Article

Bianchi Type-I Cosmological Model in the Presence of Wet Dark Fluid with Magnetic Flux

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Abstract

The object of this paper is to investigate the nature of Bianchi type-I cosmological model in presence of wet dark fluid and magnetic flux. To obtain deterministic solution of said model a few plausible assumptions regarding to it are introduced such as scalar expansion θ is proportional to eigen value σ_1^1 of shear tensor σ_j^i. A new equation of state for the dark energy component of the universe has been used. It is modelled on the equation of state $p = \gamma(\rho - \rho_*)$ which can describe a liquid, for example water. The exact solutions to the corresponding field equations are obtained in quadrature form. The solution for constant deceleration parameter have been studied in detailed for both power-law and exponential form. In addition to this we have discuss the geometrical and physical properties of said model.

Keywords: Bianchi type-I space-time, Wet dark fluid (WDF), Magnetic flux, Cosmological parameters.

1. Introduction

The occurrence of magnetic field on a galactic scale is well established fact today and their importance for a variety of astrophysical phenomenon is generally acknowledged by several authors. The renowned authors, Reiss et al. [1], Perlmutter et al. [2], Sahni [3] have studied the nature of the dark energy component of the universe as the one of the deepest mysteries of universe. We are motivated to use the wet dark fluid (WDF) as a model for a dark energy which stems from an empirical equation of state proposed by Hayward [4] and Tait [5] to treat water and aqueous solutions. Modification of the Friedmann equation such as Cardassion expansion referred by Freese et al.[6], Freese [7], Gondolo et al.[8] as well as what might be derived from brane cosmology given by Deffayet et al.[9], Dvali et al.[10], Dvali et al.[11] have also been used to explain the acceleration of the universe.

Harrison [12], Asseo and Sol [13] and Kim et al.[14] have pointed out the importance of magnetic field in the different context. Saha [15] has investigated Bianchi type-I string

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cosmological model in the presence of magnetic field and he has obtained explicit analytic solutions.

In this research article, we have introduced the magnetic flux in the system of wet dark fluid. This model is in the spirit of generalized Chaplygin gas (GCG) by Gorini et al.[16]. The equation of state for WDF is in the form

$$p_{WDF} = \gamma(\rho_{WDF} - \rho_*) \tag{1}$$

It is motivated by the fact that, a good approximation for many fluids, including water, in which the internal attraction of the molecules makes negative pressures. One of the virtues of this model is that the square of the sound speed c_s^2, which depends on $\frac{\partial p}{\partial \rho}$ can be positive, even while giving rise to cosmic acceleration in the current epoch. The parameters γ and ρ_* are taken to be positive and we restrict ourselves to $0 \leq \gamma \leq 1$. Note that if c_s denotes the adiabatic sound speed in WDF, then $\gamma = c_s^2$ (Babichev *et al.*[17]). To find the WDF energy density, we use the energy conservation equation as

$$\dot{\rho_{WDF}} + 3H(p_{WDF} + \rho_{WDF}) = 0 \tag{2}$$

where H is Hubble parameter.
From the equation of state (1) and using $3H = \frac{\dot{V}}{V}$ in the equation (2) and on solving we obtained

$$\rho_{WDF} = \frac{\gamma}{1+\gamma}\rho_* + \frac{C}{V^{1+\gamma}} \tag{3}$$

where C is the constant of integration and V is the volume expansion.WDF naturally includes two components: a piece that behaves as a cosmological constant as well as a standard fluid with an equation of state $p = \gamma\rho$, if we take $C > 0$, it confirm that the fluid will not violate the strong energy condition.

$$\begin{aligned} p_{WDF} + \rho_{WDF} &= (1+\gamma)\rho_{WDF} - \gamma\rho_* \\ &= (1+\gamma)\frac{C}{V^{1+\gamma}} \geq 0 \end{aligned} \tag{4}$$

According Holman and Naidu [18], the wet dark fluid has been used as dark energy in the homogeneous, isotropic FRW case and the early stage of expansion of the universe exhibits substantially non-Friedmannian behavior given by Zeldovich [19]. The author Singh et al.[20] has studied Bianchi type-I universe with wet dark fluid. Recently Patil et al. [21,22] has studied Non shearing LRS Bianchi type-III and Bianchi type-IX string cosmological model in presence of magnetic flux with bulk viscosity, also Patil et al. [23,24,25] has studied LRS Bianchi type-V cosmological model in presence of perfect fluid and magnetic flux with variable magnetic permeability and Bianchi type-IX and V cosmological model with two fluid in presence of magnetic flux.

In this paper, we have studied the Bianchi type-I cosmological model with matter term and dark energy treated as a dark fluid satisfying the equation of state (1) in presence of magnetic flux. The solution has been obtained in the quadrature form. The models with constant deceleration parameter have been studied in detail.

2. Fundamental Equations and General Solutions

We consider Bianchi type-I metric

$$ds^2 = a_0^2(dx^0)^2 - a_1^2(dx^1)^2 - a_2^2(dx^2)^2 - a_3^2(dx^3)^2 \tag{5}$$

in which $a_0 = 1,\ x^0 = t$. The metric functions a_1, a_2, a_3 are functions of time t only.
The Einstein field equation for metric (5) has the following form

$$\frac{\ddot{a_2}}{a_2} + \frac{\ddot{a_3}}{a_3} + \frac{\dot{a_2}}{a_2}\frac{\dot{a_3}}{a_3} = kT_1^1 \tag{6}$$

$$\frac{\ddot{a_1}}{a_1} + \frac{\ddot{a_3}}{a_3} + \frac{\dot{a_1}}{a_1}\frac{\dot{a_3}}{a_3} = kT_2^2 \tag{7}$$

$$\frac{\ddot{a_1}}{a_1} + \frac{\ddot{a_2}}{a_2} + \frac{\dot{a_2}}{a_2}\frac{\dot{a_1}}{a_1} = kT_3^3 \tag{8}$$

$$\frac{\dot{a_2}}{a_2}\frac{\dot{a_3}}{a_3} + \frac{\dot{a_2}}{a_2}\frac{\dot{a_1}}{a_1} + \frac{\dot{a_1}}{a_1}\frac{\dot{a_3}}{a_3} = kT_0^0 \tag{9}$$

where k is Einstein gravitational constant and the dots over the letters denotes differentiation with respect to time t.

The energy momentum tensor for system of wet dark fluid and magnetic field is

$$T_j^i = (\rho_{WDF} + p_{WDF})u_j u^i - p_{WDF}\,\delta_j^i + E_j^i \tag{10}$$

in which u^i is the flow vector satisfying the relation

$$g_{ij}u^i u^j = 1 \tag{11}$$

the electromagnetic field E_j^i is given by

$$E_j^i = \bar{\mu}\left[|h|^2\left(u_j u^i - \frac{1}{2}\delta_j^i\right) - h_j h^i\right] \tag{12}$$

where $\bar{\mu}$ is a constant characteristic of the medium and called the magnetic permeability,

We have only one non-trivial component of F_{ij} which is $F_{23.}$ then the first set of Maxwell equation $F_{\mu\nu;\beta} + F_{\nu\beta;\mu} + F_{\beta\mu;\nu} = 0$, one finds

$$F_{23.} = I, \quad I = Constant. \tag{13}$$

Finally, we obtain the electromagnetic field tensor E_j^i as

$$E_0^0 = E_1^1 = -E_2^2 = -E_3^3 = \frac{I^2}{2\bar{\mu}a_2^2a_3^2} \tag{14}$$

Using co-moving system of co-ordinate and equation (14) in equation (10) we have obtain the energy momentum tensors as

$$T_0^0 = \rho_{WDF} + \frac{I^2}{2\bar{\mu}a_2^2a_3^2} \tag{15}$$

$$T_1^1 = -p_{WDF} + \frac{I^2}{2\bar{\mu}a_2^2a_3^2} \tag{16}$$

$$T_2^2 = -p_{WDF} - \frac{I^2}{2\bar{\mu}a_2^2a_3^2} \tag{17}$$

$$T_3^3 = -p_{WDF} - \frac{I^2}{2\bar{\mu}a_2^2a_3^2} \tag{18}$$

Using equations (15)-(18) in field equations (6)-(9), we obtain

$$\frac{\dot{a_2}}{a_2}\frac{\dot{a_3}}{a_3} + \frac{\dot{a_2}}{a_2}\frac{\dot{a_1}}{a_1} + \frac{\dot{a_1}}{a_1}\frac{\dot{a_3}}{a_3} = k\left(\rho_{WDF} + \frac{I^2}{2\bar{\mu}a_2^2a_3^2}\right) \tag{19}$$

$$\frac{\ddot{a_2}}{a_2} + \frac{\ddot{a_3}}{a_3} + \frac{\dot{a_2}}{a_2}\frac{\dot{a_3}}{a_3} = k\left(-p_{WDF} + \frac{I^2}{2\bar{\mu}a_2^2a_3^2}\right) \tag{20}$$

$$\frac{\ddot{a_1}}{a_1} + \frac{\ddot{a_3}}{a_3} + \frac{\dot{a_1}}{a_1}\frac{\dot{a_3}}{a_3} = k\left(-p_{WDF} - \frac{I^2}{2\bar{\mu}a_2^2a_3^2}\right) \tag{21}$$

$$\frac{\ddot{a_1}}{a_1} + \frac{\ddot{a_2}}{a_2} + \frac{\dot{a_2}}{a_2}\frac{\dot{a_1}}{a_1} = k\left(-p_{WDF} - \frac{I^2}{2\mu a_2^2a_3^2}\right) \tag{22}$$

Here we define volume scale factor as

$$V = a_1 a_2 a_3 \tag{23}$$

Subtracting equation (21) from (22) and Solving , We have the relation

$$\frac{a_2}{a_3} = Dexp\left(X\int\frac{dt}{V}\right), \quad \text{where} \quad D,\ X \ \text{are integration constants} \tag{24}$$

and the expansion scalar θ and eigen value σ_1^1 are as follows

$$\theta = \left(\frac{\dot{a_1}}{a_1} + \frac{\dot{a_2}}{a_2} + \frac{\dot{a_3}}{a_3}\right) \tag{25a}$$

$$\sigma_1^1 = -\frac{1}{3}\left(4\frac{\dot{a_1}}{a_1} + \frac{\dot{a_2}}{a_2} + \frac{\dot{a_3}}{a_3}\right) \tag{25b}$$

We have the condition that, the expansion scalar θ is proportional to the eigen value σ_1^1 of mixed shear tensor σ_j^i (Bali [26] and Saha [15]). We have the relation $\theta = 3n\sigma_1^1$, where $(3n)$ is proportionality constant.

Solving this equation by using equations (25a) and (25b) we get

$$a_1 = z(a_2 a_3)^N,$$

where z is integration constant and $N = -\frac{(n+1)}{(4n+1)}$,

Here we have set integration constant $z = 1$ for the simplification, hence

$$a_1 = (a_2 a_3)^N \tag{26}$$

Using equations (23) and (26), we obtain

$$a_1 = V^{N/_{N+1}} \tag{27}$$

Using equation (24) and (26), we obtain

$$a_2 = V^{\frac{1}{2(N+1)}}\sqrt{D}\exp\left(\frac{1}{2}\left(X\int\frac{dt}{V}\right)\right) \tag{28}$$

$$a_3 = V^{\frac{1}{2(N+1)}}\frac{1}{\sqrt{D}}\exp\left(-\frac{1}{2}\left(X\int\frac{dt}{V}\right)\right) \tag{29}$$

3.The Geometrical and Physical Significance

Using equation (3) in equation (1), we have

$$p_{WDF} = \frac{\gamma c}{V^{(1+\gamma)}} - \frac{\gamma}{1+\gamma}\rho_* \tag{30}$$

Adding equation (20)-(22) and three times equation (19), we get

$$2\left(\frac{\ddot{a_1}}{a_1} + \frac{\ddot{a_2}}{a_2} + \frac{\ddot{a_3}}{a_3}\right) + 4\left(\frac{\dot{a_2}}{a_2}\frac{\dot{a_3}}{a_3} + \frac{\dot{a_2}}{a_2}\frac{\dot{a_1}}{a_1} + \frac{\dot{a_1}}{a_1}\frac{\dot{a_3}}{a_3}\right) = \frac{kI^2}{\bar{\mu}a_2^2a_3^2} - 3k(p_{WDF} - \rho_{WDF}) \tag{31}$$

From equation (23), we have

$$\left(\frac{\ddot{a_1}}{a_1} + \frac{\ddot{a_2}}{a_2} + \frac{\ddot{a_3}}{a_3}\right) + 2\left(\frac{\dot{a_2}}{a_2}\frac{\dot{a_3}}{a_3} + \frac{\dot{a_2}}{a_2}\frac{\dot{a_1}}{a_1} + \frac{\dot{a_1}}{a_1}\frac{\dot{a_3}}{a_3}\right) = \frac{\ddot{V}}{V} \tag{32}$$

From equation (31) and (32), we have

$$\frac{\ddot{V}}{V} = \frac{kI^2}{2\,\bar{\mu}a_2^2a_3^2} - \frac{3k}{2}(p_{WDF} - \rho_{WDF}) \tag{33}$$

Subtracting equation (3) from (30), we get

$$p_{WDF} - \rho_{WDF} = \frac{-2\gamma}{1+\gamma}\rho_* + \frac{c(\gamma-1)}{V^{(1+\gamma)}} \tag{34}$$

Using equation (34) in equation (33), we obtain

$$\frac{\ddot{V}}{V} = \frac{kI^2}{2\bar{\mu}a_2^2a_3^2} - \frac{3k}{2}\left(\frac{-2\gamma}{1+\gamma}\rho_* + \frac{c(\gamma-1)}{V^{(1+\gamma)}}\right) = \frac{kI^2}{2\bar{\mu}a_2^2a_3^2} + \frac{3k\gamma}{1+\gamma}\rho_* - \frac{3kc(\gamma-1)}{2V^{(1+\gamma)}} \tag{35}$$

Using equation (26) and equation (27) and substituting

$\chi = \frac{kI^2}{2\bar{\mu}}$, $\eta = 3k\rho_*$, $\omega = \frac{3kc}{2}$, in equation (35), we get

$$\ddot{V} = \chi V^{N-1/_{N+1}} + \eta V\frac{\gamma}{1+\gamma} - \frac{\omega(\gamma-1)}{V^{\gamma}} \tag{36}$$

On integrating equation (36), we get

$$\dot{V} = \sqrt{\chi \frac{N+1}{N} V^{2N/N+1} + \eta V^2 \frac{\gamma}{1+\gamma} + 2\omega V^{1-\gamma}} \tag{37}$$

Further integrating equation (37), we obtain

$$t = \int \left(\chi \frac{N+1}{N} V^{2N/N+1} + \eta V^2 \frac{\gamma}{1+\gamma} + 2\omega V^{1-\gamma} \right)^{-1/2} dV + t_0 \tag{38}$$

where t_0 is constant of integration.

Substituting the values from equations (37), (27), (28) and (29) in metric (5) we have

$$ds^2 = \left(\chi \frac{N+1}{N} V^{2N/N+1} + \eta V^2 \frac{\gamma}{1+\gamma} + 2\omega V^{1-\gamma} \right)^{-1} (dV)^2 - V^{\frac{2N}{N+1}} (dx)^2 - \left[V^{\frac{1}{2(N+1)}} \sqrt{D} \exp\left(\frac{1}{2} \left(X \int \frac{dt}{V} \right) \right) \right]^2 (dy)^2 - \left[V^{\frac{1}{2(N+1)}} \frac{1}{\sqrt{D}} \exp\left(-\frac{1}{2} \left(X \int \frac{dt}{V} \right) \right) \right]^2 (dz)^2 \tag{39}$$

$$\theta = \frac{\dot{V}}{V} = \sqrt{\chi \frac{N+1}{N} V^{-2/N+1} + \eta \frac{\gamma}{1+\gamma} + 2\omega V^{-(1+\gamma)}} \tag{40}$$

$$q = \left(2 - 3 \frac{\left(\chi V^{2N/N+1} + \eta V^2 \frac{\gamma}{1+\gamma} - \frac{\omega(\gamma-1)}{V^{\gamma-1}} \right)}{\left(\chi \frac{N+1}{N} V^{2N/N+1} + \eta V^2 \frac{\gamma}{1+\gamma} + 2\omega V^{1-\gamma} \right)} \right) \tag{41}$$

$$\sigma^2 = \frac{1}{3} \left[\chi \left(\frac{N+1}{N} \right) V^{\frac{-2}{N+1}} + \eta \frac{\gamma}{1+\gamma} + 2\omega V^{-(1+\gamma)} \right] \frac{4N^2+1-4N}{4(N+1)^2} + \frac{X}{4V^2} \tag{42}$$

4. Some Special Cases

Case I: $\gamma = 1$ and $N = 1$

From equations (27), (28), (29), (3), (30), (38), (40), (41) and (42) are yields

$$a_1 = V^{1/2}$$

$$a_2 = V^{\frac{1}{4}} \sqrt{D} \exp\left(\frac{1}{2} \left(X \int \frac{dt}{V} \right) \right)$$

$$a_3 = V^{\frac{1}{4}} \frac{1}{\sqrt{D}} \exp\left(-\frac{1}{2} \left(X \int \frac{dt}{V} \right) \right)$$

$$\rho_{WDF} = \left(\frac{1}{2}\rho_* + \frac{c}{V^2}\right)$$

$$p_{WDF} = \frac{c}{V^2} - \frac{1}{2}\rho_*$$

$$t = log\left(\sqrt{\frac{\eta}{2}}V + \sqrt{\frac{2}{\eta}}\chi + \sqrt{\left(\sqrt{\frac{\eta}{2}}V + \sqrt{\frac{2}{\eta}}\chi\right)^2 + \left(\sqrt{2\omega - \frac{2\chi}{\eta}}\right)^2}\right) + t_0$$

$$\theta = \sqrt{2\chi V^{-1} + \frac{\eta}{2} + 2\omega V^{-2}}$$

$$q = \left(2 - 3\frac{\chi V + V^2\frac{\eta}{2}}{\left(2\chi V + \eta V^2\frac{1}{2} + 2\omega\right)}\right)$$

$$\sigma^2 = \frac{1}{3}\left\{\left[2\chi V^{-1} + \frac{\eta}{2} + 2\omega V^{-2}\right]\left(\frac{1}{16}\right) + \frac{3X}{4V^2}\right\}$$

The metric (39) takes the form

$$ds^2 = \left(\frac{2\chi}{V} + \frac{\eta V^2}{2} + 2Z\right)^{-1} dV^2 - V(dx^1)^2 - V^{1/2}D\exp\left(X\int\frac{dt}{V}\right)(dx^2)^2$$
$$-V^{1/2}D^{-1}\exp\left(-X\int\frac{dt}{V}\right)(dx^3)^2$$

Graphical Representation: For $\gamma = 1$ and $N = 1$

$$\rho_{WDF} = \left(\frac{1}{2}\rho_* + \frac{c}{V^2}\right), \text{ for } \rho_* = c = 1$$

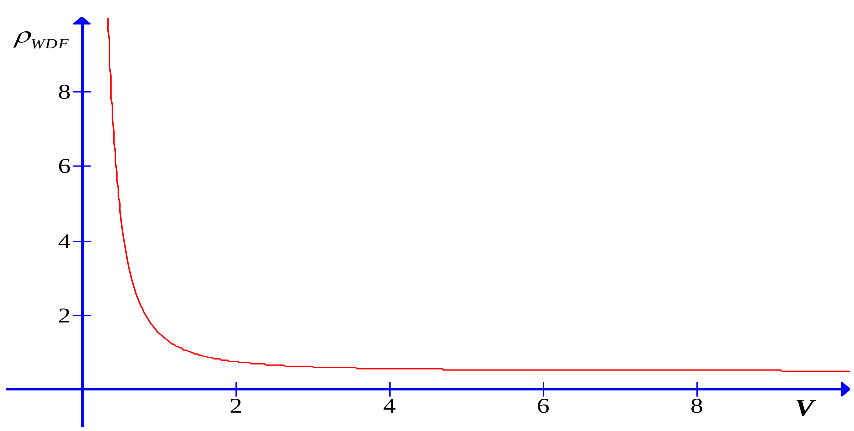

Fig. 1

From fig.-1, it clears that as volume increases, density decreases suddenly and after a stage it will be stable.

$p_{WDF} = \frac{c}{V^2} - \frac{1}{2}\rho_*$, for $\rho_* = c = 1$

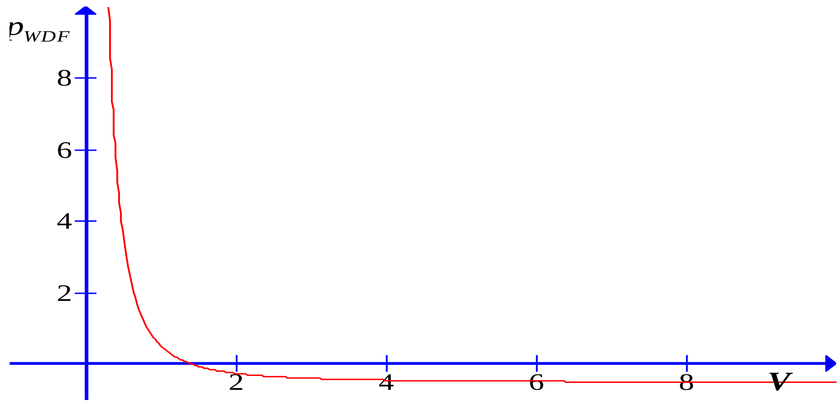

Fig. 2

From fig.-2, it shows that as volume increase, pressure decreases and it goes to negative.

Case II : $\gamma = 0$ And $N = 1$

From equations (27), (28), (29), (3), (30), (38), (40), (41) and (42) are yields

$$a_1 = V^{1/2}$$

$$a_2 = V^{\frac{1}{4}}\sqrt{D}\exp\left(\frac{1}{2}\left(X\int\frac{dt}{V}\right)\right)$$

$$a_3 = V^{\frac{1}{4}}\frac{1}{\sqrt{D}}\exp\left(-\frac{1}{2}\left(X\int\frac{dt}{V}\right)\right)$$

$$\rho_{WDF} = \frac{c}{V}\ , \quad p_{WDF} = 0$$

$$t = \frac{\sqrt{(2\chi+2\omega)V}}{2\chi+2\omega} + t_0$$

$$\theta = \sqrt{2\chi V^{-1} + 2\omega V^{-1}}$$

$q = \left(2 - 3\frac{(\chi V + \omega V)}{(2\chi V + 2\omega V)}\right)$

$\sigma^2 = \frac{1}{3}\left\{[2\chi V^{-1} + 2\omega V^{-1}]\left(\frac{1}{16}\right) + \frac{3X}{4V^2}\right\}$

The line element is

$$ds^2 = \left(\frac{2\chi}{V} + \frac{\eta V^2}{2} + 2Z\right)^{-1} dV^2 - V(dx^1)^2 - V^{1/2} D\exp\left(X\int\frac{dt}{V}\right)(dx^2)^2$$
$$-V^{1/2}D^{-1}\exp\left(-X\int\frac{dt}{V}\right)(dx^3)^2$$

Graphical Representation: For $\gamma = 0$ and $N = 1$

$\rho_{WDF} = \frac{c}{V}$, $p_{WDF} = 0$, for $c = 0$

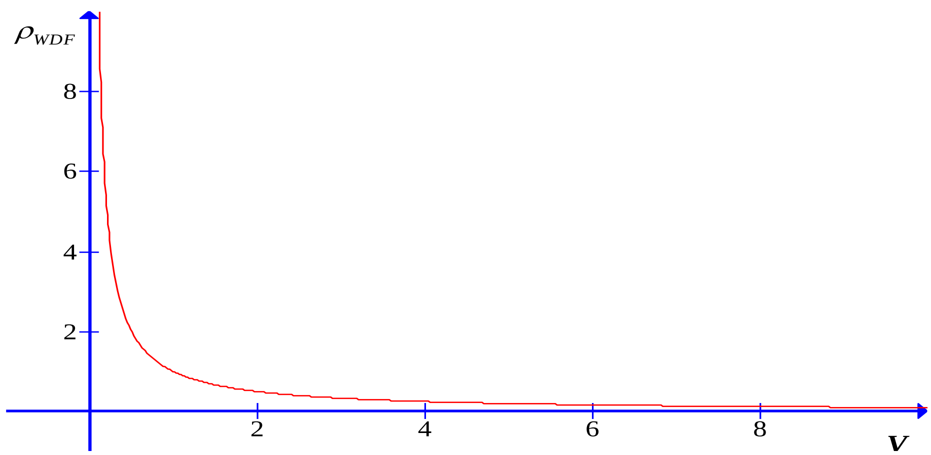

Fig.3

From fig.3, as volume increases density decrease gradually.

5. Models with constant deceleration parameter

Case I: Power law ($N = 1$)

We take the power law $V = at^b$ where a and b are constant.

From equations (27), (28), (29), (3), (30), (38), (40), (41) and (42) are yields

$a_1 = a^{1/2}t^{b/2}$

$$a_2 = a^{\frac{1}{4}} t^{b/4} \sqrt{D} \exp\left(\frac{1}{2}\left(X \int \frac{dt}{V}\right)\right)$$

$$a_3 = a^{\frac{1}{4}} t^{b/4} \frac{1}{\sqrt{D}} \exp\left(-\frac{1}{2}\left(X \int \frac{dt}{V}\right)\right)$$

$$\rho_{WDF} = \left(\frac{\gamma}{1+\gamma}\rho_* + \frac{\gamma c}{a t^{b(1+\gamma)}}\right)$$

$$p_{WDF} = \frac{\gamma c}{a t^{b(1+\gamma)}} - \frac{\gamma}{1+\gamma}\rho_*$$

$$\theta = \frac{b}{t}$$

$$q = \frac{3}{b} - 1$$

$$\sigma^2 = \frac{1}{3}\left\{\left[\left(\frac{b}{t}\right)^2\right]\left(\frac{1}{16}\right) + \frac{3X}{4t^{2b}a^2}\right\}$$

The line element is

$$ds^2 = dt^2 - a t^b (dx^1)^2 - a^{1/2} t^{b/2} D \exp\left(X \int \frac{dt}{V}\right)(dx^2)^2 - a^{1/2} t^{b/2} D^{-1} \exp\left(-X \int \frac{dt}{V}\right)(dx^3)^2$$

Graphical Representation:- Power Law : $V = at^b$

$$\rho_{WDF} = \left(\frac{\gamma}{1+\gamma}\rho_* + \frac{\gamma c}{a t^{b(1+\gamma)}}\right) \quad \text{for} \quad \gamma = 1,\ \rho_* = c = a = b = 1$$

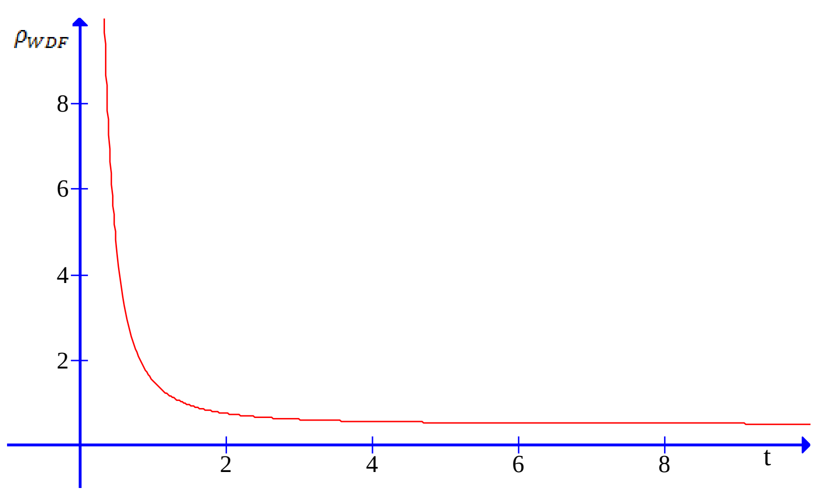

Fig.4

As time increases density decreases gradually.

$p_{WDF} = \frac{\gamma c}{at^{b(1+\gamma)}} - \frac{\gamma}{1+\gamma}\rho_*$ for $\gamma = 1,\ \rho_* = c = a = b = 1$

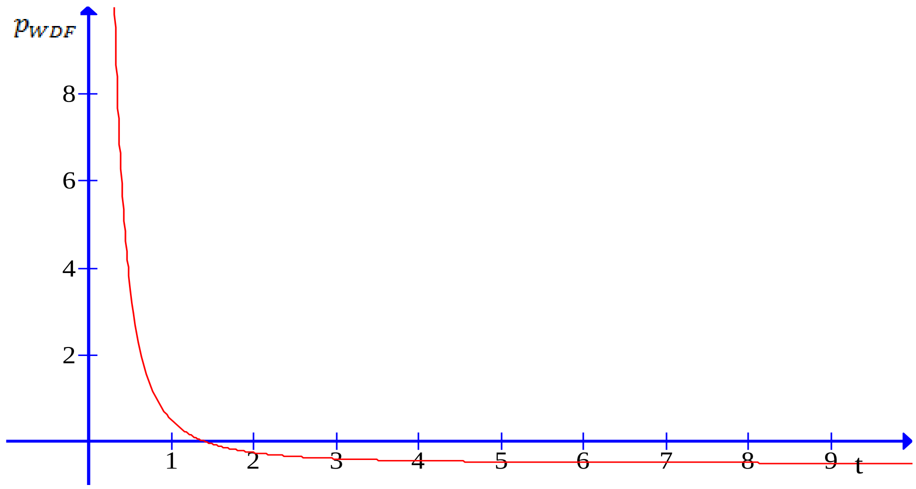

Fig.5

As time increases pressure decreases and it goes to negative.

Case II: Exponential form ($N = 1$)

$V = \alpha e^{\beta t}$ where α and β are constant.

From equations (27), (28), (29), (3), (30), (38), (40), (41) and (42) are yields

$$a_1 = \alpha^{1/2} e^{\beta t/2}$$

$$a_2 = \alpha^{\frac{1}{4}} e^{\beta t/4} \sqrt{D} \exp\left(\frac{Xe^{-\beta t}}{-2\alpha\beta}\right)$$

$$a_3 = \alpha^{\frac{1}{4}} e^{\beta t/4} \frac{1}{\sqrt{D}} \exp\left(\frac{Xe^{-\beta t}}{2\alpha\beta}\right)$$

$$\rho_{WDF} = \left(\frac{\gamma}{1+\gamma}\rho_* + \frac{\gamma c}{\alpha e^{\beta t(1+\gamma)}}\right)$$

$$p_{WDF} = \frac{\gamma c}{\alpha e^{\beta t(1+\gamma)}} - \frac{\gamma}{1+\gamma}\rho_*$$

$$\theta = \beta$$

$q = -1$

$\sigma^2 = \frac{1}{3}\left\{\beta^2\left(\frac{1}{16}\right) + \frac{3X}{4\alpha e^{\beta t}}\right\}$

The line element is

$$ds^2 = dt^2 - \alpha e^{\beta t}(dx^1)^2 - \alpha^{1/2} e^{\beta t/2} D \exp\left(X\int\frac{dt}{V}\right)(dx^2)^2 - \alpha^{1/2} e^{\beta t/2} D^{-1} \exp\left(-X\int\frac{dt}{V}\right)(dx^3)^2$$

Graphical Representation:-Exponential form: $V = \alpha e^{\beta t}$

$\rho_{WDF} = \left(\frac{\gamma}{1+\gamma}\rho_* + \frac{\gamma c}{\alpha e^{\beta t(1+\gamma)}}\right)$ for $\gamma = 1, \rho_* = c = \alpha = \beta = 1$

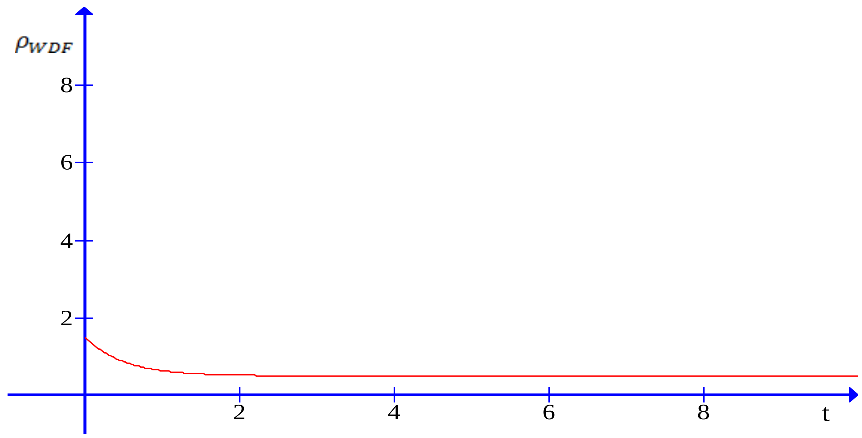

Fig.6

From fig.-6 it is clear that, the density slowly decreases as time increases.

$p_{WDF} = \frac{\gamma c}{\alpha e^{\beta t(1+\gamma)}} - \frac{\gamma}{1+\gamma}\rho_*$ for $\gamma = 1, \rho_* = c = \alpha = \beta = 1$

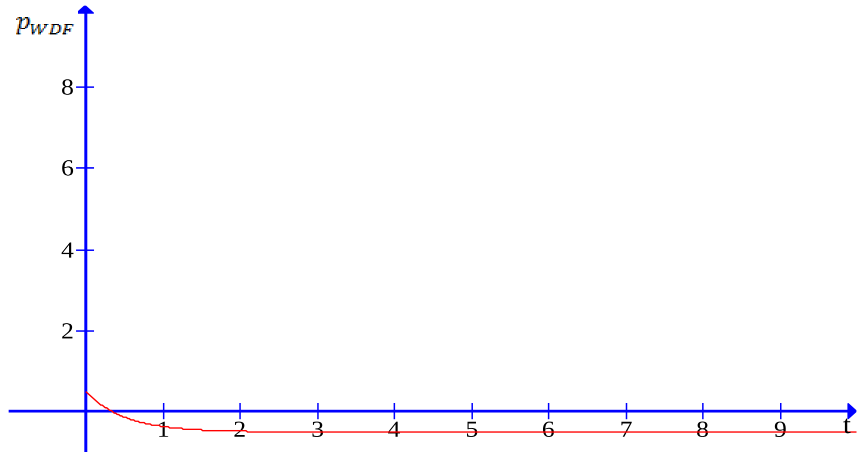

Fig. 7

From fig.7 it shows that, the pressure decreases and it goes to negative as time increases.

6. Conclusion

In this paper, we have investigated the nature of Bianchi type-I cosmological model for the dark energy component of the universe. The solution has been obtained in quadrature form. The models with constant deceleration parameter have been discussed in details. The model get shrink in presence of magnetic field and expand in its absence respectively. As t tends to zero, it tends to infinity, and as t increases or decreases respectively model shrink or expand, correspondingly, the scalar expansion increases and shear scalar σ decreases. For both the fluids Zeldovich and dust , the model reduces as t increases.

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References

[1] A G Riess et al, Astron. J. 116, 1009 (1998).

[2] S Perlmutter et al, Astrophys. J. 157, 565 (1998).

[3] V Sahni, arXiv:astro-ph/0403324 (preprint) (2004).

[4] A T J Hayward, Brit. J. Appl. Phys. 18, 965 (1967).

[5] P G Tait, The voyage of HMS Challenger (H.M.S.O, London,) 2, 1, (1988).

[6] K Freese and M Lewis, Phys. Lett. B540, 1 (2002).

[7]K Freese, Nucl. Phys. (Proc. Suppl.)B124, 50 (2003).

[8] P Gondolo and K Freese, Phys. Rev. D68, 063509 (2003).

[9] C Deffayet, G R Dvali and G Gabadadze, Phys. Rev. D65, 044023 (2002).

[10] G Dvali, G Gabadadze and M Porrati, Phys. Lett. B485, 208 (2000).

[11] G Dvali and M S Turner, arXiv:astro-ph/0301510 (2003).

[12] E. R.Harrison, Physical Review Letters. Vol. 30, 5, 188-190, (1973).

[13] E.Asseo, H.Sol, Physics Reports.Vol. 148, 6, 307-435, (1987).

[14] K. T.Kim, P. G.Tribble, P. P. Kronberg, Astrophys. Journal.Vol. 379, 1, 80-88, (1991).

[15] B. Saha, Astrophysics Space Sci. Vol. 315, 99-104, (2008).

[16] V Gorini, A Kamenshchik, U Moschella and V Pasquier, arXiv:gr-qc/0403062(preprint) (2004).

[17] E Babichev, V Dokuchaev and Y Eroshenkos, arXiv:astro-ph/0407190 (preprint)(2004).

[18] R Holman and S Naidu, arXiv:astro-ph/0408102 (preprint) (2005).

[19] Ya B Zeldovich and I D Novikov, Relativistic astrophysics (Chicago University Press, Chicago, USA, 1975) Vol. II.

[20] T.Singh , R. Chaubey , Pramana J. of Phys. 71, 3 (2008).

[21] V. Patil, S. Bhojne, Int. J. of Advances in Sci. Engg. and Tech. 1, 80-82, (2015).

[22] V. Patil, S. Bhojne, International J. of Research in Engg. and Applied Sci. 6, 2, (2016).

[23] V. Patil, S. Bhojne , International J. of Advanced Research, 6, 6 (2016).

[24] V. Patil, S. Bhojne , International J. Of Pure And Applied Research in Engg. And Tech.4, 9, (2016).

[25] V. Patil, S. Bhojne , Prespacetime J. 7, 6, (2016).

[26] R. Bali, Int. J. Theor. Phys. 25, 755 (1986).