Research Article *V R Chirde et al, Carib.j.SciTech, 2016, Vol.4, 920-930*

Bianchi Type III Cosmological models with strange Quark matter attached to string cloud in Brans-Dicke Theory of gravitation and general theory of relativity

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Key words: Type III, Quark matter, Cosmic strings, Brans-Dicke theory, General relativitys

ISSN 0799-3757

http://caribjscitech.com/

Abstract:

In this paper, we have studied the Bianchi type III space time with strange quark matter attached to string cloud in Brans – Dicke theory of gravitation and general theory of gravitation. To get a deterministic solution, Use the linear relationship between the metric potentials and some important features of the models thus obtained have been investigated. Also it is investigated that the presence of scalar field changes the matter distribution without affecting the geometry of the space-time.

Introduction:

Brans-Dicke theory of gravitation is a theoretical framework to explain gravitation. It is a well-known competitor of Einstein's more popular theory of general relativity. It is an example of a scalar-tensor theory, a gravitational theory in which the gravitational interaction is mediated by a scalar field as well as the tensor field of general relativity. Brans-Dicke theory introduced a scalar tensor theory of gravitation involving a scalar function in addition to the familiar general relativistic metric tensor. In this theory the scalar field has the dimension of inverse of gravitational constant and its role is confined to its effects on gravitational field equations.

Brans – Dicke [1] field equations for combined scalar and tensor fields are

$$G_{ij} = -8\pi\phi^{-1}T_{ij} - \omega\phi^{-2}(\phi,_i \phi,_j - \frac{1}{2}g_{ij}\phi,_k \phi^{'k}) - \phi^{-1}(\phi_{i;j} - g_{ij}\phi^{;k}_{;k}) \quad (1)$$

and

$$\phi^{'k}_{;k} = 8\pi(3+2\omega)^{-1}T \quad (2)$$

Where

$G_{ij} = R_{ij} - \frac{1}{2}Rg_{ij}$ is the Einstein tensor, T_{ij} is the stress energy tensor of matter and ω is the dimensionless coupling constant , comma and semicolon denotes partial and co-variant differentiation respectively. The equation of motion

$$T^{ij}_{;j} = 0 \quad (3)$$

are consequence of the field equations (1) and (2).

In this study, we have attached strange quark matter to the string cloud. It is plausible to attach strange quark matter to the string cloud. As one of such transition during the phase transition of the universe could be Quark Glucon plasma (QGP) harden gas(called quark-hadrons phase transition) when cosmic temperature was $T \cong 200MeV$. In the decade 1980's and 1990's, experiments at CERN's Super Proton Synchrotron (SPS) has credited to form the QGP; in 2000, the results led CERN to announce indirect evidence for a "new state of matter". Institutions such as Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) are pursuing this experiments. In Brookhaven National Laboratory [2,3,4], the quark-gluon plasma is created as a perfect liquid. There are many authors who contributed in study of quark matter and the relation between quark matter and domain walls and also string. Two ways of formation of strange quark matter have been proposed by Itoh [5], Bodmar [6]and Witten [7]**.** One of them is the quark – hadrons phase transition in the early universe and another one is conversion of neutron stars into strange ones at ultrahigh densities. In the theories of strong interaction, it is hypothysed that the breaking of physical vacuum takes place inside hadrons to form quark bag models. As a result, vacuum energy densities inside and outside a hadrons become essentially different and the vacuum pressure on the bag wall equilibrates the pressure of quarks thus making the system stabilized. If the hypothesis of the quark matter is true, some neutron stars could actually be stars built entirely of strange matters have been examined by Alcock et al.[8] and Haensel et al. [9]. Strange star properties have been studied by Cheng et al. [10] and Strange quark matter attached to the string cloud in spherical symmetric space-time admitting conformal motion have been investigated by Yavuz et al. [11]. The study of general relativistic treatment of strings have been proposed by Stachel [12] and Leterier [13]. Anisotropic flow of charged and identified hadrons in the quark-gluon string model for Au + Au collisions at 200 Ge V. by Barau et al [14]. Quark-gluon string model description of baryon production have been studied by Arakelyan et al. [15]. Duality between static strings and quark anti-quark configuration in the Randall-Sendrum scenarios have been obtained by Boschi-Fillo et al. [16].

A new sets of EOSs for strange matter based on a model of inter quark potential which has the following features: a) asymptotic freedom, b) confinement at zero baryon density and deconfinement at high baryon density, c) chiral symmetry restoration and d) gives stable uncharged β -stable matter have been obtained by Dey et al. [17]. Charged strange quark matter in the spherically symmetric space-time admitting conformal motion have been investigated by Mak and Harko [18].

The possibility of the existence of quark matter dates back to the early 1970s.Yilmaz et al. [19] obtained strange quark matter for the Roberts-Walker model in the context of the general theory of relativity. In the general theory of relativity, higher-dimensional Roberts-Walker cosmological models in the presence of quark-gluon plasma constructed by Yilmaz and Yavuz [20], also a Bianchi type-III cosmological model with strange quark matter attached to string cloud investigated by Adhav et al. [21]. Five-D Kaluza-Klein cosmological model with strange quark matter attached to string cloud and domain wall studied by Yilmaz [22, 23]. Also n-dimensional Kaluza-Klein cosmological model with strange quark matter attached to string cloud and domain wall investigated by Adhav et al. [24]. Khadekar et al. [25] have confined their work to the quark matters attached to the topological defects in general relativity. Axially symmetric space-time with strange quark matter attached to the string cloud studied by Katore and Shaikh [26], by using the assumption of law of variation for the Hubble Parameter which is proposed by Bermann [27]. The solutions of Einstein field equations for the string cosmological model with bulk viscous fluid obtained by D D Pawar [28]. Geometry of quark and strange quark matter in higher dimensional general relativity have been discussed by Khadekar et al. [29]. Bianchi Type I cosmological model with strange quark matter attached to string cloud in self-creation theory have been studied by S. P. Kandalkar et al. [30].

Several aspects of of Brans – Dicke cosmology have been extensively investigated by many authors. The work of Singh et al. [31] give a detailed that several authors discussed Brans-Dicke cosmological models. Exact Bianchi type V perfect fluid cosmological models in Brans-Dicke theory of gravitation, have been investigated by Rao et al. [32]. Axially symmetric string cosmological models in Brans-Dicke theory of gravitation, have been discussed by Rao et al. [33] & the Bianchi type II , VIII and IX magnetized cosmological models in Brans-Dicke theory of gravitation have been studied by Rao et al. [34]. The higher dimensional string cosmological model in scalar tensor theory of gravitation, Bianchi type II, VIII and IX string cosmological models with viscosity in Brans-Dicke theory of gravitation, axially symmetric string cosmological models with bulk viscosity in self creation theory of gravitation and axially symmetric perfect fluid cosmological models in Brans-Dicke theory of gravitation have been investigated by Rao and Sireesha [35, 36, 37, 38] respectively. LRS Bianchi type I dark energy cosmological model in Brans-Dicke theory of gravitation have been studied by Rao et al. [39]. Higher-dimensional Bianchi type-III universe with strange quark matter attached to string cloud in general relativity and the plane symmetric cosmological solutions for quark matter coupled with the string cloud and domain walls in the context of Rosen's bimetric theory have been investigated by P.K.Sahoo et al. [40,41] respectively. Bianchi type-III cosmological model with strange quark matter attached to the string cloud in Barber's second self-creation theory of gravitation and Plane symmetric cosmologies with strange quark matter attached to the string cloud with bulk viscous fluid are studied in the context of Brans-Dicke theory have been studied by K.L. Mahanta et al. [42,43].

Recently, Axially symmetric and plane symmetric cosmological solutions for quark matter coupled with string cloud and domain walls in biometric theory have been studied by Sahoo and Mishra [44,45]. Very recently axially symmetric space-time with strange quark matter attached to string cloud in Brans–Dicke Theory of gravitation and Bianchi type-II, VIII & IX cosmological models with strange quark matter attached to string cloud in Brans–Dicke and general theory of gravitation have been obtained by Rao and Sireesha [46, 47] respectively.

Motivated by the aforesaid discussion in this paper, we have studied Bianchi type-III cosmological model with strange quark matter attached to the string cloud in the scalar tensor theory of gravitation proposed by Brans – Dicke and in general relativity. Some important features of the models are also investigated.

Metric and Energy momentum Tensor:

We consider the Bianchi Type III metric in the form

$$ds^2 = dt^2 - A^2 dx^2 - B^2 e^{-2x} dy^2 - C^2 dz^2 \tag{4}$$

Where A, B, C are functions of cosmic time t alone and a is constant.

The energy momentum tensor for string cloud (Letelier 1983) is given by

$$T_{ij} = \rho u_i u_j - \rho_s x_i x_j \tag{5}$$

Here ρ is the rest energy density for the cloud of strings with particles attached to them and ρ_s is the string tension density. They are related by

$$\rho = \rho_p + \rho_s \quad (6)$$

Where ρ_p is the particle energy density .

Therefore, we have quark pressure

$$p_q = \frac{\rho_q}{3} \quad (7)$$

Where ρ_q is the quark energy density. The total energy density is

$$\rho = \rho_q + B_c \quad (8)$$

where B_c is the vacuum energy density.

And the total pressure is

$$p = p_q - B_c \quad (9)$$

We know that string is free to vibrate. The different vibration modes of the strings represent the different types of particles because these different modes are seen as different masses or spins. Therefore, here we will take quarks instead of particles in the string cloud. Hence we consider strange quark matter energy density instead of particle energy density in the string cloud. In this case from equation (6), we get

$$\rho = \rho_q + \rho_s + B_c \quad (10)$$

From equation (5), and (10), (Yavuz et al. 2005) we have energy momentum tensor for strange quark matter attached to the string cloud as

$$T_{ij} = (\rho_q + \rho_s + B_c)u_i u_j - \rho_s x_i x_j \quad (11)$$

where u_i is the four velocity of the particles and x_i is the unit space like vector representing the direction of string.

We have u_i and x_i with satisfying conditions

$$u_i u^i = -x_i x^i = 1 \quad \text{and} \quad u^i x_i = 0 \quad (12)$$

We have taken the direction of string along z- axis. Then the components of energy momentum tensor are

$$T_1^1 = T_2^2 = 0,\ T_3^3 = \rho_s,\ \ T_4^4 = \rho \quad (13)$$

Where ρ and ρ are functions of t only.

III. Solutions Of Field Equations:-

With the help of Eqs. (5), (6) and (10), for the metric (4), the field equations (1) and (2), can be written as

$$\frac{B_{44}}{B} + \frac{C_{44}}{C} + \frac{B_4}{B}\frac{C_4}{C} + \frac{\omega}{2}(\frac{\phi_4}{\phi})^2 + \frac{\phi_{44}}{\phi} + \frac{\phi_4}{\phi}\left(\frac{B_4}{B} + \frac{C_4}{C}\right) = 0 \quad (14)$$

$$\frac{A_{44}}{A} + \frac{C_{44}}{C} + \frac{A_4}{A}\frac{C_4}{C} + \frac{\omega}{2}(\frac{\phi_4}{\phi})^2 + \frac{\phi_{44}}{\phi} + \frac{\phi_4}{\phi}\left(\frac{A_4}{A} + \frac{C_4}{C}\right) = 0 \quad (15)$$

$$\frac{A_{44}}{A} + \frac{B_{44}}{B} + \frac{A_4}{A}\frac{B_4}{B} - \frac{1}{A^2} + \frac{\omega}{2}(\frac{\phi_4}{\phi})^2 + \frac{\phi_{44}}{\phi} + \frac{\phi_4}{\phi}\left(\frac{A_4}{A} + \frac{B_4}{B}\right) = 8\pi\phi^{-1}\rho_s \quad (16)$$

$$\frac{A_4}{A}\frac{B_4}{B} + \frac{A_4}{A}\frac{C_4}{C} + \frac{B_4}{B}\frac{C_4}{C} - \frac{1}{A^2} - \frac{\omega}{2}(\frac{\phi_4}{\phi})^2 + \frac{\phi_4}{\phi}\left(\frac{A_4}{A} + \frac{B_4}{B} + \frac{C_4}{C}\right) = 8\pi\phi^{-1}\rho \quad (17)$$

$$\left(\frac{A_4}{A} - \frac{B_4}{B}\right) = 0 \quad (18)$$

$$\phi_{44}+\phi_4\left(\frac{A_4}{A}+\frac{B_4}{B}+\frac{C_4}{C}\right)=\frac{8\pi(\rho+\rho_s)}{(3+2\omega)} \tag{19}$$

$$\rho_4+(\rho-\rho_s)\frac{C_4}{C}+\rho\left(\frac{A_4}{A}+\frac{B_4}{B}\right)=0 \tag{20}$$

where suffix 4 denote partial differentiation with respect to t.
From equation (18), we get

$$A=B \tag{21}$$

With the help of equation (21), The equations (14)- (17) & (19)- (20) reduces to

$$\frac{B_{44}}{B}+\frac{C_{44}}{C}+\frac{B_4}{B}\frac{C_4}{C}+\frac{\omega}{2}(\frac{\phi_4}{\phi})^2+\frac{\phi_{44}}{\phi}+\frac{\phi_4}{\phi}\left(\frac{B_4}{B}+\frac{C_4}{C}\right)=0 \tag{22}$$

$$\frac{2B_{44}}{B}+\left(\frac{B_4}{B}\right)^2-\frac{1}{B^2}+\frac{\omega}{2}(\frac{\phi_4}{\phi})^2+\frac{\phi_{44}}{\phi}+\frac{\phi_4}{\phi}\left(\frac{2B_4}{B}\right)=8\pi\phi^{-1}\rho_s \tag{23}$$

$$\left(\frac{B_4}{B}\right)^2+\frac{2B_4}{B}\frac{C_4}{C}-\frac{1}{B^2}-\frac{\omega}{2}(\frac{\phi_4}{\phi})^2+\frac{\phi_4}{\phi}\left(\frac{2B_4}{B}+\frac{C_4}{C}\right)=8\pi\phi^{-1}\rho \tag{24}$$

$$\phi_{44}+\phi_4\left(\frac{2B_4}{B}+\frac{C_4}{C}\right)=\frac{8\pi(\rho+\rho_s)}{(3+2\omega)} \tag{25}$$

$$\rho_4+(\rho-\rho_s)\frac{C_4}{C}+\rho\left(2\frac{B_4}{B}\right)=0 \tag{26}$$

To solve the above set of nonlinear field equations (22) – (26), we assume that the shear scalar σ in this model is proportional to expansion θ scalar relation which leads to

$$B=C^n \tag{27}$$

Where n is an arbitrary constant.
Using this relationship, the field equations (22) to (26) reduces to

$$(n+1)\frac{C_{44}}{C}+n^2\left(\frac{C_4}{C}\right)^2+\frac{\omega}{2}(\frac{\phi_4}{\phi})^2+\frac{\phi_{44}}{\phi}+(n+1)\frac{\phi_4}{\phi}\frac{C_4}{C}=0 \tag{28}$$

$$\frac{2nC_{44}}{C}+(3n^2-2n)\left(\frac{C_4}{C}\right)^2-\frac{1}{C^{2n}}+\frac{\omega}{2}(\frac{\phi_4}{\phi})^2+\frac{\phi_{44}}{\phi}+2n\frac{\phi_4}{\phi}\frac{C_4}{C}=8\pi\phi^{-1}\rho_s \tag{29}$$

$$(n^2+2n)\left(\frac{C_4}{C}\right)^2-\frac{1}{C^{2n}}-\frac{\omega}{2}(\frac{\phi_4}{\phi})^2+(2n+1)\frac{\phi_4}{\phi}\frac{C_4}{C}=8\pi\phi^{-1}\rho \tag{30}$$

$$\phi_{44}+(2n+1)\phi_4\frac{C_4}{C}=\frac{8\pi(\rho+\rho_s)}{(3+2\omega)} \tag{31}$$

$$\rho_4+[(1+2n)\rho-\rho_s]\frac{C_4}{C}=0 \tag{32}$$

From above equations, the solution of field equations (28) – (31), is given by

$$A=[k_3(k_1t+k_2)]^{\frac{n}{k_3}} \tag{33}$$

$$B=[k_3(k_1t+k_2)]^{\frac{n}{k_3}} \tag{34}$$

$$C = \left[k_3(k_1 t + k_2)\right]^{\frac{1}{k_3}}, \quad \text{where} \quad k_3 = \frac{n^2+n+1}{n+1}, n \neq -1 \tag{35}$$

$$\phi = \left[k_3(k_1 t + k_2)\right]^{r} \tag{36}$$

Where

$$r = 0, or \ r = \frac{-2n}{(\omega+2)(n^2+n+1)}$$ and $k_1 \neq 0 \,\&\, k_2$ are arbitrary constants.

The Bianchi type III model with strange quark matter attached with cosmic string corresponding to equations (33),(34) and (35), can be written as

$$ds^2 = dt^2 - \left[k_3(k_1 t + k_2)\right]^{\frac{2n}{k_3}}\left\{dx^2 + e^{-2x}dy^2\right\} - \left[k_3(k_1 t + k_2)\right]^{\frac{2}{k_3}} dz^2 \tag{37}$$

Using equation (24), we get the string energy density

$$\rho = \frac{\left[k_3(k_1 t + k_2)\right]^{r-2}}{8\pi}\left\{\begin{array}{l}\left[n^2 + 2n - \frac{\omega}{2}k_3{}^2 r^2 + (2n+1)k_3 r\right]k_1{}^2 \\ - \frac{a^2}{\left[k_3(k_1 t + k_2)\right]^{\frac{-2n}{n^2+2n+1}}}\end{array}\right\} \tag{38}$$

Using the equation (23), we get the tension density

$$\rho_s = \frac{\left[k_3(k_1 t + k_2)\right]^{r-2}}{8\pi}\left\{\begin{array}{l}\left[3n^2 - 2nk_3 + \frac{\omega}{2}k_3{}^2 r^2 + +r(r-1)k_3{}^2 + 2nrk_3\right]k_1{}^2 \\ - \frac{1}{\left[k_3(k_1 t + k_2)\right]^{\frac{-2n}{n^2+2n+1}}}\end{array}\right\} \tag{39}$$

The string particle density is given by

$$\rho_p = \rho - \rho_s$$

$$= \frac{\left[k_3(k_1 t + k_2)\right]^{r-2}}{8\pi}\left\{\left[2n(1+k_3) - 2n^2 - \omega k_3{}^2 r^2 + r(r-1)k_3{}^2 + k_3 r\right]k_1{}^2\right\} \tag{40}$$

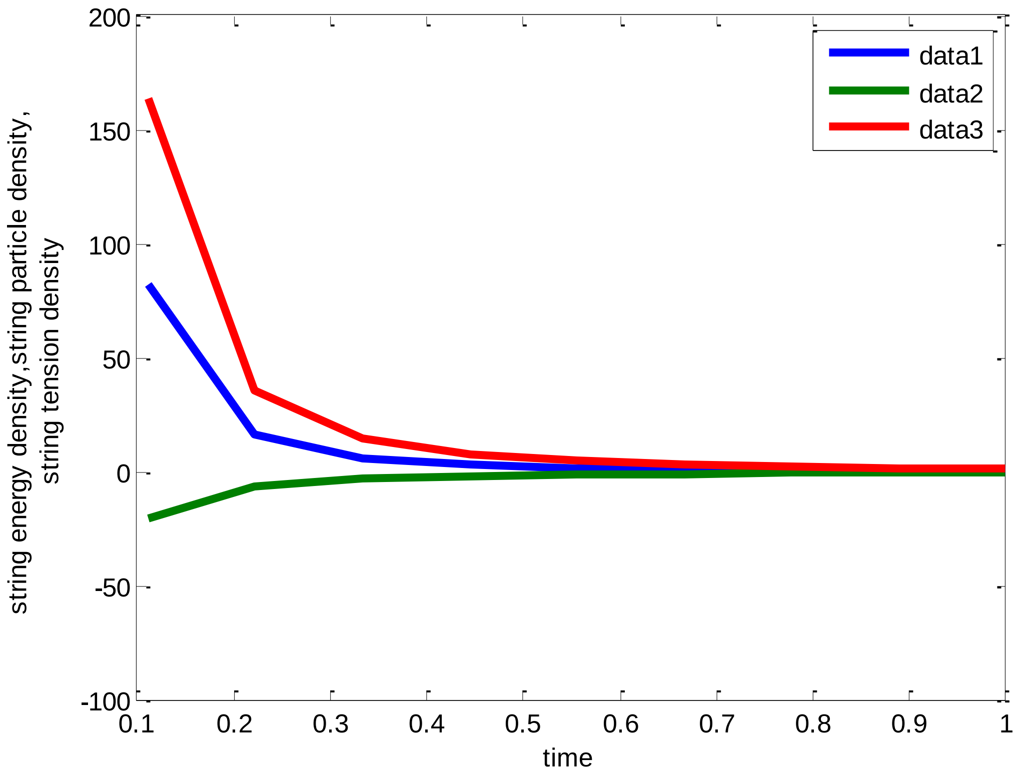

Fig. 1 here $\omega = 1, n = 1, k_1 = 1, k_2 = 0$

Data 1: string energy density verses time

Data 1: string particle density verses time

Data 3: string tension density verses time

The quark energy density is given by

$$\rho_q = \rho - B_C$$

$$= \frac{[k_3(k_1 t + k_2)]^{r-2}}{8\pi}\left\{\begin{array}{l}\left[n^2 + 2n - \frac{\omega}{2}k_3^{\ 2}r^2 + (2n+1)k_3 r\right]k_1^{\ 2} \\ - \frac{1}{[k_3(k_1 t + k_2)]^{\frac{-2n}{n^2+2n+1}}}\end{array}\right\} - B_C \tag{41}$$

The quark pressure is given by

$$p_q = \frac{\rho_q}{3}$$

$$= \frac{[k_3(k_1 t + k_2)]^{r-2}}{24\pi}\left\{\begin{array}{l}\left[n^2 + 2n - \frac{\omega}{2}k_3^{\ 2}r^2 + (2n+1)k_3 r\right]k_1^{\ 2} \\ - \frac{1}{[k_3(k_1 t + k_2)]^{\frac{-2n}{n^2+2n+1}}}\end{array}\right\} - \frac{B_C}{3} \tag{42}$$

Hence the metric represented by equation (37) together with (36) and (38) to (42) represents the Bianchi Type III cosmological model with strange quark matter attached to string cloud in Brans-Dicke theory of gravitation, where the dimensionless constant ω and arbitrary constant n are related by

$$\omega^2\left[2n^4+10n^3+12n^2-(n^2+2n+1)T\right]+4\omega\left[2n^4+8n^3+7n^2-(n^2+2n+1)T\right] +4\left[2n^4+7n^3+4n^2-(n^2+2n+1)T\right]=0\quad (3)$$

Where $T=\frac{2}{k_1^2}\left[k_3(k_1t+k_2)\right]^{\frac{2}{n^2+n+1}}$

Bianchi Type III cosmological model with strange quark matter attached to string cloud in general theory of gravitation:

If $r=0$, using (36), we get

$$\phi = cons\tan t \tag{44}$$

using equation (38), we get the string energy density

$$\rho=\frac{\left[k_3(k_1t+k_2)\right]^{-2}}{8\pi}\left\{\left[n^2+2n\right]k_1^{\ 2}-\frac{a^2}{\left[k_3(k_1t+k_2)\right]^{\frac{-2n}{n^2+n+1}}}\right\} \tag{45}$$

Using the equation (39), we get the tension density

$$\rho_s=\frac{\left[k_3(k_1t+k_2)\right]^{-2}}{8\pi}\left\{\left[3n^2-2nk_3\right]k_1^{\ 2}-\frac{a^2}{\left[k_3(k_1t+k_2)\right]^{\frac{-2n}{n^2+n+1}}}\right\} \tag{46}$$

The string particle density is given by

$$\rho_p=\rho-\rho_s$$

$$=\frac{\left[k_3(k_1t+k_2)\right]^{-2}}{8\pi}\left\{\left[2n(1+k_3)-2n^2\right]k_1^{\ 2}\right\} \tag{47}$$

The quark energy density is given by

$$\rho_q=\rho-B_C$$

$$=\frac{\left[k_3(k_1t+k_2)\right]^{-2}}{8\pi}\left\{\left[n^2+2n\right]k_1^{\ 2}-\frac{a^2}{\left[k_3(k_1t+k_2)\right]^{\frac{-2n}{n^2+n+1}}}\right\}-B_C \tag{48}$$

The quark pressure is given by

$$p_q=\frac{\rho_q}{3}$$

$$=\frac{\left[k_3(k_1t+k_2)\right]^{-2}}{24\pi}\left\{\left[n^2+2n\right]k_1^{\ 2}-\frac{a^2}{\left[k_3(k_1t+k_2)\right]^{\frac{-2n}{n^2+n+1}}}\right\}-\frac{B_C}{3} \tag{49}$$

Hence the metric (37) together with (45) to (49) represents the Bianchi Type III cosmological model with strange quark matter attached to string cloud in general theory of relativity. Also it is observed that when ω tends to infinity then r tends to zero and the Bianchi Type III cosmological model with strange quark matter attached to string cloud in Brans-Dicke theory of gravitation will reduce to cosmological model in general theory of relativity.

Some other important properties of the models:

Some important parameters of the model, which are important for the discussion of cosmological model (37) are the following.

Spatial volume

$$V = \sqrt{-g} = \left[k_3 (k_1 t + k_2)\right]^{\frac{2n+1}{k_3}} e^{-ax} \tag{50}$$

Scalar of expansion

$$\theta = \frac{(2n+1)(n+1)k_1}{(n^2+n+1)(k_1 t + k_2)} \tag{51}$$

The mean Hubble parameter

$$H = \frac{(2n+1)(n+1)k_1}{3(n^2+n+1)(k_1 t + k_2)} \tag{52}$$

Shear scalar,

$$\sigma^2 = \frac{1}{2}\sigma_{ij}\sigma^{ij}$$

$$= \frac{7(2n+1)^2(n+1)^2 {k_1}^2}{18(n^2+n+1)^2(k_1 t + k_2)^2} \tag{53}$$

The average anisotropy parameter,

$$A_m = \frac{2}{3}\frac{\sigma^2}{H^2} = \frac{7}{3} \tag{54}$$

The deceleration parameter is given by

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

$$q = \frac{n^2+2}{(2n+1)(n+1)} \quad \text{for} \quad n \neq -1, -\frac{1}{2} \tag{55}$$

The deceleration parameter $q < 0$ for $-1 < n < -\frac{1}{2}$ and $q > 0$ for $n > -\frac{1}{2}$ or $n < -1$.

If $q < 0$, the model accelerates and when $q > 0$, the model decelerates in the standard way. Hence the model sometimes decelerates in the standard way and later accelerates which is in accordance with the present day scenario. However, in spite of the fact that the universe, in this case, decelerates in the standard way it will accelerate in finite time due to cosmic re collapse where the universe in turns inflates " decelerates and then accelerates" (Nojiri and Ordintsov 2003).

The density parameter Ω is given by

$$\Omega = \frac{\rho}{3H^2}$$

$$= \frac{3\left[k_3(k_1 t + k_2)\right]^r}{8\pi(2n+1)^2 {k_1}^2} \left\{ \begin{array}{l} \left[n^2 + 2n - \frac{\omega}{2}{k_3}^2 r^2 + (2n+1)k_3 r \right] {k_1}^2 \\ - \dfrac{1}{\left[k_3(k_1 t + k_2)\right]^{\frac{-2n}{n^2+2n+1}}} \end{array} \right\} \tag{56}$$

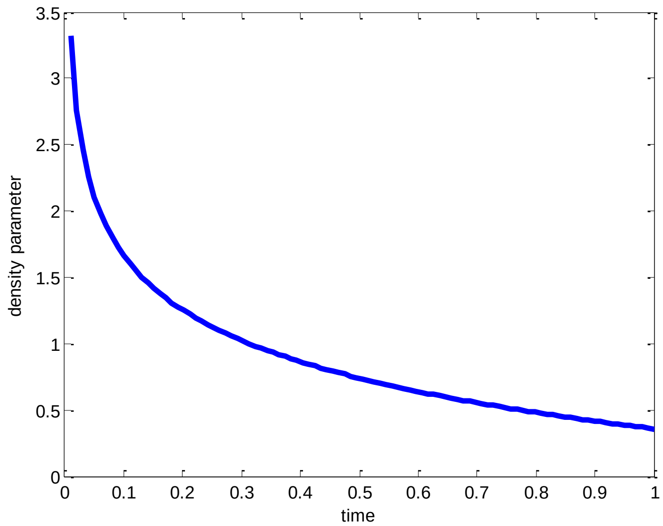

Fig.2 Density parameter verses time (here $\omega = 1, n = 1, k_1 = 1, k_2 = 0$ **)**

Conclusion:

We have investigated an anisotropic Bianchi type III cosmological model with strange quark matter attached to string cloud in Brans-Dicke theory of gravitation and also in general relativity. We observed that the model (37) has singularity at $t = -\frac{k_2}{k_1}$ for $n > 0$. Also we observed that the proper volume will be zero, for $t = -\frac{k_2}{k_1}$, and when the spatial volume becomes infinitely large for $t \to \infty$. At $t = -\frac{k_2}{k_1}$, it is observed that the model accelerates for $-1 < n < -\frac{1}{2}$ and the model decelerates for $n > -\frac{1}{2}$ or $n < -1$. Hence the model sometimes decelerates in the standard way and later accelerates which is in accordance with the present day scenario. At $t = -\frac{k_2}{k_1}$, the expansion scalar θ, Shear scalar σ and Hubble Parameter H tends to infinity, whereas when $t \to \infty$, the expansion scalar θ, Shear scalar σ and Hubble Parameter H tends to zero. Also we observed that $A_m \neq 0$ i.e., which indicates that this universe is anisotropic. It is observed that density parameter Ω reduces with time. For our model $\frac{\sigma}{\theta} \approx .6236$ which is greater than the present upper limits 10^{-5} as obtained by Collins [49] from indirect arguments concerning the isotropy of the primordial black body radiation. It is always possible to get Bianchi type III cosmological model with strange quark matter attached to string cloud in general relativity, as spatial case, when either $r = 0$ or $\omega \to \infty$.

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