CHAPTER 7

ANISOTROPIC GHOST DARK ENERGY COSMOLOGICAL MODEL WITH HYBRID EXPANSION LAW

7.1 Introduction

The last two decades of research made in Observational Cosmology have brought about a revolution in our understanding of the universe. The cosmological observations such as type Ia supernovae (SNeIa) (Riess et al., 1998; Perlmutter et al., 1999), galaxy red shift surveys (Fedeli et al., 2009), Cosmic Microwave Background Radiation (Caldwell and Doran, 2004; Huang et al., 2006), Large Scale Structure (Daniel et al., 2008) suggest that the universe is undergoing a phase of late cosmic acceleration. For this acceleration a new type of energy with negative pressure is supposed to be responsible which is commonly known as dark energy (DE) (Peebles and Ratra, 2003).

In Physical Cosmology and Astronomy, the simplest model for dark energy is the cosmological constant \( \Lambda \). The cosmological constant corresponds to a fluid with a constant equation of state \( \omega = -1 \) and is consistent with all observational data. But from the theoretical point of view it is plagued with the fine tuning and cosmic

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coincidence problem (Weinberg, 1989; Overduin and Coperstock, 1998). For these reasons the cosmological constant with dynamical character is preferred over the constant cosmological constant. To further investigate the true nature of dark energy and the accelerated expansion of the universe, many dynamical dark energy models have been proposed, such as Quintessence (Barreiro et al., 2000), phantom (Caldwell, 2002), k-essence (Picon et al., 2001), tachyon (Bagla et al., 2003), Chaplygin gas (Bento et al., 2002), Holographic dark energy (Li, 2004) etc.

Among the various models of dark energy, a new model called Veneziano ghost dark energy (GDE) introduced to describe the accelerated expansion of the universe (Urban and Zhitnitsky, 2009), has attracted a lot of interest in recent years (Urban and Zhitnitsky, 2010; Ohta, 2011; Cai et al., 2011a). This model has been created from the Veneziano ghost of chromodynamics (QCD) (Veneziano, 1979). The $U(1)_A$ problem in low energy effective theory can be explained by Veneziano ghost field. Although the ghost field has no contribution to the vacuum energy density in Minkowski space-time, it contributes to the vacuum energy density proportional to $\Lambda_{QCD}^3H$ i.e. $(10^{-3} \text{eV})^4$ with $H(\text{Hubble parameter}) \sim 10^{-33} \text{eV}$ and $\Lambda_{QCD}(\text{QCD mass scale}) \sim 100 \text{eV}$ in a curved space-time (Zhitnitsky, 2010; Holdom, 2011; Zhitnitsky, 2011). This numerical coincidence means that the ghost dark energy model gets rid of fine-tuning problem. The energy density of ghost dark energy is given by the relation $\rho_e = \tau H$ (Ohta, 2011) where $\tau$ is a constant parameter. A generalized model was proposed by Cai (Cai et al., 2012) for which energy density is given as $\rho_e = \eta H + \xi H^2$, $\eta$ and $\xi$ being constant parameters.
Experimental studies of the isotropy of the cosmic microwave background radiation (CMBR) (Bennett et al. 2013) support the existence of anisotropic expansion phase of the evolution of the universe, which evolves into an isotropic one (Misner, 1968, Chimento, 2004). This very fact forces one to study the evolution of the universe with the anisotropic background. Bianchi type space-times provide such a framework. Several researchers (Saha, 2005; Koivisto and Mota, 2006; Bali and Pradhan, 2007; Akarsu and Kilinc, 2010) have used Bianchi type models to study the evolution of the universe with the anisotropic background. Kumar and Yadav (2011) studied power law and exponential law cosmologies within the framework of Bianchi type -V models with non-interacting matter fluid and dark energy components. Kumar (2013) investigated Bianchi type -V space-time by considering the average scale factor that yields multiplication of power law and exponential law which we call hybrid expansion law (HEL). Recently Mishra and Tripathy (2015), Das and Sultana (2015) have studied cosmological models by considering hybrid expansion law. The above mentioned works have inspired us to study the Bianchi type VI\textsubscript{0} space time filled with dark matter and anisotropic ghost dark energy using hybrid expansion law.

This Chapter is organized as follows. The metric and field equations are given in Sec. 7.2. Solutions of the field equations are presented in Sec. 7.3. In Sec. 7.4, we consider the state finder diagnostic analysis. We conclude this Chapter with a brief discussion in Sec. 7.5.
7.2. Metric and field equations

We consider the anisotropic Bianchi type- VI0 line element in the form

\[ ds^2 = dt^2 - A^2 dx^2 - B^2 e^{2x} dy^2 - C^2 e^{-2x} dz^2 \] (7.1)

where A, B, C are the metric functions of cosmic time t.

We assume that the universe is filled with matter and an anisotropic fluid composed of the ghost dark energy components.

The Einstein field equations are

\[ R_{ij} - \frac{1}{2} g_{ij} R = -(T_{ij} + \bar{T}_{ij}) \] (8\pi G = 1 and c = 1) (7.2)

where \( R_{ij} \) is the Ricci tensor, \( R \) is the Ricci scalar, \( T_{ij} \) and \( \bar{T}_{ij} \) are the energy-momentum tensor for matter and anisotropic ghost dark energy respectively.

The energy-momentum tensor for matter is

\[ T_{ij} = \text{diag}[\rho_m, 0, 0, 0] \] (7.3)

where \( \rho_m \) is the energy density of matter.

The energy-momentum tensor for anisotropic ghost dark energy is taken as

\[ \bar{T}_{ij} = \text{diag}[\rho_e, -p_e^x, -p_e^y, -p_e^z] \] (7.4)

where \( \rho_e \) is the energy density for the ghost dark energy, \( p_e^x, p_e^y \) and \( p_e^z \) are the pressures in the directions of x, y and z axes respectively.
By parameterizing it, we get

\[ \bar{T}_{ij} = \text{diag} \left[ 1, -\omega_x, -\omega_y, -\omega_z \right] \rho_e \]

\[ = \text{diag} \left[ 1, -\omega_e, -(\omega_e + \delta), -(\omega_e + \gamma) \right] \rho_e \] (7.5)

where \( \omega_x = \omega_e, \omega_y = \omega_e + \delta, \omega_z = \omega_e + \gamma \) are the directional EoS parameters along x, y, z axes respectively. \( \omega_e \) is the deviation free EoS parameter of the fluid and \( \delta, \gamma \) are the skewness parameters which are the deviations from \( \omega_e \) along the y and z axes respectively.

With Eqs. (7.3) and (7.5), Einstein’s field equations (7.2) for the metric (7.1) lead to the following system of equations

\[ \frac{B}{B} + \frac{C}{C} + \frac{B}{B} \frac{C}{C} + \frac{1}{A^2} = -\omega_e \rho_e \] (7.6)

\[ \frac{C}{C} + \frac{\dot{A}}{A} + \frac{\dot{C}}{C} \frac{A}{A} - \frac{1}{A^2} = -\left(\omega_e + \delta\right) \rho_e \] (7.7)

\[ \frac{\dot{A}}{A} + \frac{\dot{B}}{B} + \frac{\dot{A}}{A} \frac{B}{B} - \frac{1}{A^2} = -\left(\omega_e + \gamma\right) \rho_e \] (7.8)

\[ \frac{A}{A} \frac{B}{B} + \frac{B}{B} \frac{C}{C} + \frac{C}{C} \frac{A}{A} - \frac{1}{A^2} = \rho_m + \rho_e \] (7.9)

\[ \frac{\dot{C}}{C} - \frac{\dot{B}}{B} = 0 \] (7.10)

where an over dot (\( \cdot \)) denotes ordinary differentiation with respect to the cosmic time \( t \).

The average scale factor \( a \) and the spatial volume \( V \) for anisotropic Bianchi type -VI_0 space-time are defined as
\[ a = V^{\frac{1}{3}} = (ABC)^{\frac{1}{3}} \quad (7.11) \]

The directional Hubble parameters, expressing the volumetric expansion rates of the universe along the \(x\), \(y\) and \(z\) directions respectively are

\[ H_x = \frac{\dot{A}}{A}, H_y = \frac{\dot{B}}{B}, H_z = \frac{\dot{C}}{C} \quad (7.12) \]

and the average Hubble parameter giving the volumetric expansion of the universe is defined as follows

\[ H = \frac{\dot{V}}{3V} = \frac{1}{3}(H_x + H_y + H_z) \quad (7.13) \]

The average anisotropy parameter \(A_m\) and the deceleration parameter \(q\) are defined as

\[ A_m = \frac{1}{3} \sum_{i=1}^{3} \left( \frac{\Delta H_i}{H} \right)^2 \quad (7.14) \]

where \(\Delta H_i = H_i - H\) \((i = x, y, z)\)

and \(q = -\frac{a\ddot{a}}{a^2}\) \(\quad (7.15)\)

**7.3. Cosmological solutions of the field equations:**

Integrating \((7.10)\), we obtain

\[ C = lB \quad (7.16) \]

where \(l\) is an integrating constant. Now if we put the value of \((7.16)\) in \((7.8)\) and subtract the result from \((7.7)\), we obtain that the skewness parameters along \(y\) and \(z\) axes are equal, i.e. \(\delta = \gamma\).
Solving Eqs. (7.6) and (7.7) after using Eq. (7.16), we get the relation

\[
\frac{\dot{A}}{A} - \frac{\dot{B}}{B} = c_1 V e^{-\frac{2}{\delta \rho_e} \int \frac{\rho_e}{A B} dt}
\]  

(7.17)

where \( c_1 \) is the constant of integration.

In order to solve the above equation, we use the condition followed by Adhav (2011)

\[
\frac{\dot{A}}{A} - \frac{\dot{B}}{B} = \delta \rho_e - \frac{2}{A^2}
\]  

(7.18)

This makes the Eq. (7.17) integrable. Many works are found in the literature where the condition (7.18) is imposed (Adhav, K. S., 2011; Das K., Sultana, T., 2015; Santhi, M. V., Aditya, Y., Rao, V. U. M., 2016).

Then using (7.18), Eq. (7.17) takes the form

\[
\frac{\dot{A}}{A} - \frac{\dot{B}}{B} = \frac{c_1}{V} e^{-t}
\]  

(7.19)

Using (7.16) and (7.18) the field equations (7.6) – (7.10) can now be written as

\[
4 \frac{\ddot{B}}{B} + 2 \frac{\dot{B}^2}{B^2} - \frac{\dot{A}}{A} + \frac{\ddot{A}}{A} = -(2\omega_e + \delta) \rho_e
\]  

(7.20)

\[
2 \frac{\ddot{A}}{A} + 2 \frac{\ddot{B}}{B} + 2 \frac{\dot{A} \dot{B}}{AB} + \frac{\dot{A}}{A} - \frac{\dot{B}}{B} = -\omega_e \rho_e
\]  

(7.21)

\[
4 \frac{\ddot{A}}{AB} + 2 \frac{\ddot{B}}{B^2} + \frac{\ddot{A}}{A} - \frac{\ddot{B}}{B} = \rho_m + (1 + \delta) \rho_e
\]  

(7.22)

Also the continuity equation becomes
\[
\dot{\rho}_m + 3H \rho_m + \dot{\rho}_e + 3H(1 + \omega_e)\rho_e + 2\delta \rho_e \frac{\dot{B}}{B} = 0
\] (7.23)

Since the two fluids considered are non-interacting, the continuity equation (7.23) can be separately taken for matter as well as for ghost dark energy so that the continuity equation for matter is

\[
\dot{\rho}_m + 3H \rho_m = 0
\] (7.24)

and the continuity equation for the ghost dark energy is

\[
\dot{\rho}_e + 3H(1 + \omega_e)\rho_e + 2\delta \rho_e \frac{\dot{B}}{B} = 0
\] (7.25)

The field equations (7.20) – (7.22) are a system of three linearly independent equations with five unknown parameters \(A, B, \rho_m, \omega_e, \rho_e\). Thus, in order to obtain explicit solutions of the system, two additional constraints relating these parameters are required.

Firstly, we consider the energy density of generalized ghost dark energy defined by Cai (Cai et al., 2012) as

\[
\rho_e = \eta H + \xi H^2
\] (7.26)

where \(\eta\) and \(\xi\) are constants.

Secondly, the average scale factor ‘\(a\)’ is assumed as a combination of power law and exponential law (Akarsu et al., 2014a)

\[
a = a_0 \left(\frac{t}{t_0}\right)^\alpha e^{\beta \left(\frac{t}{t_0} - 1\right)}
\] (7.27)
where $\alpha$ and $\beta$ are non-negative constants and $a_0$ and $t_0$ respectively denote the scale factor and age of the universe today. The relation (7.27) gives the exponential law when $\alpha = 0$ and the power law when $\beta = 0$. This law, which is a combination of exponential and power law, is commonly known as hybrid expansion law (HEL).

Using (7.27) in Eq. (7.11) we get the spatial volume $V$ of the model as

$$V = a^3 = a_0^3 \left( \frac{t}{t_0} \right)^{3\alpha} e^{3\beta \left( \frac{t}{t_0} \right)^{-1}}$$  \hspace{1cm} (7.28)$$

Again Eq. (7.19) gives

$$\frac{A}{B} = c_2 \exp \left[ c_1 a_0^{-3} \int e^{-t} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} \right)^{-1}} dt \right]$$  \hspace{1cm} (7.29)$$

Eqs. (7.16), (7.28) and (7.29) yield

$$A = c_2^2 \left[ \frac{2}{3} \right]^{-\frac{1}{3}} a_0^{-3} \left( \frac{t}{t_0} \right)^{\alpha} e^{\beta \left( \frac{t}{t_0} \right)^{-1}}$$

$$\times \exp \left[ \frac{2c_1 a_0^{-3}}{3} \int e^{-t} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} \right)^{-1}} dt \right]$$  \hspace{1cm} (7.30)$$

$$B = c_2^2 \left[ \frac{1}{3} \right]^{-\frac{1}{3}} a_0^{-2} \left( \frac{t}{t_0} \right)^{\beta \left( \frac{t}{t_0} \right)^{-1}}$$

$$\times \exp \left[ -\frac{c_1 a_0^{-3}}{3} \int e^{-t} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} \right)^{-1}} dt \right]$$  \hspace{1cm} (7.31)$$

$$C = c_2^2 \left[ \frac{2}{3} \right]^{-\frac{2}{3}} a_0^{-1} \left( \frac{t}{t_0} \right)^{\alpha} e^{\beta \left( \frac{t}{t_0} \right)^{-1}}$$
\[ \times \exp \left[ -c_1 a_0^{-3} \int e^{-t} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} - 1 \right)} \right] \] (7.32)

where \( c_2 \) is a constant of integration.

The expressions for the directional Hubble parameters, average Hubble parameter, the deceleration parameter and the anisotropic parameter then become

\[ H_x = \frac{A}{A} = \frac{\alpha}{t} + \frac{\beta}{t_0} + \frac{2c_1 a_0^{-3}}{3} e^{-t} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} - 1 \right)} \] (7.33)

\[ H_y = H_x = \frac{\beta}{B} = \frac{\zeta}{t} = \frac{\alpha}{t} + \frac{\beta}{t_0} - \frac{c_1 a_0^{-3}}{3} e^{-t} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} - 1 \right)} \] (7.34)

\[ H = \frac{1}{3} (H_x + 2H_y) = \frac{\alpha}{t} + \frac{\beta}{t_0} \] (7.35)

\[ q = -1 - \frac{\dot{H}}{H^2} = -1 + \alpha t_0^2 (\alpha t_0 + \beta t)^{-2} \] (7.36)

\[ A_m = \frac{2}{9H^2} \left( H_x - H_y \right)^2 \]

\[ = \frac{2c_1^2 a_0^{-6}}{9} e^{-2t} \left( \frac{t}{t_0} \right)^{-6\alpha} e^{-6\beta \left( \frac{t}{t_0} - 1 \right)} \left( \frac{\alpha}{t} + \frac{\beta}{t_0} \right)^{-2} \] (7.37)

Now, by using Eqs.(7.30), (7.31), (7.32) in Eq.(7.24), (7.26), (7.18), we obtain the expressions for energy density of matter, energy density of ghost dark energy and the skewness parameter as

\[ \rho_m = c_3 a_0^{-3} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} - 1 \right)} \] (7.38)

where \( c_3 \) is an integrating constant.
\[ \rho_e = \eta (\alpha t_0 + \beta t) t^{-1} t_0^{-1} + \xi (\alpha t_0 + \beta t)^2 t^2 t_0^{-2} \]  \hspace{1cm} (7.39)

\[ \delta = \frac{H_x - H_y + \frac{2}{\eta H + \xi H^2}}{\eta H + \xi H^2} \]  \hspace{1cm} (7.40)

and from Eq. (7.25), we obtain

\[ \omega_e = -1 - \frac{2}{3} \frac{\delta_B}{H} - \frac{\dot{\rho}_e}{3H\rho_e} \]  \hspace{1cm} (7.41)

which relates the equation of state parameter \( \omega_e \) of the ghost dark energy to the average Hubble parameter \( H \) and the metric function \( B \).

**Fig.1** The variation of the deceleration parameter \( q \) vs. cosmic time \( t \) with \( \alpha = 0.1 \), \( \beta = 1.55 \) and \( t_0 = 13.7 \)

From Fig. 1, we observe that the deceleration parameter \( q \) is positive at early stage of the universe and negative for late time universe. It indicates that \( q \) is a decreasing function of ‘\( t \)’ and the universe exhibits transition from deceleration to acceleration.
Fig.2 The variation of anisotropic parameter $A_m$ vs. cosmic time $t$ with $c_1 = 0.12$, $a_0 = 1$, $\alpha = 0.1$, $t_0 = 13.7$, $\beta = 1.55$.

From Fig. 2, we see that the anisotropic parameter $A_m \to 0$ as $t \to \infty$. It means that our universe approaches isotropy at late times.

Fig.3 The variation of matter energy density $\rho_m$ and ghost dark energy density $\rho_e$ vs. cosmic time $t$. Here the black line and the blue line represents the ghost dark energy density and the matter energy density respectively with $c_3 = 0.01$, $a_0 = 1$, $t_0 = 13.7$, $\alpha = 0.1$, $\beta = 1.55$, $\eta = 0.5$, $\xi = 1.3$.
From Fig. 3, it is clear that both matter energy density and ghost dark energy density decrease with time. At late times the ghost dark energy density tends to some constant value and matter energy density tends to zero.

\( t_0 = 13.7, \alpha = 0.1, \beta = 1.55, \eta = 0.5, \xi = 1.3, c_1 = 0.12, c_2 = 0.05, l = 0.2 \)

Fig. 4 shows that the skewness parameter \( \delta \to 0 \) at later times. Thus at later age of the universe the anisotropy of the ghost dark energy becomes isotropic.

\( t_0 = 13.7, \alpha = 0.1, \beta = 1.55, \eta = 0.5, \xi = 1.3, c_1 = 0.12, c_2 = 0.05, l = 0.2 \)

Fig. 5 The variation of EOS parameter \( \omega_e \) vs. cosmic time \( t \) with \( c_3 = 0.01, a_0 = 1, t_0 = 13.7, \alpha = 0.1, \beta = 1.55, \eta = 0.5, \xi = 1.3, c_1 = 0.12, c_2 = 0.05, l = 0.2 \).
Fig. 5 shows that EOS parameter of ghost dark energy $\omega_e$ tends to $-1$ at late times. Thus at late times it behaves like $\Lambda$CDM model. The cosmological data sets, especially the SNe Ia data (Riess et al., 2004; Riess et al., 2007; Astier et al., 2006), the three years WMAP data (Spergel et al., 2003), the SDSS data (Eisenstein et al., 2005; Bamba et al., 2012) all indicate that the $\Lambda$CDM model or the model that reduces to $\Lambda$CDM serves as a standard model to describe the cosmological evolution.

The expressions for matter energy density parameter $\Omega_m$ and dark energy density parameter $\Omega_e$ are defined as

$$\Omega_m = \frac{\rho_m}{3H^2}$$

$$= \frac{1}{3} c_3 \left( \frac{a}{t} + \frac{\beta}{t_0} \right)^{-2} a_0^{-3} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} - 1 \right)} \quad (7.42)$$

and

$$\Omega_e = \frac{\rho_e}{3H^2}$$

$$= \frac{1}{3} \left( \frac{a}{t} + \frac{\beta}{t_0} \right)^{-2} \left[ \eta \left( \frac{a}{t} + \frac{\beta}{t_0} \right) + \xi \left( \frac{a}{t} + \frac{\beta}{t_0} \right)^2 \right] \quad (7.43)$$

and the total energy density parameter is

$$\Omega = \Omega_m + \Omega_e$$

$$= \frac{1}{3} \left( \frac{a}{t} + \frac{\beta}{t_0} \right)^{-2} \left[ c_3 a_0^{-3} \left( \frac{t}{t_0} \right)^{-3\alpha} e^{-3\beta \left( \frac{t}{t_0} - 1 \right)} + \eta \left( \frac{a}{t} + \frac{\beta}{t_0} \right) + \xi \left( \frac{a}{t} + \frac{\beta}{t_0} \right)^2 \right] \quad (7.44)$$
Fig. 6 The variation of total energy density parameter $\Omega$ vs. cosmic time $t$ with $c_3 = 0.01$, $a_0 = 1$, $t_0 = 13.7$, $\alpha = 0.1$, $\beta = 1.55$, $\eta = 0.5$, $\xi = 1.3$.

Fig. 6 shows that the total energy density $\Omega$ of the universe approaches to 1 showing thereby that at late times the universe becomes spatially homogeneous, isotropic and flat.

7.4. State finder diagnosis:

The viability of dark energy models can be tested through the state finder diagnostic pair \{r, s\} which provides us an idea about the geometrical nature of the model. The pair \{r, s\} are defined (Akarsu et al., 2014b) as

\[
r = \frac{\ddot{a}}{aH^2}
\]

\[
s = \frac{r - 1}{3(q - \frac{3}{2})}
\]  \hspace{1cm} (7.45)
In the above definition of \( s \), there is \( \frac{3}{2} \) in the place of \( \frac{1}{2} \) in the original definition \( s = \frac{r-1}{3(q-\frac{1}{2})} \) (Sahni et al., 2003). This is to avoid the divergence of \( s \) when \( q = \frac{1}{2} \).

Using Eqs. (7.27), (7.35), (7.36) in Eq. (7.45), the state finder pair can be obtained as

\[
\begin{align*}
  r &= 1 - 3\alpha t^{-2} \left( \frac{\alpha}{t} + \frac{\beta}{t_0} \right)^{-2} + 2\alpha t^{-3} \left( \frac{\alpha}{t} + \frac{\beta}{t_0} \right)^{-3} \\
  s &= \frac{2\alpha t_0^2 [3\beta t + (3\alpha - 2)t_0]}{3(\beta t + \alpha t_0)[5(\beta t + \alpha t_0)^2 - 2\alpha t_0^2]} \quad (7.46)
\end{align*}
\]

Eq. (7.46) shows that at the beginning of cosmic time, the state finder pair for the model are \( \{1 + \frac{2\alpha - 3\alpha}{\alpha^2}, \frac{6\alpha - 4}{15\alpha^2 - 6\alpha}\} \) whereas at late time of cosmic evolution, the model behaves like \( \Lambda \)CDM with the state finder pair having values \{1,0\}.

### 7.5 Conclusion:

In this Chapter, we study the anisotropic Bianchi type-VI\(_0\) space-time filled with dark matter and anisotropic ghost dark energy. We find the solution of Einstein’s field equations by considering hybrid expansion law for the average scale factor. We also study the expansion history of the universe. It is seen that the anisotropic parameter and the skewness parameter of the ghost dark energy tend to zero at later age of the universe. It is also observed that the ghost dark energy tends to some constant value but the matter energy density becomes zero at the later age of the universe. Also \( \Omega \), the total energy density tends to 1 at the later age of the universe. Thus our model becomes spatially homogeneous, isotropic and flat at later times. Moreover, it is found that EOS parameter
of ghost dark energy tends to $-1$ and the values of state finder pair become $r = 1$, $s = 0$ at late times. Thus our model corresponds to the $\Lambda$CDM model.