cosmological implications with a phase-plane analysis is a very useful and common method. However, most studies only focus on the Quintessence models (including Phantom, Quintessence, and quintom) with unique exponential potential and Tachyon models (including Phantom Tachyon) with inverse square potential. Correspondingly, the dynamical systems are two dimensional autonomous systems with those particular forms of potentials [24, 25].

2.1 Quintessence field

Most cosmological models implicitly assume that matter and dark energy interact only gravitationally. In the absence of an underlying symmetry that would suppress a matter-dark energy coupling (or interaction), there is no a priori reason for dismissing it. Cosmological models in which dark energy and matter do not evolve separately but interact with one another were first introduced to justify the small value of the cosmological constant [26]. Recently, various proposals at the fundamental level, including field Lagrangians, have been advanced to account for the coupling. Scalar field Lagrangians coupled with matter do not generate scaling solutions with a long enough DM dominated period as required by structure formation. The phenomenological model we are going to discuss was constructed to account for late acceleration in the framework of Einstein's relativity and to significantly alleviate the mentioned coincidence problem and escapes the limits imposed by it[27, 28].

Most of the dark energy studies are carried out within the Quintessence pattern of a slowly rolling canonical scalar field with a potential. For that reason, we will first consider the Quintessence realization of the HEL. In general relativity, the effective energy density and EoS parameter of the fluid follow as below [20]:

$$\rho_{eff}(t) = 3(\frac{\alpha}{t} + \frac{\beta}{t_0})^2 \tag{1}$$

$$W_{eff} = \frac{2}{3}\frac{\alpha}{t^2}(\frac{\alpha}{t} + \frac{\beta}{t_0})^{-2} - 1 \tag{2}$$

The potential and EoS parameter as a function of time (t) are then given by the following expression:

$$\dot{\phi}^2(t) = \frac{2\alpha}{t^2} \tag{3}$$

$$V(t) = 3(\frac{\alpha}{t} + \frac{\beta}{t_0})^2 - \frac{\alpha}{t^2} \tag{4}$$

$$W(t) = \frac{\frac{2\alpha}{t^2}}{3(\frac{\alpha}{t} + \frac{\beta}{t_0})^2} - 1 \tag{5}$$

2.2 Tachyon field

Quintessence pattern relies on the potential energy of scalar fields to drive the late time acceleration of the Universe. On the other hand, it is also possible to relate the late time acceleration of the Universe to the kinetic term of the scalar field by relaxing its canonical kinetic term. This idea is known as k-essence [29]. Tachyon fields can be taken as a particular case of k-essence models with Dirac-Born-Infeld (DBI) action and can also be motivated by the string theory [30]. That item together with $p = w\rho$, give the following relations:

$$\dot{\phi}^2 = \frac{\frac{2\alpha}{t^2}}{3(\frac{\alpha}{t} + \frac{\beta}{t_0})^2} \tag{6}$$

$$V(t) = 3(\frac{\alpha}{t} + \frac{\beta}{t_0})^2\sqrt{1 - \frac{\frac{2\alpha}{t^2}}{3(\frac{\alpha}{t} + \frac{\beta}{t_0})^2}} \tag{7}$$

$$w = \frac{\frac{2\alpha}{t^2}}{3(\frac{\alpha}{t} + \frac{\beta}{t_0})^2} - 1 \tag{8}$$

2.3 Phantom field

Quintessence and Tachyon fields investigated in the previous two subsections can yield EoS parameters $w \geq -1$. However, present observations allow slight Phantom values for the EoS parameter, i.e., $w < -1$. Sources behaving as a Phantom field can arise in braneworlds, Brans-Dicke scalar-tensor gravity and may be motivated by S-brane constructions in the string theory [15, 20]. On the other hand, the Phantom energy can, in general, be simply described by a scalar field with a potential $V(\phi)$ like the Quintessence dark energy, yet with a negative kinetic term [31]. Accordingly, the energy density and pressure of the Phantom field can be given by

$$\rho = -\frac{1}{2}\dot{\phi}^2 + V(\phi) \tag{9}$$

$$P = -\frac{1}{2}\dot{\phi}^2 - V(\phi) \tag{10}$$

where ϕ is the Phantom field with potential $V(\phi)$. We rescale time as $t \longrightarrow t_s - t$, where t_s is a sufficiently positive reference time. Thus, the HEL ansatz [1] becomes

$$a = a_0(\frac{t_s - t}{t_s - t_0})^{\alpha} e^{[}\beta(\frac{t_s - t}{t_s - t_0} - 1)] \tag{11}$$

The effective EoS parameter and energy density ρ are respectively:

$$\rho_{eff}(t) = 3(\frac{\alpha}{t_s - t} + \frac{\beta}{t_s - t_0})^2 \tag{12}$$

$$w_{eff} = \frac{2}{3}\frac{\alpha}{(t_s - t)^2}(\frac{\alpha}{t_s - t} + \frac{\beta}{t_s - t_0})^{-2} - 1 \tag{13}$$

Thus, we can get following equations from Eqs $(14 - 18)$:

$$\dot{\phi}^2 = \frac{-2\alpha}{(t_s - t)^2} \tag{14}$$

$$V(t) = 3(\frac{\alpha}{t_s - t} + \frac{\beta}{t_s - t_0})^2 - \frac{\alpha}{(t_s - t)^2} \tag{15}$$

$$w = \frac{\frac{2\alpha}{(t_s - t)^2}}{3(\frac{\alpha}{t_s - t} - \frac{\beta}{t_s - t_0})^2} \tag{16}$$

where α and β are non-negative constants $(\alpha = 0.488, \beta = 0.444)$.

3 Results & Discussion

In the current paper, we have investigated scalar field models for ansatz that are produced with power-law and exponential type of functions. We have also carried out the evolution of large scale structures in a single scalar field reconstruction using Quintessence, Tachyon and Phantom fields and compared them with the standard model (ΛCDM). Following that purpose, we have applied dark energy effect on formation. We have used two numerical data, namely WMAP9 and Planck to study how the radius changes with redshift in these models. It helps us obtain virilization of models, which agrees to structure formation in Cosmological observations. Results are regularized in three subsections. First, we will investigate Planck data first, then WACDM and finally WCDM.

3.1 Planck Data

Cosmological observations prior to Planck were consistent with the simplest models of inflation within the slow-roll paradigm. Planck data are remarkably consistent with the predictions of the base ΛCDM cosmology. In the following section, we will use Planck numerical data [33] to investigate dark energy effect on structure formation in background under two circumstances: (a) radiation and matter(dark and light separately), (b) radiation, matter and dark energy , in the BG.

Since the HEL model predicts the beginning of universe with radiation and the current accelerating phase of the universe at the same time. However, from the CMB test it does not accommodate the matter-dominated era properly unless we consider the parameter α. Thus, with the current form of HEL, radiation alone cannot construct structure [15].

According to Newton's gravity law, the radius of dark and baryonic matter can be given by

$$\begin{aligned}\frac{dr_b}{da} &= \frac{1}{aH((-r_b^2H^2\delta_b + \frac{2GM}{r_b})^{-\frac{1}{2}})}\\ \frac{dr_d}{da} &= \frac{1}{aH((-3r_d^2H^2\delta_d + \frac{2GM}{r_d})^{-\frac{1}{2}})}\end{aligned} \tag{17}$$

Where $a_0 = 1$ and δ is matter density contrast. Now using Planck data [32, 33] and Harrison-Zeldovich spectrum data [16], we obtain numerical data that shows in Tab.1.

In the other case, Friedmann equation encompasses radiation, matter and energy. There, the numerical value of Planck data is placed in ΛCDM and scalar field models follow as Tab.1.

We plotted radius evolution of scalar fields and ΛCDM models in Fig.1 by considering the values of model parameters given in Table 3 from Planck data. According to virial theorem, when the kinetic energy of structure abates, the total energy becomes potential energy. In this phase, the structure spends its maximum radius. For comparison, all of the models are in a plot which shows all models have similar behavior for DM. In other words, Planck data are compatible with the predictions of the base ΛCDM cosmology. By using this data, standard model can be explained as structure formation. Hence, dark energy in the background makes a delay in formation of BM and intensifies its radius. Accompanying the existence of dark energy is entailing an intensification of DM virial radius. For scalar field models, dark energy is a factor to the accretion of DM radius. However, BM cannot be constructed with such data.

Table 1: The mass of baryonic and DM ($10^{12} M_{\odot}$) with radiation and dark energy in background in three models. Using Planck numerical data to investigate dark energy effect on structure formation in background under two circumstances (a) and (b).

	$Model$	Com	$R_{Max}(Kpc)$	$R_{vir}(Kpc)$	Z_{Max}	Z_{vir}
a	Plank	DM	156.268±2.315	81.809±1.404	5.7±0.020	3.4±0.012
		BM	467.657±4.428	250.161±2.705	1.3±0.007	0.45±0.001
b	ΛCDM	DM	156.263±2.315	83.247±1.407	5.7±0.020	3.4±0.012
		BM	467.750±4.429	251.441±2.709	1.25±0.007	0.35±0.001
b	Phantom	DM	156.263±2.315	83.247±1.407	5.7±0.001	3.4±0.012
		BM	421.7±4.421	421.7±4.421	2.05±0.009	2.05±0.009
b	Tachyon & Quintessence	DM	156.263±2.315	83.247±1.407	5.7±0.020	3.4±0.012
		BM	422.494±4.429	422.494±4.429	2.05±0.009	2.05±0.009

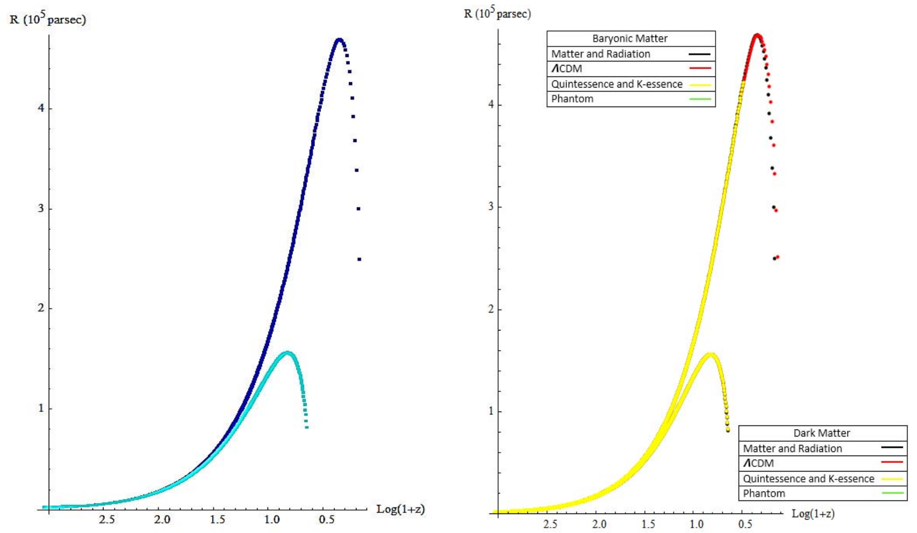

Figure 1: Left: Radial evolution of BM (dark blue) and DM (light blue) for mass = $10^{12} M_{\odot}$ from Planck Data. In this model, radiation and matter exist in background. Right: Diagrams show radial evolution of BM and DM for ΛCDM model (red), Phantom model (green), Tachyon and Quintessence models (yellow). Black curve shows matter and radiation in background. Dots relate virialization of model. In BM, this compatible is interrupted for log $(1 + Z) < 0.5$.

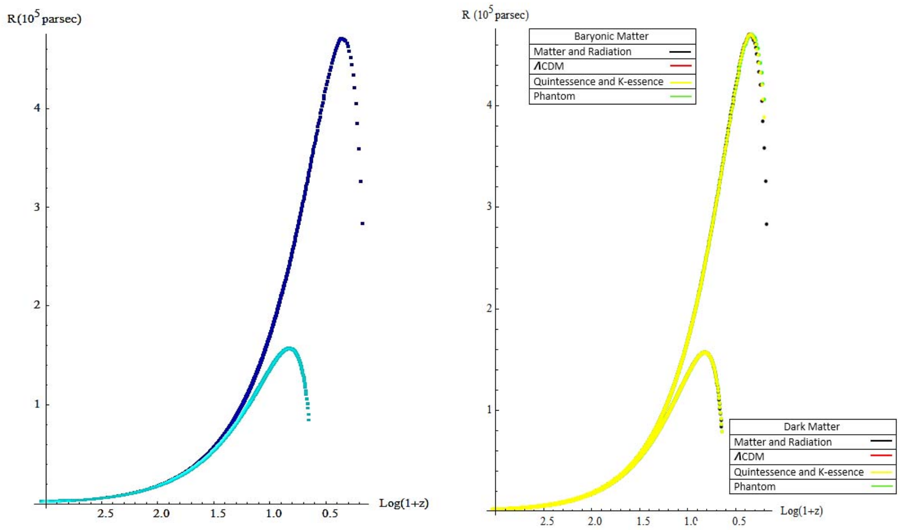

Figure 2: The same as in Figure 1 but by using WACDM Data. Black curve shows matter and radiation in background. Dots relate virialization of model.

3.2 WACDM Data

A major challenge for cosmology today is to elucidate the nature of the dark energy driving the accelerated expansion of the Universe. Among cosmological models, there is one that depicts flat universe with dark energy where equation of state is time-dependent. Scalar field models are time-dependent. Therefore, we analyzed redshifts in which parameter of state has a negative value. For Tachyon and Quintessence models, this value is $z < 2.273$. However, in the case of the Phantom scenario, the ansatz and Hubble parameter diverge as $t \longrightarrow t_s$, and thus expose the Universe to Big Rip. We supposed that in flat universe, radiation, matter and energy exist in the background. Tab.2 shows numerical data that is given from WACDM data.

Table 2: The same as in Table 1 but by using WACDM Data.

	$Model$	$Comp$	$R_{Max}(Kpc)$	$R_{vir}(Kpc)$	Z_{Max}	Z_{vir}
a	Scalar	DM	157±2.316	84.087±1.410	5.74±0.020	3.44±0.012
	field	BM	469.245±4.431	283.47±3.070	1.34±0.007	0.49±0.001
b	Phantom	DM	157±2.316	78.914±1.397	5.74±0.020	3.39±0.011
		BM	470.181±4.432	406.64±4.360	1.24±0.007	0.59±0.001
b	Tachyon &	DM	157±2.316	78.914±1.397	5.74±0.020	3.39±0.011
	Quintessence	BM	469.967±4.431	388.905±4.115	1.29±0.007	0.59±0.001

Since DM is constructed earlier than BM, for investigating dark energy effect on structure, we compare redshift virilism with a state wherein energy is not in the background. Our study shows that dark energy alongside time-dependent parameter of state and baryon acoustic oscillations. These are the factor for the reducing of DM radius. Due to lack of data on the absence of baryonic acoustic waves in the background, we are left unable to delineate its impact on the structures. The absence mentioned is on the account of the simultaneous existence of dark energy and BAO in the background.

3.3 WCDM Data

WCDM data has investigated flat universe with dark energy by observing the effect of baryon acoustic oscillations. The BAO angular scale serves as a standard ruler and allows us to map out the expansion history of the Universe after last scattering. The BAO scale, which is extracted from galaxy redshift surveys, provides a constraint on the late-time geometry and breaks degeneracies with other cosmological parameters.

3.3.1 $WCDM(BAO + H_0)\&WCDM(H_0)$

Within the following subsection, first, we studied WCDM data for scalar fields under two circumstances: (a) WCDM (H_0+BAO), (b) WCDM (H_0) data then, inspected the presence of dark energy in the background. Tab.3 , Tab.4 and Fig.3 show numerical data that is given from WCDM data.

Table 3: The same as in Table 1 but by using WCDM($H_0 + BAO$) Data.

	$Model$	Com	$R_{Max}(Kpc)$	$R_{vir}(Kpc)$	Z_{Max}	Z_{vir}
a	Scalar	DM	156.783±2.317	81.955±1.405	5.71±0.020	3.41±0.012
	field	BM	469.13±4.430	255.459±2.715	1.31±0.007	0.46±0.001
b	Phantom	DM	156.778±2.317	83.553±1.408	5.71±0.020	3.41±0.012
		BM	469.056±4.430	466.667±4.427	1.26±0.006	1.01±0.005
b	Tachyon &	DM	156.778±2.317	83.553±1.408	5.71±0.020	3.41±0.012
	Quintessence	BM	468.786±4.429	464.351±4.421	1.31±4.421	1.01±0.005

Table 4: The same as in Table 1 but by using WCDM(H_0) Data.

	$Model$	Com	$R_{Max}(Kpc)$	$R_{vir}(Kpc)$	Z_{Max}	Z_{vir}
a	Scalar	DM	157.337±2.318	81.578±1.403	5.8±0.022	3.45±0.012
	field	BM	470.402±4.432	281.74±2.773	1.35±0.007	0.5±0.001
b	Phantom	DM	157.374±2.318	85.616±1.411	5.75±0.021	3.45±0.012
		BM	471.203±4.439	312.244±3.001	1.25±0.007	0.4±0.001
b	Tachyon &	DM	157.374±2.318	85.616±1.411	5.75±0.021	3.45±0.012
	Quintessence	BM	470.832±4.433	275.387±2.755	1.3±0.007	0.4±0.001

The presence of baryon acoustic oscillations plays a critical role in the postponing of dark and baryonic matter structure formation. Respectively, it causes increasing and decreasing virial radius of dark and baryonic matter. Dark energy, without taking BAO into accounts, is the reason for the declining of BM radius. If we consider both of them, we will be facing an increment of DM radius.

3.3.2 $\Lambda CDM(BAO + H_0)\&\Lambda CDM(H_0)$

Through this instance, we studied ΛCDM data for standard model under two circumstances: (a) $\Lambda CDM(BAO + H_0)$, (b) $\Lambda CDM(H_0)$ data. Then, we suppose that in flat universe, radiation, matter and energy exist in the background. Tab.5 and Fig.4 show this success.

Dark energy in this data grows virial radius of both of them. The structure formation in a standard model is dependent on BAO. In other words, BAO is a necessity factor for constructing structure in the standard model.

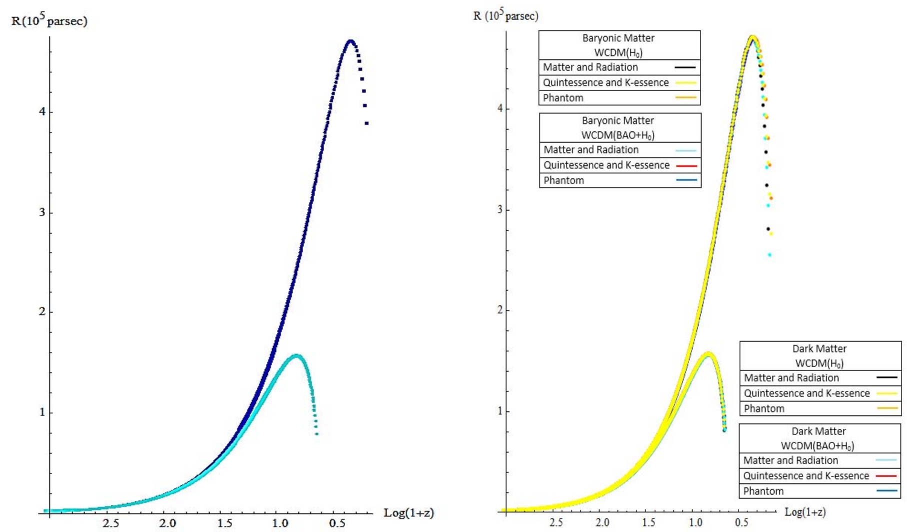

Figure 3: The same as in Figure 1 but by using Left: $WCDM(BAO + H_0)\&WCDM(H_0)$ Data. Right: $WCDM(BAO + H_0)\&WCDM(H_0)$ Data for Phantom, Tachyon and Quintessence models that radiation, matter and dark energy exist in background. Dots relate virialization of model.

Table 5: The same as in Table 1 but by using ΛCDMData.

	$Data$	Com	$R_{Max}(Kpc)$	$R_{vir}(Kpc)$	Z_{Max}	Z_{vir}
a	ΛCDM	DM	157.111±2.316	80.160±1.398	5.77±0.022	3.42±0.012
	$(BAO + H_0)$	BM	470.175±4.430	260.364±2.601	1.32±0.007	0.47±0.001
a	ΛCDM	DM	157.55±2.319	78.948±1.389	5.79±0.022	3.44±0.012
	(H_0)	BM	471.371±4.433	268.541±2.696	1.34±0.007	0.49±0.001
b	ΛCDM	DM	157.149±2.316	84.078±1.409	5.72±0.022	3.42±0.012
	$(BAO + H_0)$	BM	470.144±4.432	271.715±2.720	1.27±0.007	0.37±0.001
b	ΛCDM	DM	157.545±2.317	645.903±2.544	5.79±0.021	-1.91±0.001
	(H_0)	BM	471.203±4.431	914.531±10.117	1.29±0.007	-1.91±0.001

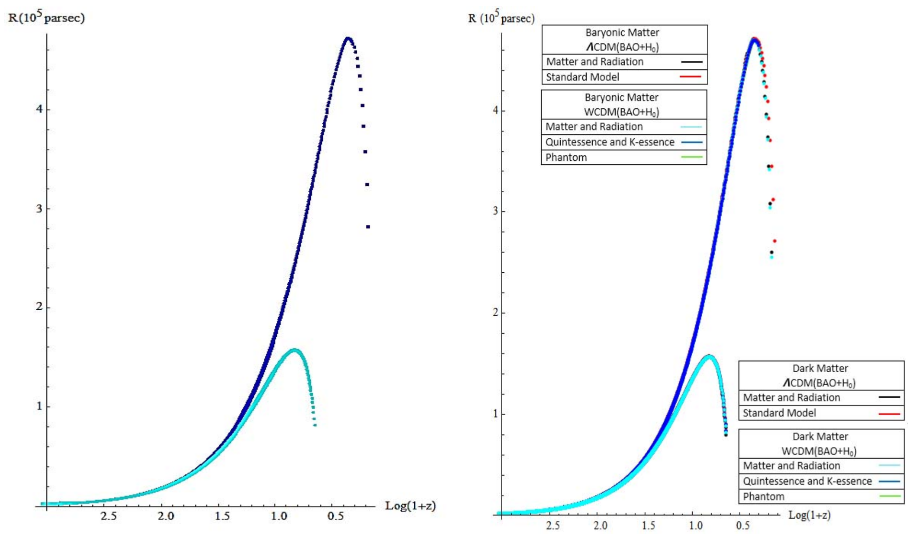

Figure 4: The same as in Figure 1. Left:$\Lambda CDM(BAO + H_0)$&$\Lambda CDM(H_0)$ Data. Right: ΛCDM Data.

4 Conclusion

In this paper, We have examined the hybrid form of scale factor, namely, a product of power law and an exponential function, which provides a simple mechanism of transition from decelerating to accelerating phase. Two numerical data are utilized to study how the radius of structures can remark in these models, as the virialization of structures depends strongly on the background. We used different data sets to fix the cosmological parameters to get a solution for a spherical region under collapse. We dealt with the problem of the structure formation in the framework of Cosmological Models under the influence of dark energy and BAO.

The mechanism of structure formation for DM and BM is different. Due to hierarchical structure formation, because of gravitational instability, density perturbations have given rise to collapsed DM structures, is called halos. These DM halos provide the backdrop for the subsequent formation of all collapsed baryonic structures, including stars, galaxies, and galaxy clusters.

We showed that the dark energy dominated background delays the virialization of structures and formation of BM which proceeds a larger structures. In other word, it causes an increase of virial radius of DM without deferment. Using Planck data in scalar field models shows that dark energy is an element to the intensification of dark matter radius. However, BM cannot be constructed with such data. Our study on WACDM data shows that the presence of dark energy alongside time-dependent parameter of state and baryon acoustic oscillations are shrinking reasons of radius for DM and absence of structure for BM. Due to lack of data on the absence of baryonic acoustic waves in the background, we are left unable to delineate its impact on the structures.

Finally on WCDM data, the presence of baryon acoustic oscillations plays an influential role in postponing. In turn, it causes decrease and increase to virial radius of dark and baryonic matter and the absence of BAO delays formation and abates virial radius of BM. The structure formation in a standard model is dependent on BAO. WCDM and ΛCDM have the same effect on formation if we do not consider dark energy in BG. Planck data, in comparing with WMAP, has important role in describing standard model.

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