Journal of Physical Science and Environmental Studies
Vol. 1 (5), pp. 68-75, December, 2015
ISSN 2467-8775
Review
http://pearlresearchjournals.org/journals/jpses/index.html

Kantowski-Sacks Interacting Holographic Dark Energy Model in Barber's Self Creation Theory

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Accepted 5 September, 2015

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ABSTRACT

We study the holographic dark energy models with Kantowski-Sachs (KS) space-time in Barber's second self-creation theory of gravitation. The solutions of the field equations are obtained with the help of two assumptions viz., (i) power law assumption for the average scale factor and (ii) a relation between two metric coefficients. It is observed that, in the KS model, the EoS parameter of dark energy transits from quintessence era toward vacuum era. Some properties of physical and kinematical parameters are also discussed.

Keywords: Interacting, Holographic, Dark Energy, Self-Creation Theory, PACS: 98.80.ES; 98.80-K.

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INTRODUCTION

To extend the concept of theory of general relativity, Brans and Dicke (1961) have developed a theory which includes a long range scalar field interacting equally with all forms of matter with the exception of electromagnetism. Barber (1982) has proposed two continuous self-creation theories by modifying the general relativity and Brans and Dicke (BD) theory. The Barber's first theory is considered to be an alternative to BD theory but Brans (1987) has pointed out that the first theory severely violates the equivalence principle. The second theory is a modification of general relativity to a variable G theory and the gravitational coupling of the Einstein field equations is allowed to be a variable scalar on the space time manifold. It is postulated that this scalar couples to the trace of the energy momentum tensor. Hence the field equations, in Barber's second theory, are

$$R_{ij} - \frac{1}{2} g_{ij} R = -\frac{8\pi}{\phi} T_{ij} \qquad (1)$$

Where R_{ij} is the Ricci tensor; $R = g^{ij} R_{ij}$ is the Ricci scalar; and T_{ij} is the energy momentum tensor and.

$$\Box \phi = \frac{8\pi}{3} \eta T . \qquad (2)$$

Where $\Box \phi = \phi_{;k}^{;k}$ is the invariant D'Alembertian and the contracted tensor T is the trace of the energy momentum tensor described all non-gravitational and non-scalar field matter. In this theory the scalar field does not directly gravitate, but simply divides the matter tensor and acting as a reciprocal gravitational constant. The measurements of the deflection of light restrict the value of the coupling to $|\eta| \le 10^{-1}$. In the limit $\eta \to 0$, this theory leads to Einstein's theory in every respect. The Barber's second self-creation theory has been extensively discussed by Soleng (1987). Reddy (1987), Mohanty et al. (2002) Mohanty and Sahu (2006), Panigrahi and Sahu (2004), Rathore (2010), Venkateswarlu and Pavan kumar (2006) and Venkateswarlu et al. (2008).

In recent times the occurrence of an accelerated expansion of the universe is observed in the literature. The most important and striking aspect of particle physics cosmology is the origin of the accelerated expansion of the universe. It is believed that the theory of dark energy having negative pressure is mostly responsible for this situation. Standard cosmology can only explain this observational fact if the cosmic fluid in recent past is dominated by exotic matter having large negative pressure. Further, the observations predict that nearly 73% of our universe is filled up with that type of components like dark energy (DE). The simplest choice for the dark energy candidate is the cosmological constant 'Λ' and the favored cosmological model which fits most of the observational data is the Λ–cold–dark–matter (ΛCDM) model which represents a vacuum energy density having equation of state parameter (EoS) $\omega = -1$. Although the model predicts cosmic acceleration as well as a reasonable agreement with observational data, there are some upsetting issues related to this model, namely, cosmological constant problem (Weinberg, 1989; Carroll, 2001) (the huge discrepancy between the observed value of the cosmological constant and the one predicted in quantum field theory), coincidence problem (Copeland et al., 2006) (although generically small, but the cosmological constant happens to be exactly of the value required to become dominant at the present epoch) and, recently, it was shown that the CDM model may also suffer from the age problem (Yang and Zhang, 2010).

Due to those problems in the above model, scalar field models, namely, quintessence (Caldwell et al., 2002), phantom (Hooft,1993), K–essence (Armendariz-Picon et al., 2001), Tachyon (Padmanabhan, 2002), Quintom (Elizalde et al., 2004) attracted special attention as dynamical DE models. In recent years, an interesting observation is made to determine the nature of dark energy in quantum gravity which is termed as holographic dark energy (Bekenstein, 1973; Hooft,1993; Bousso,1999; Cohen, 1999; Susskind, 1994). The holographic principles say that the entropy of a system scales not with its volume but with its surface area Li (2004). The holographic dark energy density ρ_Λ and the Hubble parameter H are connected by

$$\rho_\Lambda = H^2 \qquad (3)$$

Which does not contribute to the present accelerated expansion of the Universe. Granda and Olivers (2008) proposed another relation between holographic dark energy density ρ_Λ and the Hubble parameter H in the following form.

$$\rho_\Lambda \approx \left(\alpha H^2 + \beta \dot{H}\right) \qquad (4)$$

Where α and β are constants. Sarkar and Mahanta (2013) Samanta (2013) Sheykhi and Jamil (2011), Gitumani (2014) have studied the holographic dark energy models with quintessence. Karami and Fehri (2010) has studied the correspondence between the quintessence, tachyon, K-essence and dilation scalar field models with the new holographic dark energy model in non-flat FRW model. In 2003, Sahni et al. (2003). proposed state finder parameters {r, s} which are defined as

$$r = \frac{\dddot{a}}{aH^3}\text{, and}\qquad s = \frac{r-1}{3(q-\frac{1}{2})}$$

Where the overhead dot denotes differentiation with respect to *t.* Here *'a'* is the average scale factor of the FRW model and H and $q = \left(-\frac{a\ddot{a}}{\dot{a}^2}\right)$ are the Hubble parameter and the deceleration parameter, respectively.

In fact the parameter *'r'* forms the next step in the hierarchy of the geometrical cosmological parameters after H and q. These dimensionless parameters characterize the properties of dark energy in a model in independent manner. According to Sahni et al. (2003), trajectories in the {r, s} plane corresponding to different cosmological models demonstrate qualitative different behavior, and therefore, the state finder diagnostic together with observations may discriminate between different DE models. Inspired by the above work, some more general geometrical cosmological parameters are introduced. In fact, they are obtained from the Taylor series expansion of the scale factor. These geometrical cosmological parameters are the jerk parameter j (same as r), snap parameter s (different from the above defined s parameter by Sahni et al. (2003), lerk parameter l and *m* parameter. The study of the above four parameters for a particular dark energy model together with the deceleration parameter is known as the Cosmography of the model. In this connection, one may see the evolution equations for the modified and the interacting modified holographic Ricci dark energy and their state finder diagnoses (Mathew et al., 2013). In the present work, we study the Kantowski-Sachs space-time in Barber's second self-creation theory of gravitation with holographic dark energy. We study the cosmographic analysis for the interacting DE model for the above three choices of the interaction term. Some physical and geometrical properties of the model are studied. Conclusions are given at the end.

KANTOWSKI-SACHS METRIC AND FIELD EQUATIONS

We consider the Kantowski-Sachs metric in the form

$$ds^2 = dt^2 - A^2 dr^2 - B^2\left(d\theta^2 + \sin^2\theta\, d\phi^2\right)$$
(5)

Where A and B are functions of time only. Kantowski-Sachs class of metric represents homogeneous but anisotropic ally expanding (contracting) cosmologies and provides models where the effect of anisotropy can be estimated and compared with FRW class of cosmologies. The energy momentum tensor for matter and holographic dark energy are defined as

$$\left.\begin{aligned} T_{ij} &= \rho_m u_i u_j \\ \overline{T}_{ij} &= (\rho_h + P_h) u_i u_j + g_{ij} P_h \end{aligned}\right\} \quad (6)$$

Where ρ_m are pressure and energy density of matter, ρ_h is holographic dark energy and P_h is pressure of the holographic dark energy Also, the energy conservation equation is

$$T^{ij}_{;j} + \overline{T}^{ij}_{;j} = 0 \quad (7)$$

The velocity u^i describes the 4 velocity which has components (1, 0, 0, 0) for a cloud of particles. The energy momentum tensor for matter and the holographic dark energy is given by

$$T_i^{\ j} + \overline{T}_i^{\ j} = diag\left[T_1^1 + \overline{T}_1^{\ 1}, T_2^2 + \overline{T}_2^{\ 2}, T_3^3 + \overline{T}_3^{\ 3}, T_4^4 + \overline{T}_4^{\ 4}\right]$$
(8)

Here we are dealing with an anisotropic holographic dark energy. We can parameterize Equation (4) as

$$T_i^{\ j} + \overline{T}_i^{\ j} = diag\left[P_h, P_h, P_{h,} \rho_m + \rho_h\right] \quad (9)$$

For the line element (5) the field Equations (6) and (7) leads to the following system of equations:

$$2\frac{\ddot{B}}{B} + \frac{\dot{B}^2}{B^2} + \frac{1}{B^2} = -\frac{8\pi}{\phi} P_h \quad (10)$$

$$\frac{\ddot{A}}{A} + \frac{\ddot{B}}{B} + \frac{\dot{A}\dot{B}}{AB} = -\frac{8\pi}{\phi} P_h \quad (11)$$

$$\frac{2\dot{A}\dot{B}}{AB} + \frac{\dot{B}^2}{B^2} + \frac{1}{B^2} = \frac{8\pi}{\phi}\left(\rho_m + \rho_h\right) \quad (12)$$

$$\ddot{\phi} + \left(\frac{\dot{A}}{A} + 2\frac{\dot{B}}{B}\right)\dot{\phi} = \frac{8\pi}{3}\left(\rho_m + \rho_h + 3P_h\right) \quad (13)$$

Using barotropic equation of state $P_h = \omega \rho_h$, we may write the continuity Equation (3) of the matter and dark energy as

$$\dot{\rho}_m + \left(\frac{\dot{A}}{A} + 2\frac{\dot{B}}{B}\right)\rho_m + \dot{\rho}_h + \left(\frac{\dot{A}}{A} + 2\frac{\dot{B}}{B}\right)(1+\omega)\rho_h = 0 . \quad (14)$$

Here we are considering the minimally increasing interacting matter and holographic dark energy components. Hence both components conserve separately, so that from Akarsu and Kilinc (2010) we have

$$\dot{\rho}_m + \left(\frac{\dot{A}}{A} + 2\frac{\dot{B}}{B}\right) \rho_m = 0 \quad (15)$$

$$\dot{\rho}_h + \left(\frac{\dot{A}}{A} + 2\frac{\dot{B}}{B}\right) (1+\omega)\rho_h = 0 \quad (16)$$

Where

$$\omega = \frac{P_h}{\rho_h} . \quad (17)$$

The following are the physical and geometrical parameters to be solved in Barber's self creation field equations for the space time given by Equation (1).The expansion scalar θ for this metric is $\theta = \frac{\dot{A}}{A} + 2\frac{\dot{B}}{B}$. Defining the directional Hubble parameters along the axis of symmetry are $H_1 = \frac{\dot{A}}{A}$ and $H_2 = \frac{\dot{B}}{B}$. The scalar expansion can be expressed in terms of the directional Hubble parameters as $\theta = \left(H_1 + 2H_2\right)$.The shear scalar for the plane symmetric metric defined in (1) is expressed as

$$\sigma^2 = \frac{1}{2}\left[\sum_i H_i^{\ 2} - \frac{1}{3}\theta^2\right] = \frac{1}{3}\left(H_1 - H_2\right)^2 \quad (18)$$

The shear scalar may be taken to be proportional to the expansion scalar which envisages a linear relationship between the directional Hubble parameters H_1 and H_2 as $H_1 = m\, H_2$. This assumption leads to an anisotropic relation between the scale factors A and B as

$A = B^m$ (19)

Where m is an arbitrary positive constant. If $m = 1$, the model becomes isotropic model otherwise the model becomes anisotropic model. The mean Hubble parameter can now be expressed as

$$H = \frac{1}{3}(m+2)H_2 .$$

The average anisotropic parameter $A_m = \frac{1}{3}\sum\left(\frac{\Delta H_i}{H}\right)^2$ for the model is

$$A_m = 2\left(\frac{m-1}{m+2}\right)^2 . \quad (20)$$

SOLUTION AND THE MODEL

Now Equations (6-9) are a system of four independent equations in six unknowns. Firstly, we assume a constant deceleration parameter which favours a power law form for average scale factor. Moreover, it has become a usual practice in the literature to use a power law to address different issues in cosmology in the framework of scalar tensor theories. The scale factor of the universe can be fixed from the behaviour of the deceleration parameter or the assumed dynamics of the late time accelerated universe.

The average scale factor *a (t)* of the Kantowski-Sachs space time is assumed as

$$a = (AB^2)^{\frac{1}{3}} = t^n \quad (21)$$

Using Equations (15 and 17), the solution of the field equations can be expressed as

$$A = t^{\frac{3mn}{m+2}}$$
$$B = t^{\frac{3n}{m+2}} \quad (22)$$

And the scalar field is given by

$$\phi(t) = c_1 t^{\frac{1-3n}{2}+\frac{\sqrt{(3n-1)^2-4\eta X}}{2}} + c_2 t^{\frac{1-3n}{2}-\frac{\sqrt{(3n-1)^2-4\eta X}}{2}} \quad (23)$$

Where $X = 6n^2(m^2+2) - 4n(m-1)(m+2)$. Now the corresponding KS model in Barber second self-creation theory can be written as

$$ds^2 = dt^2 - t^{\frac{6mn}{m+2}}dr^2 - t^{\frac{6n}{m+2}}\left(d\theta^2 + \sin^2\theta\, d\phi^2\right) \quad (24)$$

The model given by Equation (24) possess singularity at m=-2. The following are the physical and geometrical parameters for the model:

(i) -The expansion scalar θ for this metric: $\theta = \frac{3n}{t}$

(ii) The mean Hubble parameter: $H = \frac{n}{t}$

(iii) The shear scalar: $\sigma^2 = \frac{3(m-1)^2 n^2}{(m+2)^2 t^2}$

(iv) The spatial Volume: $V = t^{3n}$

It may be observed that the model starts with big-bang. Figure 1. Depicts the variation of the scalar field ϕ with time. The scalar field oscillates initially and becomes zero at late times. Cosmologies with a power law scale factor are widely discussed in the literature (Kumar, 2012). The success of the power law model lies with the fact that models with $m \geq 1$ do not encounter the horizon problem and do not witness the flatness problem. From the analysis of observational constraints from *H (z)* and SNIa data, Kumar (2012) has shown that a power law cosmology is viable in the description of the acceleration of the present day universe even though it fails to produce primordial nucle synthesis. Now using Equation (24) in (10) and (12) with the help of (23), we obtain the pressure of holographic energy

$$P_h = -\frac{c_1 t^{\frac{1-3n}{2}+\frac{\sqrt{(3n-1)^2-4\eta X}}{2}} + c_2 t^{\frac{1-3n}{2}-\frac{\sqrt{(3n-1)^2-4\eta X}}{2}}}{16\pi}$$

$$\left\{\left(\frac{(m+3)\left[9n^2 - 3n(m+2) + 9n^2(1+m^2)\right]}{(m+2)^2 t^2}\right) + \frac{1}{t^{\frac{6n}{(m+2)}}}\right\} \quad 25$$

The behaviour of holographic pressure with reference to cosmic time is shown in the following figure. From Figure (2), the holographic pressure takes negative values at early times and vanishes at late times. Using Equation (24) in (15) we get the energy density of dark matter as

$$\rho_m = \frac{\rho_0}{t^{3n}} \quad (26)$$

Now using Equations (26), (24) and (23) in Equation (17), we obtain energy density of holographic dark energy as

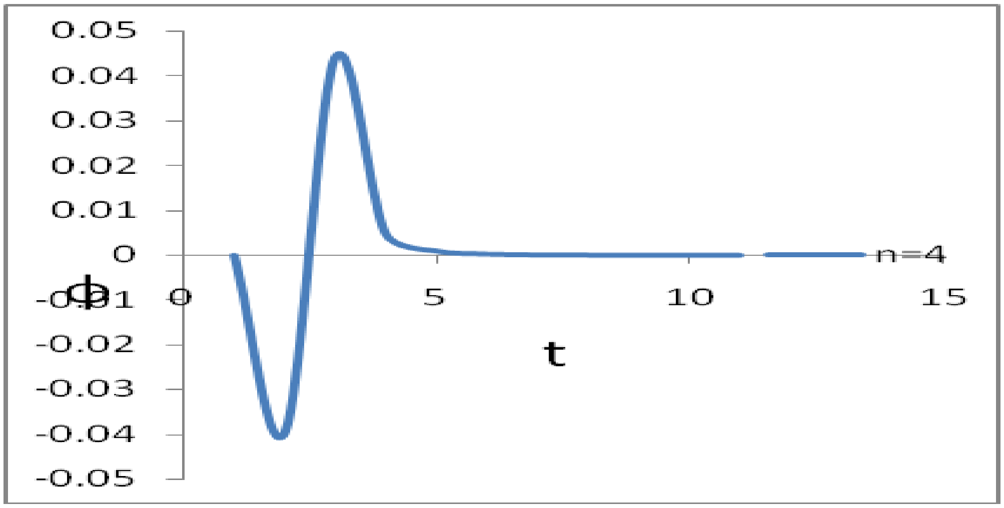

Figure 1. Plot of scalar field φ vs. time *t* for m=3, n=4, η=0.003.

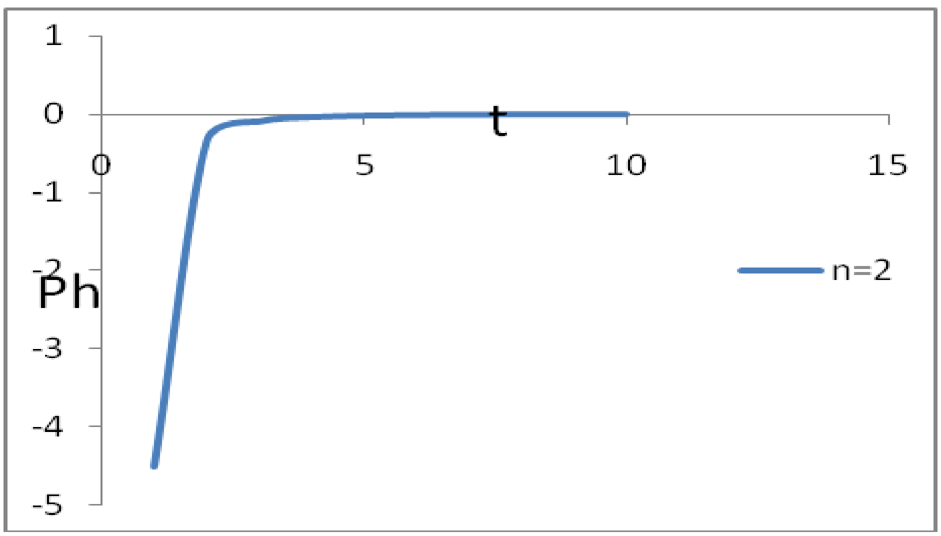

Figure 2. Plot of holographic pressure vs. time for m=3, n=2, η=0.002.

$$\rho_h = \frac{c_1 t^{\frac{1-3n}{2}+\frac{\sqrt{(3n-1)^2-4\eta X}}{2}} + c_2 t^{\frac{1-3n}{2}-\frac{\sqrt{(3n-1)^2-4\eta X}}{2}}}{8\pi}\left(\frac{9n^2(2m+1)}{(m+2)^2 t^2} + \frac{1}{t^{\frac{6n}{(m+2)}}} - \frac{\rho_0}{t^{3n}}\right) \tag{27}$$

Figure 3 shows the flight of holographic density which starts at high value initially and suddenly drops. As time increase, the holographic density reduces to a small value and becomes zero. Using Equation (14), (21) and (23), The EOS parameter of holographic dark energy is given by

$$\omega = -\frac{\left(\frac{(m+3)\left[9n^2-3n(m+2)+9n^2(1+m^2)\right]}{(m+2)^2 t^2}\right) + \frac{1}{t^{\frac{6n}{(m+2)}}}}{\left(\frac{9n^2(2m+1)}{(m+2)^2 t^2} + \frac{1}{t^{\frac{6n}{(m+2)}}} - \frac{\rho_0}{t^{3n}}\right)} \tag{28}$$

Which shows that ω is a function of cosmic time. From Figure 4, the equation of state parameter ω takes on negative values in the range $-1 \le \omega < -0.4$. Therefore, dark energy density transits from vacuum era to quintessence era in Barber's second self creation theory. At the early stage EoS parameter in Barber's second self creation theory mimic vacuum era, this is mathematically

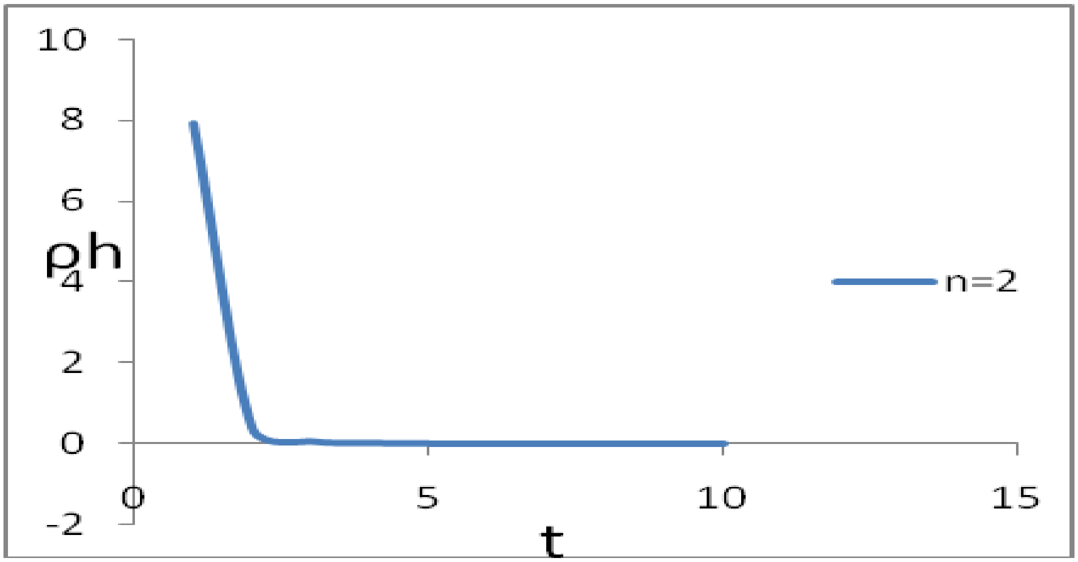

Figure 3. Plot of holographic density vs. time for m=3, n=2, η=0.002.

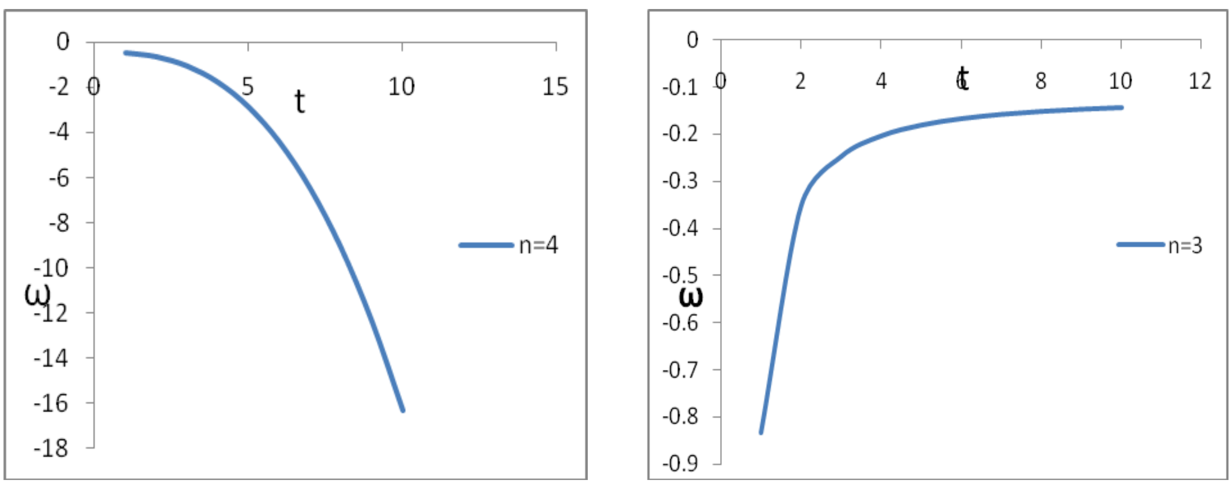

Figure 4. The plot of EOS parameter ω vs. time t for m=3, n=4, η=0.002, The plot of EOS parameter ω vs. time t for m=2, n=3, η=0.002.

equivalent to the cosmological constant. This class of value of EoS parameter is called quintessence $\omega < \frac{-1}{3}$, which is a necessary condition to accelerate the universe (Sahni et al., 2003). In the KS model, the EoS parameter of dark energy transits from quintessence $\frac{-1}{3} > \omega > -1$ era toward vacuum era $\omega = -1$. From this figure we observe that the dark energy model, for *n=2, 3, 4 and m=3*, evolves from the matter dominated era to quintessence era for *n=0.1, 0.15, 0.2* and *m=3* and ultimately approaches to cosmological constant era. The coincident parameter is given by

$$r = \frac{\rho_h}{\rho_m} = \frac{c_1 t^{\frac{1-3n}{2}+\frac{\sqrt{(3n-1)^2-4\eta X}}{2}} + c_2 t^{\frac{1-3n}{2}-\frac{\sqrt{(3n-1)^2-4\eta X}}{2}}}{8\pi\rho_0}\left(\frac{9n^2(2m+1)}{(m+2)^2}t^{(3n-2)} + t^{\frac{3mn}{(m+2)}} - 1\right) \quad (29)$$

The matter density parameter Ω_m and holographic dark energy density parameter Ω_h are given by

$$\Omega_m = \frac{\rho_m}{3H^2} \text{ and } \Omega_h = \frac{\rho_h}{3H^2} \quad (30)$$

Using Equations (25), (26) and (30) we get the overall density parameter as

$$\Omega = \Omega_m + \Omega_h = \frac{\rho_0 t^{2-3n}}{3n^2} + \left[\frac{c_1 t^{\frac{1-3n}{2}+\frac{\sqrt{(3n-1)^2-4\eta X}}{2}} + c_2 t^{\frac{1-3n}{2}-\frac{\sqrt{(3n-1)^2-4\eta X}}{2}}}{24n^2\pi} \left(\frac{9n^2(2m+1)}{(m+2)^2} + \frac{1}{t^{\frac{6n}{(m+2)}-2}} - \frac{\rho_0}{t^{3n-2}} \right) \right] \quad (31)$$

Deceleration parameter $q = -\frac{\ddot{a}}{aH^2}$ and jerk parameter $j = \frac{\dddot{a}}{aH^2}$ are considered as important quantities in the description of the dynamics of universe. The observational constraints as set upon these parameters in the present epoch from type Ia supernova and X-ray cluster gas mass fraction measurements are $q_0 = -0.81 \pm 0.14$ and $j_0 = 2.16 \pm^{0.81}_{-0.76}$.

In a recent work, the deceleration parameter is constrained from *H(z)* and SN Ia data to be $q = -0.34 \pm 0.05$ (Kumar, 2012). Experimentally it is challenging to measure the deceleration parameter and jerk parameter and one needs to observe objects of red shift $z \geq 1$. In an attempt to investigate the accelerated expansion of the universe, the sign and behaviour of these parameters have been considered in different manners in different works. The time variation of the deceleration parameter is under debate even though, in certain models, a time varying *q* leads to a cosmic transit from early deceleration to late time acceleration (Yadav and Sharma, 2013; Adhav, 2011; Akarsu and Dereli, 2012; Pradhan et al., 2011). However, at a late of time of cosmic expansion, the deceleration parameter is believed to vary slowly with time or to become a constant. A constant deceleration parameter leads to two different volumetric expansions of the universe, namely the power law expansion and exponential expansion.

In a model with exponential expansion, the radius scale factor increases exponentially with time, leading to a constant Hubble rate. In a model with power law expansion of the volume scale factor, the scale factor can be expressed as a cosmic time raised to some positive power. The Hubble parameter for such a power law model behaves reciprocally to the cosmic time. In the present work, we are interested in models describing a late time universe with the predicted cosmic acceleration and therefore we will consider the power law expansion of the scale factor corresponding to a constant and variable (decaying) mean Hubble rate, that is, $H = H_0$ and $H = \frac{n}{t}$, where H_0 and n are positive constants. It is worth to mention here that the choice of a constant deceleration parameter cannot provide a time dependent cosmic transition from a deceleration phase in the past to an accelerated phase at late times. The deceleration parameter for this model is $q = \frac{1}{n} - 1$. In order to be in the safe zone for accelerated expansion, the predicted deceleration parameter should be negative and that can be achieved only if $n > 1$. In terms of the deceleration parameter, the parameter m can be expressed as $n = \frac{1}{1+q}$. Considering the observational constraints from (Rapetti et al., 2007), we put the constraints on n to be $3.03 \leq n \leq 20$. Corresponding to the constraints from (Kumar, 2012) n can be constrained in the range $1.4085 \leq n \leq 1.6393$. The jerk parameter is calculated to be $j = \frac{(n-1)(n-2)}{n^2}$ and can be constrained in the range $0.69 \leq j \leq 17.1$ (Rapetti et al., 2007), and $-0.1716 \leq j \leq -0.1407$ (Kumar, 2012). It is worth to mention here that the exact determination of the jerk parameter involves the observation of high-z supernovae, which is a tough task. Therefore, current observational data have not yet been able to identify the range or sign of the jerk parameter.

Conclusion

In the present work, we have investigated the Kantowski-Sachs model in Barber's second self-creation cosmology with holographic dark energy. The shear scalar is considered to be proportional to the scalar expansion, which simulates a linear relationship among the directional Hubble rates incorporating anisotropy in expansion rates along different spatial directions. It is observed that the model possess a singularity at $m = -2$. It is further noted that the scalar field shows oscillating behaviour at early time and becomes zero as time approaches to infinity. Since $q = \frac{1}{n} - 1$, the model acceleration/deceleration depend on the value of the constant n. The anisotropic nature of the model does not affect the behaviour of the scalar field. It is found that if $\eta \to 0$, the Barbers self-creation theory tends to general theory of relativity in all respects. The expressions for the EoS parameter, deceleration parameter and fraction parameter of dark energy are obtained for two mentioned cutoffs and found that phantom crossing is possible in both the cutoffs by tuning the free parameters of the model. Note that in almost every cosmological model the fine tuning of parameters is necessary and our model also is no exception. Models considered in this paper are of considerable interest and may be useful in self-creation cosmology to study the large-scale dynamics of the physical universe.

REFERENCES

Adhav KS (2012). LRS Bianchi type-I cosmological model with linearly varying deceleration parameter.Eur. Phys. J. Plus 126:122 (2011)

Akarsu O, Dereli T (2012). Cosmological models with linearly vary in deceleration parameter. Int. J. Theor. Phys. 51: 612.

Akarsu O, Kilinc CB (2010). LRS Bianchi type I models with anisotropic dark energy and constant deceleration parameter. General Relativity and Gravitation. 42:119-140. Kumar S (2012). Observational constraints on Hubble constant and deceleration parameter in power-law cosmology. Mon. Not. R. Astron. Soc. 422: 2532.

Armendariz-Picon C, Mukhanov V, Steinhardt P(2001). Essentials of k-essence J. Phys. Rev. D 63:103510.

Barber GA (1982). On two "self-creation" cosmologies," General Relativity and Gravitation.14(2): 117-136.

Bekenstein JD (1973). Black Holes and Entropy. Phys. Rev. D 7: 2333.

Bousso R (1999). A Covariant Entropy Conjecture. J.High Energy Phys.7:4.

Brans C (1987).Consistency of field equations in "self-creation" cosmologies. General Relativity and Gravitation.19(9): 949-952.

Brans H, Dicke, R H (1961).Mach's Principle and a Relativistic Theory of Gravitation. Phy. Rev. 124(3): 925-935.

Caldwell RR, Dave R, Steinhardt PJ (2002). A phantom menace Cosmological consequences of a dark energy component with super-negative equation of state. Phys. Lett. B. 545 (1-2) :23-29.

Carroll SM (year).Can the Dark Energy Equation-of-State Parameter w be Less than -1. Phys. Rev. D. 68 : 023509-023538.

Cohen A (1999). Effective Field Theory, Black Holes, and the Cosmological Constant. Phys. Rev. Lett. 82: 497.

Copeland EJ, Sami M, Tsujikawa S (2006). Dynamics of darkenergy. Int. J. Modern Phys. 15(11) : 1753–1935.

Elizalde E, Nojiri S, Odintsov SD (2004). Late-time cosmology in a (phantom) scalar-tensor theory: Dark energy and the cosmic speed-up.Phys. Rev. D 70: 043539.

Ghanshyam SR (2010). Five dimensional perfect fluid cosmological models in barber's second self-creation theory. Adv. Stud. Theor. Phys. 4. p.213

Gitumani S (2014). Holographic Dark Energy in LRS Bianchi Type-II Space Time"**,**International Journal of Mathematics And Statistics Invention 2:38.

Granda LN (2008). Infrared cut-off proposal for the holographic density. Phys. Lett. B 669: 275.

Hooft G (1993). Dimensional reduction in quantum gravity. World Scientific Series in 20th Century Physics, vol. 4, ed. A. Ali, J. Ellis and S. Randjbar-Daemi (World Scientific, 1993), THU-93/26, gr-qc/9310026.

Karami, K., Fehri (2010). New holographic scalar field models of dark energy in non-flat universe. J. Phys. Lett. B. 684: 61.

Li M (2004). A model of holographic dark energy. J.Phys. Lett. B 603:1.

Mathew TK, Suresh J, Divakaran, D (2013).Modified holographic Ricci dark energy model and state finder diagnosis in flat universe. Int. J. Mod. Phys. D 22:1350056.

Mohanty G, Mishra B, Biswal AK (2002). Cosmological Models in Barber's Second Self-Creation Theory. Czech. J. Phys. 52:1289.

Mohanty G, Sahu RC (2006). Inhomogeneous "Mesonic Perfect Fluid Models in Modified Theory of General Relativity.Astrophys. Space Sci. 306:179.

Padmanabhan T (2002). Accelerated expansion of the universe driven by tachyonic matter.Phys. Rev. D 66: 021301.

Panigrahi UK, Sahu RC(2004). Plane Symmetric Cosmological Macro Models in Self-creation Theory of Gravitation. Czech. J. Phys. 54: 543.

Pradhan A, Amirhashchi H, Saha B (2011). Bianchi Type I Anisotropic Dark Energy Models with Constant Deceleration Parameter). Int. J. Theor. Phys. 50:2923.

Rapetti D, Allen SW, Amin MA, Blandford RD (2007). A kinematical approach to dark energy studies. Mon. Not. R. Astron.Soc. 375:1510.

Reddy DRK (1987). Bianchi type-I vacuum model in self-creation cosmology. Astrophys. Space Sci.132(2) :401-403.

Sahni V , Saini TD, Starobinsky AA, Alam U (2003). State finder—a new geometrical diagnostic of dark energy.J. Exp. Theor. Phys. Lett. 77: 201-206.

Samanta GC (2013). Holographic dark energy cosmological models with quintessence in Bianchi type-V space time. Int.J.Theor.Phys.52: 4389.

Sarkar S, Mahanta CR (2013). Holographic Dark Energy Model with Quintessence in Bianchi Type-I Space-Tim. Int.J.Theor.Phys.52: i482.

Sheykhi A, Jamil M (2011). Interacting HDE and NADE in Brans–Dicke chameleon cosmology. Phys. Lett. B 694: 284

Soleng HH (1987). Cosmic shear in inflationary models of Bianchi types VIII and IX. Astrophys. Space Sci.137:373-384.

Soleng HH (1987). Self-creation cosmological solutions. Astrophysics and Space Sci.139:13-19.

Susskind L (1994). The World as a Hologram. J. Math. Phys. (NY) 36: 6377

Venkateswarlu R, Kumar KP (2006). Higher Dimensional FRW Cosmological Models in Self-Creation Theory. Astrophys. Space Sci. 301 : 73-77.

Venkateswarlu R, Rao VUM, Kumar KP (2008). String cosmological solutions in self-creation theory of gravitation. Int. J. Theor. Phys.p.640.

Weinberg S (1989). The cosmological constant problem. Rev. Mod. Phys 61.p.1.

Yadav AK, Sharma A (2013). A transitioning universe with time varying G and decaying Λ. Res. Astron. Astrophys. 13:501

Yang RJ, Zhang SN (2010).The age problem in the ΛCDM model .Mon. Not. R. Astron. Soc. 407:1835.