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Bianchi Type-VI_0 Stiff Fluid Power Law Cosmological Model in $f(R)$ Theory of Gravity

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Abstract: - *We have formulated Bianchi Type VI_0 cosmological model in $f(R)$ theory of gravity, relating to the stiff fluid energy momentum tensor utilizing power law with Lagrangian be the self-assertive function of Ricci scalar. To tackle the field equations, we have utilized energy momentum tensor with anisotropic stiff fluid EoS. $\rho = p$. We discover the flight for the current model from the standard ΛCDM model according to the advancement of $j(t)$. We have assessed some essential cosmological physical and kinematical amounts for this model alongside his graphical conduct.*

Keyword: *Stiff Fluid, Bianchi Type-VI_0 model, $f(R)$ Gravity.*

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I. Introduction

For the vast majority of history, cosmologists have needed to depend on light in the obvious piece of the range to contemplate the Universe. One of the extraordinary cosmic accomplishments of the twentieth century was the abuse of the full electromagnetic range for galactic estimations. We currently have instruments equipped for mentioning observable facts of radio waves, microwaves, infrared light, obvious light, bright light, X-beams and gamma beams, which all compare to light floods of various (for this situation expanding) recurrence. We are in any event, entering an age where we can go past the electromagnetic range and get data of different kinds. A surprising component of perceptions of a close by cosmic explosion in 1987 was that it was likewise seen through location of neutrinos, an uncommonly pitifully interfacing sort of molecule regularly connected with radioactive rot. Exceptionally high energy grandiose beams, comprising of profoundly relativistic rudimentary particles, are currently regularly identified, however at this point there is no reasonable comprehension of their cosmic beginning. The speculative investigational affirmation [1-4] has perceived that our universe encountering a late-time speeding up. The proposition that have been advanced to clarify this noticed wonder can essentially be characterized into two classes. First the development overwhelmed by a segment with negative pressing factor, named as dark energy (DE) and second is by changing the gravity law through the adjustment of activity in everyday hypothesis general theory of relativity (GTR). The outcome acquired from Wilkinson Microwave Anisotropy Probe (WMAP) [5] shows that DE possesses 73%, dark matter involve 23% and the typical baryon matter which can be assigned by our known molecule hypothesis overcomes just about 4% of the complete energy in the Universe. The least complex understanding for this DE is the presentation of a cosmological steady relating to condition of state boundary $\omega = -1$. Additionally, in the gathered works scattered from the cosmological consistent there are different applicants of DE which is identified with the energy thickness of a dynamical scalar field, for example, pith $(\omega > -1)$ [6, 7]. Apparition field $(\omega < -1)$ [8, 9] and Quinton (that can opposite ghost district to core region) [10, 11] Chaplygin gas [12],k-essence [13-16], Tachyon field, Holographic and Age realistic dull energy. Despite these endeavors dim energy is as yet perhaps the main lacking cross examinations in hypothetical material science. Stiff fluid cosmological models make more interest in the investigation of the universe on the grounds that for these models the speed of light is equivalent to the speed of sound and its overseeing conditions have similar qualities as those of gravitational field (Zel'dovich) [17].

Adhav et al. [18] examined that in presence of bulk viscosity an inflationary effective stiff fluid cosmological model, whereas in absence of bulk viscosity the wet dark fluid degenerate to stiff fluid. Katore et al. [19] obtained when the source of gravitational field is a perfect fluid coupled with massless mesonic scalar field. Bagora[20] investigated a tilted Bianchi Type-III stiff fluid cosmological model in general relativity. Bali [21] determined Bianchi type IX stiff fluid tilted cosmological models with bulk viscosity are investigated. Amirhashchi [22] described the L.R.S. Bianchi type II stiff fluid cosmological model and verified the data regarding the kinematical parameters. Gad [23] examined a new class of axially symmetric cosmological mesonic stiff fluid models in the context of Lyra's geometry.He also found the expressions for the energy, pressure, and the massless scalar field by considering the time dependent displacement field. Dwivedi [24] presented bulk viscous Bianchi type-V cosmological models with time-dependent cosmological term Λ . Pawar and Dagwal [25] studied Bianchi Type IX two fluids cosmological models with matter and radiating source. In the model one of the fluids represents the matter content of the universe and another fluid is the CMB radiation. Galiakhmetov [26] studied the flat Friedmann universes filled by stiff fluid and non-minimally coupled material scalar field with polynomial potentials of the fourth degree are considered in the framework of the Einstein-Cartan theory. Harko et al. [27] considered the dynamics of a barotropic cosmological fluid in an anisotropic, Bianchi type I space-time in Eddington-inspired Born–Infeld (EiBI) gravity. Ghate and Salve [28] studied the Hoyle-Narlikar C-field cosmology for LRS Bianchi type-V space-times with varying cosmological constant $\Lambda(t)$, when the universe is filled with barotropic fluid distribution. Mathewa et al. [29] investigated a cosmological model dominated by a stiff fluid with a constant bulk viscosity. They classify all the possible cases of the universe predicted by the model and analyze the scale factor and the density as well as the curvature scalar.

As, there are so numerous change of activity in GTR are gotten, such as $f(R)$, $f(R,T)$ $f(T)$ $f(R,G)$ $f(T,B)$ etc. These sensibly unique fascination hypotheses are an undertaking to build a semi-traditional subject inside which GTR and the majority of its independent alternatives are frequently recuperated. An undemanding and simple adjustment to GTR is that the $f(R)$ theory of gravity. During this theory, the Ricci scalar R of Einstein–Hilbert action is replaced by operate of R . Till now a few models of $f(R)$ hypothesis are arranged.

Hasmani and Ahmed [30] attempted to study spatially homogeneous Bianchi type-I cosmological models in $f(R)$ gravity. Reddy et al. [31] studied the vacuum solutions of Bianchi Type-I and V Space time in $f(R)$ gravity theory. Banik et al. [32] applied the dynamical systems approach to investigate the spatially homogeneous and anisotropic Bianchi type-V models for the Palatini version of $f(R)$ gravity. Saiedy [33] studied time-dependent wormhole space times in the radiation background in $f(R)$ gravity and also discussed thermo dynamical properties of the time dependent wormhole in $f(R)$ gravity. Martino et al. [34] predicted a various aspects of $f(R)$ gravity at extragalactic and cosmological levels. Bamba et al. [35] investigated the oscillating effective Equation of State of the universe around the Phantom divide in $f(R)$ gravity Adhav [36] found the exact solution of the field equations for a Kantowski-Sachs space-time filled with cosmic strings in $f(R)$ gravity theory. Akbar and Rong-Gen Cai [37] shown that by applying the first law of thermodynamics to the apparent horizon of an FRW universe and assuming the geometric entropy given by a quarter of the apparent horizon area. Sharif and Shamir [38] discussed non-vacuum Bianchi Type- I and V in $f(R)$ gravity theory. Shamir [39] studied the exact vacuum solutions of Bianchi type I, III and Kantowski-Sachs space-times in the metric version of $f(R)$ gravity. Sharif and Shamir [40] used the Landau-Lifschitz energy momentum complex in the framework of $f(R)$ gravity to evaluate the energy density of plane symmetric solutions for some $f(R)$ gravity models. Capone and Ruggiero [41] reviewed that the dynamical equivalence between $f(R)$ Gravity in the metric formalism and scalar-tensor gravity and use this equivalence to deduce the past-Newtonian parameters γ and β for $f(R)$ gravity. Moraes et al. [42] studied LRS Bianchi Type-I Space-time in $f(R)$ gravity within the phantom energy dominated era. Shri Ram [43] investigated a spatially homogeneous and anisotropic Bianchi type I model filled with perfect fluid in $f(R)$ gravity theory. Hiwarkar et al. [44] proposed exact solutions of N-dimensional Bianchi Type-V space-time in $f(R)$ theory of gravity. Odintsov and Oikonomou [45-47] investigated cosmological dynamical system of $f(R)$ gravity, by constructing it in such a way so that is rendered autonomous. They also found the occurrence of future cosmological finite time singularities in the dynamical system corresponding to two cosmological theories that of vacuum $f(R)$ gravity and that of three fluids. Also they introduced a bottom-up $f(R)$ gravity reconstruction technique, in which we fix the observational indices and they seek for the $f(R)$ gravity which may realize them. Soroushfar et al. [48] considered three types of black holes in $f(R)$ gravity. Lee [49] found the method for reconstruction of $f(R)$ gravity models both from the background evaluations observations and from the large scale structured measurements. Capozziello et al. [50] investigated $f(R)$ gravity can; in general, give rise to cosmological viable models compatible with a matter-dominated epoch evolving into a late accelerated phase. Chirde and Shekh [51] found plane symmetric cosmological model with quadratics equation of state in metric version of $f(R)$ gravity. In this present context we are devoted to the study of Stiff Fluid Cosmological Model in $f(R)$ Gravity. We have assessed some essential cosmological physical and kinematical properties of the universe.

II. METRIC, $f(R)$ GRAVITY FORMALISM AND STIFF FLUID ENERGY MOMENTUM TENSOR

We consider a spatially homogeneous and anisotropic Bianchi type-VI$_0$ space-time which is depicted by the accompanying line component:

$$ds^2 = -dt^2 + A^2(t)dx^2 + B^2(t)e^{-2nx}dy^2 + C^2(t)e^{2nx}dz^2, \tag{1}$$

where A, B and C are the potential functions of cosmic time t only.

Different creators and authors [61, 63] who have pondered the above said model because of its actual consideration that is the model is spatially homogeneous and anisotropic.

The corresponding field equations are found by varying the action

$$S = \int \sqrt{-g}\left(\frac{1}{16\pi G} f(R) + L_m\right)d^4x \tag{2}$$

Where, $f(R)$ is a general function of the Ricci scalar and L_m is the matter Lagrangian. Variation of action (2) with respect to metric gives the following field equations:

$$F(R)R_{jk} - \frac{1}{2} f(R) - \nabla_j \nabla_k F(R) + g_{jk} \Box F(R) = T_{jk}^{(M)}, \tag{3}$$

where, $\Box = \nabla_j \nabla_k ; F(R) = \frac{d}{dR} f(R).$

Bhoyar et al. [52] examined Bianchi Type-I space-time with quadratics condition of state in the $f(R)$ gravity hypothesis. Arnold et al. [53] introduced a bunch of cosmological hydro dynamical reproductions that follow universe arrangement in changed $f(R)$ gravity models and are devoted to discovering observational marks to help recognize general relativity from choices utilizing this data. Sahoo and Bhattacharjee [54] discovered the happenstance issue in $f(R)$ gravity and researched the effectiveness and model independency. Borgade et al. [55] investigated $f(R)$ gravity plane symmetric cosmological models of the universe corresponding to the magnetized anisotropic dark energy momentum tensor using special law of variation.

In the current work, we are managing stiff fluid matter whose energy force tensor is given as, $T_{jk} = (p+\rho)u_j u_k - pg_{jk}$, where u^j is the four-velocity vector of the fluid satisfying $u^i = (1,1,1,-\rho)$ and satisfying $u^j u_j = -1, \rho$ be energy density of the fluid, p is the pressure and A_m be the anisotropy parameter which satisfying the general form of the EoS. $p = \rho$. With respect to stiff fluid matter, the energy momentum tensor for the given system is derived by the equation given below:

$$T_k^j = diag[T_1^1, T_2^2, T_3^3, T_4^4] = diag[p_x, p_y, p_z, -\rho] \tag{4}$$

$$T_k^j = diag[p+\rho, p+\rho, p+\rho, \rho] \tag{5}$$

$$T_k^j = diag[2p, 2p, 2p, \rho] \tag{6}$$

Various makers and space specialists have been analyzed the firm fluid cosmological model of the universe as, Pawar and Agrawal [56] built stiff fluid cosmological models by considering five dimensional Kaluza-Klein space-time dependent on Lyra geometry in the casing work of scalar tensor theory of gravity proposed by Saez and Ballester, which are acquired for two unique cases: steady dislodging vector and time subordinate relocation vector Rao et al. [57] inspected a cosmological model for a particular decision of $f(R,T) = f_1(R) + f_2(R)$ relating to stiff liquid. Tripathi et al. [58] explored inhomogeneous Bianchi type I cosmological model for solid amazing liquid appropriation. To get the deterministic arrangement of Einstein's field conditions, they accepted that the isotropic pressing factor is equivalent to energy density. Sharma et al. [59] decided inhomogeneous speculation of Bianchi type VIh string cosmological model for hardened wonderful liquid dissemination. Bhoyar and Chirde [60] examined polarized against stiff fluid cosmological models with variable cosmological constant. Jain et al. [61] introduced locally rotationally symmetric Bianchi type-V string cosmological model for hardened ideal liquid with cosmological term Λ . Mehta [62] researched Bianchi type-VI$_0$ polarized cosmological models with a period subordinate relocation field for hardened liquid dispersion inside the structure of Lyra calculation. Dagwal and Pawar [63] presented tilted Bianchi type-VI$_0$ cosmological models in general theory of relativity. To solve Einstein's field equation, they used the stiff fluid $\tilde{p}_r = \tilde{\rho}$, considering time varying radial velocity $\omega = T^{\alpha}$ and uniform radial velocity $\omega = \omega_0$.

III. FIELD EQUATIONS AND SOLUTIONS

In the presence of stiff fluid source given in condition (6), the field conditions (3) comparing to the measurement (1) lead to the accompanying arrangement of directly autonomous differential conditions of the structure:

$$\left[\frac{2n^2}{A^2}-\frac{\dot{A}}{A}\frac{\dot{B}}{B}-\frac{\dot{A}}{A}\frac{\dot{C}}{C}-\frac{\ddot{A}}{A}\right]F(R)-\frac{1}{2}f(R)+\left[2\frac{\dot{A}}{A}+\frac{\dot{B}}{B}+\frac{\dot{C}}{C}\right]\dot{F}(R)-\ddot{F}(R)=2p \tag{7}$$

$$\left[\frac{\dot{A}}{A}+2\frac{\dot{B}}{B}+\frac{\dot{C}}{C}\right]\dot{F}(R)-\left[\frac{\dot{A}}{A}\frac{\dot{B}}{B}+\frac{\dot{B}}{B}\frac{\dot{C}}{C}+\frac{\ddot{B}}{B}\right]F(R)-\frac{1}{2}f(R)-\ddot{F}(R)=2p \tag{8}$$

$$\left[\frac{\dot{A}}{A}+\frac{\dot{B}}{B}+2\frac{\dot{C}}{C}\right]\dot{F}(R)-\left[\frac{\dot{A}}{A}\frac{\dot{C}}{C}+\frac{\dot{B}}{B}\frac{\dot{C}}{C}+\frac{\ddot{C}}{C}\right]F(R)-\frac{1}{2}f(R)-\ddot{F}(R)=2p \tag{9}$$

$$\left[\frac{\dot{A}}{A}+\frac{\dot{B}}{B}+\frac{\dot{C}}{C}\right]\dot{F}(R)-\left[\frac{\ddot{A}}{A}+\frac{\ddot{B}}{B}+\frac{\ddot{C}}{C}\right]F(R)-\frac{1}{2}f(R)=\rho \tag{10}$$

Here the overhead spot signifies separation as for t . The arrangement of profoundly non-direct differential conditions are reliable, comprises of four conditions with five unknowns A, B, C, p, ρ . Henceforth, to address one can present more conditions either by a suspicions relating to some actual circumstances or a self-assertive numerical assumption.

We can utilize the special law of variation which is nothing but the connection between F and a this gives us,

$$F = \tau a^n \tag{11}$$

Without loss of generality we choose $\tau = 1$, so

$$F = \left(\frac{a_0}{t_0^n}\right)^n t^{n^2} = a^n \tag{12}$$

Here in the above equation (12) we choose, $\alpha = \left(\frac{a_0}{t_0^n}\right)$

Hence, (12) implies that,

$$F = \alpha^n t^{n^2} = a^n \tag{13}$$

As we know that the special volume is,

$$V = \sqrt{-g} = ABC \tag{14}$$

But $a = V^{1/3} = (ABC)^{1/3}$ (15)

In 1983 Berman proposed the special law of variation of Hubble's parameter yields a constant value of deceleration parameter of the universe, according to Berman's law:

$$q = \frac{d}{dt}\left(\frac{1}{H}\right)-1 \tag{16}$$

,

where, H is the Hubble's parameter.

$$H = \frac{\dot{a}}{a} \tag{17}$$

Where a is the average scale factor which given by the equation and the graphical nature of average scale factor versus cosmic time is as shown in Figure 1.

$$a = \alpha^n t^n \tag{18}$$

Behavior of scale factor having stiff fluid, cosmological model versus cosmic time with the suitable choice of constants as shown in the following Figure 1. While observing the graphical nature of the scale factor which is the function of time; it has been concluded that the scale factor is increases exponentially with infinite time interval.

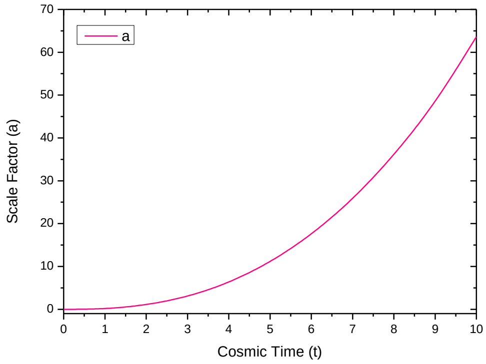

Figure1. Behavior of scale factor of stiff fluid cosmological model versus cosmic time with the appropriate choice of constants $\alpha = 0.2$ and $n = 3$.

Let us consider $B = \mu C; \mu = 1$ and $A = C^n; n \neq 0$. hence from (15) and (18), the metric potential comes out to be;

$$B = \alpha^{\frac{3}{n+2}} t^{\frac{3n}{n+2}} = C \tag{19}$$

$$A = \alpha^{\frac{3n}{n+2}} t^{\frac{3n^2}{n+2}} \tag{20}$$

The potential functions got in condition (19 and 20) are the force elements of enormous time and it will be disappears and acquired the consistent model. Spatially homogeneous and anisotropic space-time (1) with stiff fluid EoS in the metric version of $f(R)$ gravity becomes:

$$ds^2 = -dt^2 + \left[\alpha^{\frac{3n}{n+2}} t^{\frac{3n^2}{n+2}}\right]^2 dx^2 + \left[\alpha^{\frac{3}{n+2}} t^{\frac{3n}{n+2}}\right]^2 e^{-2nx} dy^2 + \left[\alpha^{\frac{3}{n+2}} t^{\frac{3n}{n+2}}\right]^2 e^{2nx} dz^2 \tag{21}$$

In the model (21), it is seen that the metric potentials are having the force term. Here we saw that the metric potentials are again the elements of vast time.

IV. PHYSICAL PROPERTIES OF THE MODEL

The Ricci Scalar, we have

$$R = 2\left[\frac{n^2}{A^2} - \frac{\dot{A}}{A}\frac{\dot{B}}{B} - \frac{\dot{B}}{B}\frac{\dot{C}}{C} - \frac{\dot{A}}{A}\frac{\dot{C}}{C} - \frac{\ddot{A}}{A} - \frac{\ddot{B}}{B} - \frac{\ddot{C}}{C}\right] \tag{22}$$

By thinking about the potential functions (19) and (20) and furthermore relational word of the field conditions (7-10) with Ricci scalar (22) and its subsidiary regarding vast time *t*; the actual qualities of the model say energy density and the pressing factor of the model with stiff fluid matter have been determined as follows:
The Ricci scalar of the model is established to be

$$R = 2\left[\left\{n^2 \alpha^{\frac{6n}{n+2}}\right\}\frac{1}{t^{\frac{9n^4}{(n+2)^2}}} - \left\{\frac{n^2(18n+27)}{(n+2)^2} - 3n\right\}\frac{1}{t^2}\right] \tag{23}$$

Condition (23) addresses the capacity of the Ricci scalar of the model; unmistakably the capacity of the Ricci scalar is proportion capacity of time.
The condition of energy density (24) and the graphical conduct of energy density with inestimable time are as demonstrated underneath:

$$\rho = 3\alpha^n \left[\begin{array}{l} \left\{\left(\frac{n^2+2n}{n+2}\right) - 3\left(\frac{n^4+2n^2}{(n+2)^2}\right) - \frac{1}{3(n^2-2)}\left(\frac{4n^2(18n+27)}{(n+2)^2} - 6n\right)\right\} t^{n^2-2} \\ + \left\{\left(\frac{n^4+2n^3}{n+2}\right)\right\} t^{n^2-1} + \left\{\frac{3n^6}{(n+2)^2 \alpha^{\frac{6n}{n+2}}}\right\} \frac{t^{n^2 - \frac{9n^4}{(n+2)^2} + 2}}{n^2 - \frac{9n^4}{(n+2)^2} + 2} \end{array}\right] \tag{24}$$

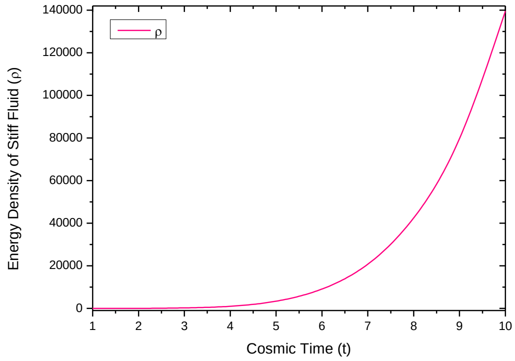

Figure 2 Behavior of energy density of stiff fluid cosmological model versus cosmic time with the appropriate choice of constants $\alpha = 0.2$ and $n = 3$.

The Pressure of the universe is given by the condition (25) and the graphical nature appeared in Figure 3.

$$p = \frac{3}{2}\alpha^n \left[\left\{ \left(\frac{n^4 + 3n^3 + n}{n+2} \right) - \frac{9n^2}{(n+2)^2} - \frac{1}{3(n^2-2)} \left(\frac{2n^2(18n+27)}{(n+2)^2} - 6n \right) - \frac{n^2(n^2-1)}{3} \right\} t^{n^2-2} + \left\{ \frac{3n^6}{(n+2)^2 \alpha^{\frac{6n}{n+2}}} \right\} \frac{t^{\left(n^2 - \frac{9n^4}{(n+2)^2} + 2\right)}}{\left(n^2 - \frac{9n^4}{(n+2)^2} + 2\right)} \right] \tag{25}$$

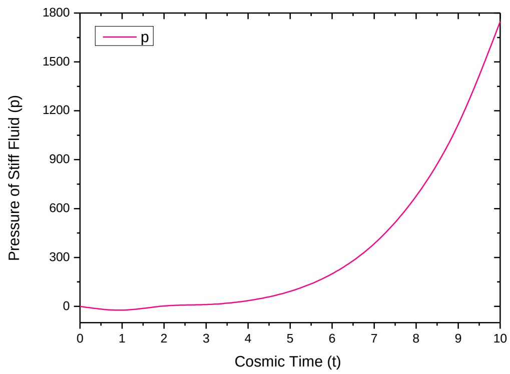

Figure 3 Behavior of pressure of stiff fluid cosmological model versus cosmic time with the appropriate choice of constants $\alpha = 0.2$ and $n = 3$.

V. KINEMATICAL PROPERTIES OF THE MODEL

The kinematical properties which are important in cosmology while discussing the geometrical behavior of the universe. By preposition of the potential function (19) and (20) and also considering the field equations (7-10) with Ricci scalar (22); the kinematical characteristics of the model say; spatial volume, Hubble parameter, expansion scalar, mean parameterized anisotropy parameter, shear scalar, deceleration parameter, jerk parameter and overall density parameter have been calculated as follows:

The spatial volume,

$$V = \alpha^3 t^{3n} \tag{26}$$

The spatial volume is the force capacity of time and the graphical conduct of the spatial volume is expanding with boundless time span and at $t = 0$ the spatial volume disappears. Conduct of spatial volume of stiff fluid cosmological model versus infinite time with the suitable selection of constants is appeared in Figure 4.

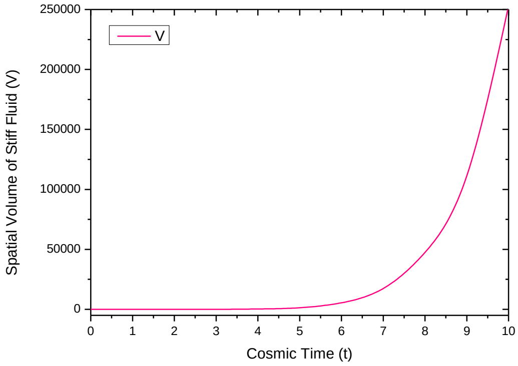

Figure 4 Behavior of spatial volume of stiff fluid matter cosmological model versus cosmic time with the appropriate choice of constants $\alpha = 0.2$ and $n = 3$.

$$H = \frac{n}{t} \tag{27}$$

Behaviors of Hubble parameter of stiff fluid cosmological model versus cosmic time with the suitable values of constants are shown graphically in Figure 5.

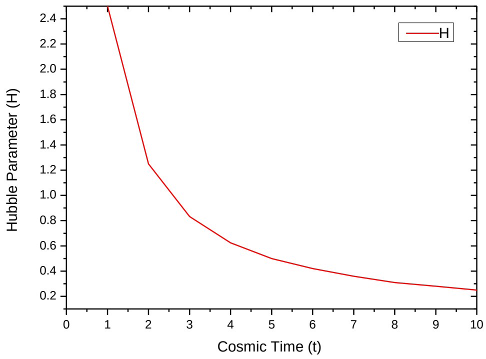

Figure 5 Behavior of Hubble parameter of stiff fluid cosmological model versus cosmic time with the suitable choice of constants $\alpha = 0.2$ and $n = 3$.

The expansion scalar,

$$\theta = 3H = \frac{3n}{t} \tag{28}$$

Behaviors of expansion scalar which is the reciprocal and positive function of time t of stiff fluid cosmological model versus cosmic time with the suitable values of constants are shown graphically in Figure 6.

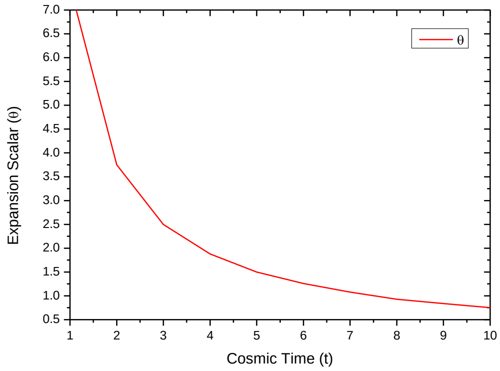

Figure 6 Behavior of expansion scalar of stiff fluid cosmological model versus cosmic time with the appropriate choice of constants $\alpha = 0.2$ and $n = 3$.

Mean anisotropy parameter,

$$A_m = \sum_{i=1}^{3}\left(\frac{H_i - H}{H}\right)^2 = \frac{2(n-1)^2}{(n+2)^2}; n \neq 1 \tag{29}$$

While introducing the appropriate values of constants in the mean anisotropy parameter it is found that the mean anisotropy parameter is constant and also not the function of cosmic time t and it will vanishes at $n=1$, hence we consider $n \neq 1$.

Similarly the Shear Scalar is

$$\sigma^2 = \frac{3n^2(n-1)^2}{(n+2)^2}\frac{1}{t^2}; n \neq 1 \tag{30}$$

After choosing suitable values of constants, the behavior of shear scalar of stiff fluid cosmological model versus cosmic time is shown in Figure 7.

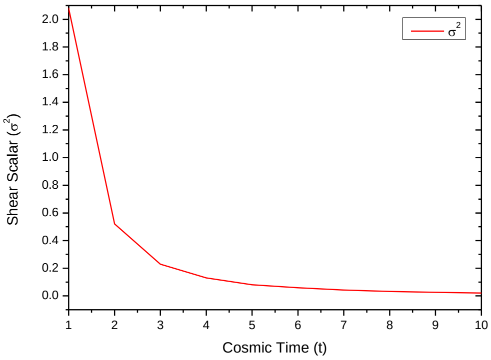

Figure 7 Behavior of shear scalar of stiff fluid cosmological model versus cosmic time with the suitable choice of constants $\alpha = 0.2$ and $n = 3$.

The Deceleration parameter is found to be,

$$q = \frac{d}{dt}\left(\frac{1}{H}\right) - 1 = \frac{1}{n} - 1 \tag{31}$$

By choosing appropriate values of constants it is observed that the deceleration parameter is the negative function of cosmic time t.

Jerk parameter are simply kinematical, since they are free of any gravity hypothesis, and every one of them are simply identified with scale factor an or redshift z. Specifically, the jerk boundary, a dimensionless third subsidiary of the scale factor $a(t)$ concerning inestimable time t, can give us the easiest way to deal with look for takeoffs from the concordance ΛCDM model. The jerk parameter is defined [65] as

$$j(t) = \frac{\dddot{a}}{aH^3} \tag{32}$$

As far as the deceleration parameter q (a dimensionless second subordinate of $a(t)$ concerning t), the jerk parameter $j(t)$ can be composed as

$$j(t) = q + 2q^2 - \frac{\dot{q}}{H} = \left(\frac{1}{n} - 1\right) + 2\left(\frac{1}{n} - 1\right)^2; n \neq 1 \tag{33}$$

The overall density parameter is found out to be;

$$\Omega = \frac{\rho}{3H^2} = \alpha^n \left[\begin{array}{l} \left\{\left(\frac{n^2+2n}{n+2}\right) - 3\left(\frac{n^4+2n^2}{(n+2)^2}\right) - \frac{1}{3(n^2-2)}\left(\frac{4n^2(18n+27)}{(n+2)^2} - 6n\right)\right\} t^{n^2-4} \\ + \left\{\frac{n^4+2n^3}{n+2}\right\} t^{n^2-3} + \left\{\frac{3n^6}{(n+2)^2 \alpha^{\frac{6n}{n+2}}}\right\} \frac{t^{n^2 - \frac{9n^4}{(n+2)^2}}}{n^2 - \frac{9n^4}{(n+2)^2}} \end{array}\right] \tag{34}$$

The behavior of overall density parameter of stiff fluid cosmological model versus cosmic time with the appropriate choice of constants is shown in Figure 8. It has been observed that the overall density parameter is positive function with an infinite time interval.

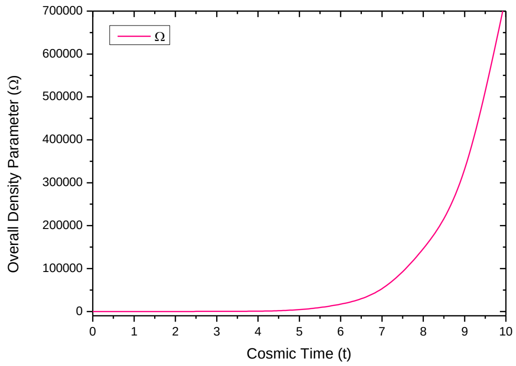

Figure 8 Behavior of overall energy density parameter of stiff fluid cosmological model versus cosmic time with the appropriate choice of constants $\alpha = 0.2$ and $n = 3$.

VI. CONCLUSION

In this context with stiff fluid equation of state (EoS), in the metric version of $f(R)$ gravity has been investigated. We inferred that the model of the universe with anisotropic stiff fluid is the speeding up, growing and consequently doesn't show isotropy. An accurate solution of the field equations compare to power law which gives solitary model. The energy density and pressure of the model is increases infinitely for stiff fluid EoS $p = \rho$ and hence vanishes at $t = 0$. The average scale factor and spatial volume of the investigated model are increases with cosmic time t and both are vanishes at $t = 0$. The obtained deceleration parameter is constant and shows deceleration at $n = 3$ and for the same value the jerk parameter is having with positive value. Hence the deceleration and jerk parameter are obtained having good agreement with recent observations. Subsequently, it is show that the universe is surely going through a sped up expansion stage following the decelerated one. This is reliable with the current perceptions. Also, we discover the flight for the current model from the standard ΛCDM model as per the development of $j(t)$. We have assessed some essential cosmological physical and kinematical parameters for this model alongside his graphical conduct.

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