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Bianchi Type-I Cosmological Model with Time Varying Λ

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ABSTRACT: In this paper we have considered a Bianchi type -I metric with bulk Viscous fluid with string in the context of Einstein theory. To solve the Einstein field equations, we have considered a power law relation of metric potentials as Shear scalar is proportional to expansion scalar to solve the Einstein field equations. Then physical and geometrical aspects of the model has been discussed.

Keywords: Bianchi type-I; Viscous fluid; Einstein theory; cosmological models.

I. INTRODUCTION:

Cosmology is the study of the Universe as a whole, as one single object-the ultimate "Big Picture". The Cosmological Principle, which states that on the large scale the Universe is homogeneous and isotropic, is the starting point for this branch of astronomy. In the recent years, the problem of string cosmology along with bulk viscosity has attracted by the researchers because cosmic strings are topologically stable [1] and it give rise to density perturbations which leads to the formation of galaxies [2]. Due to large scale of galaxies in our Universe, it can be described by a perfect fluid. However, a realistic treatment of problems it requires consideration of material distribution other than the perfect fluid [3]. When neutrino decoupling occurs, the matter behaves as a viscous fluid in an early stage of the Universe. The presence of the coefficient of bulk viscosity is not constant but plays an important role like it decreases as the Universe expands [4].

II. FIELD EQUATIONS AND ITS SOLUTIONS:

The Bianchi Type-I cosmological model for a cloud string with bulk viscosity is considered to develop a cosmological model with an assumption of an equation of state along with a relation between metric potential for getting solution of the field equations. The Bianchi Type metric we consider here is

$$ds^2 = -dt^2 + A^2dx^2 + B^2dy^2 + Cdz^2 \tag{1}$$

where A, B and C are functions of time t.

The energy momentum tensor for Bulk Viscous fluid with cloud of string is

$$T_i^j = \rho u_i u^j - \lambda x_i x^j - \zeta\theta(u_i u^j + g_{ij}) \tag{2}$$

where ρ is the energy density of the cloud of string with particles attached to them, λ is the tension density of the cloud of string, θ is the scalar of expansion, ζ is the coefficient of bulk viscosity.

The direction of string satisfies the relations

$$u^j u_i = -\chi^i \chi_j = -1, u^i \chi_i = 0 \tag{3}$$

The Einstein equation which we consider here is

$$G_{ij} + \Lambda g_{ij} = T_{ij} \tag{4}$$

Consider the Bianchi type metric

Energy momentum tensor for Bulk Viscous fluid with string

$$\frac{\ddot{B}}{B} + \frac{\ddot{C}}{C} + \frac{\dot{B}\dot{C}}{BC} = \zeta\theta + \Lambda \tag{5}$$

$$\frac{\ddot{A}}{A} + \frac{\ddot{C}}{C} + \frac{\dot{A}\dot{C}}{AC} = \zeta\theta + \Lambda \tag{6}$$

$$\frac{\ddot{A}}{A} + \frac{\ddot{B}}{B} + \frac{\dot{A}\dot{C}}{AC} = \lambda + \zeta\theta + \Lambda \tag{7}$$

$$\frac{\dot{A}\dot{B}}{AB} + \frac{\dot{B}\dot{C}}{BC} + \frac{\dot{C}\dot{A}}{CA} = \rho + \Lambda \tag{8}$$

To get a stable solution here we establish a relation between

$$\rho = \kappa\lambda, 0 < \kappa < 1, \tag{9}$$

Here we have five field equations with seven unknowns, hence we required two additional conditions to stabilize the system of equations.

Assuming shear scalar is proportional to expansion scalar the condition for metric potentials

$$B = C^n \tag{10}$$

The universe is expanding in nature hence the volume can be considered as an exponential function as $V = t^m, m > 0$

$$A = t^{\frac{mn}{2n+1}} \exp\left[\left(\frac{k(2n+1)-kn}{(1-m)(2n+1)}\right) t^{1-m}\right] \tag{11}$$

$$B = t^{\frac{mn}{2n+1}} \exp\left(-\frac{kn}{(1-m)(2n+1)} t^{1-m}\right) \tag{12}$$

$$C = t^{\frac{m}{2n+1}} \exp\left(\frac{-k}{(1-m)(2n+1)} t^{1-m}\right) \tag{13}$$

Using the values of metric potentials one can evaluate the values of

$$\lambda = \lambda_1 t^{-2m} + \lambda_2 t^{-m-1} + \lambda_3 t^{-2} \tag{14}$$

$$\Lambda = \Lambda_1 t^{-2m} + \Lambda_2 t^{-m-1} + \Lambda_3 t^{-2} \tag{15}$$

$$\theta = \frac{N_1(2n+1)}{nt} \tag{16}$$

$$\zeta = \zeta_1 t^{-2m} + \zeta_2 t^{-m-1} + \zeta_3 t^{-2} \tag{17}$$

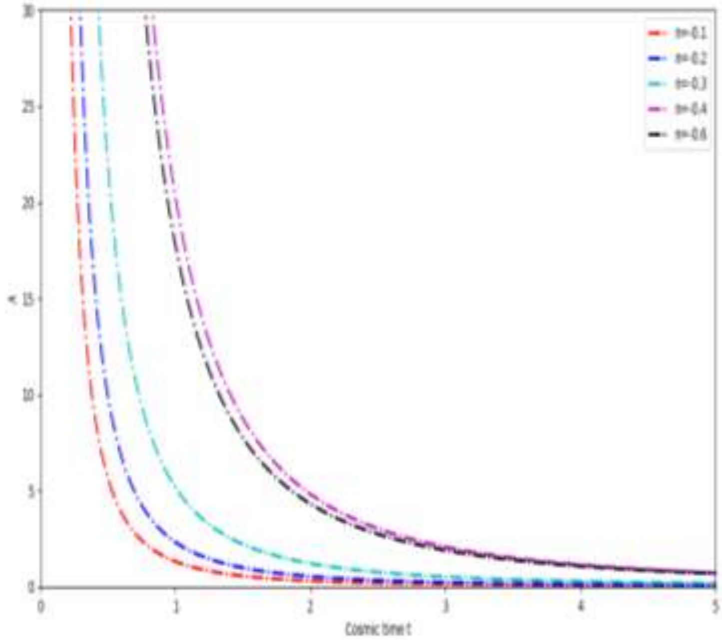

Fig.1: Variation of string energy density verses cosmic time.

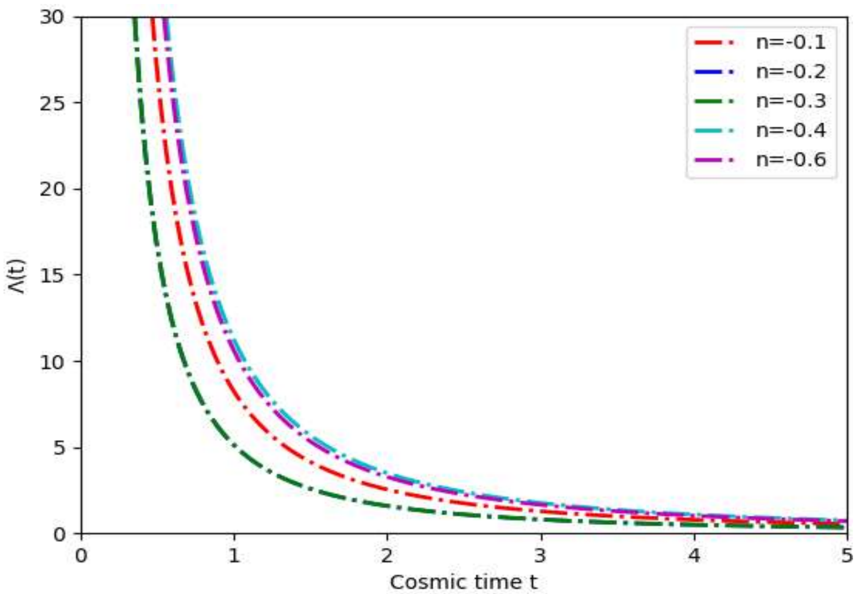

Fig.2: Variation of cosmological constant versus cosmic time.

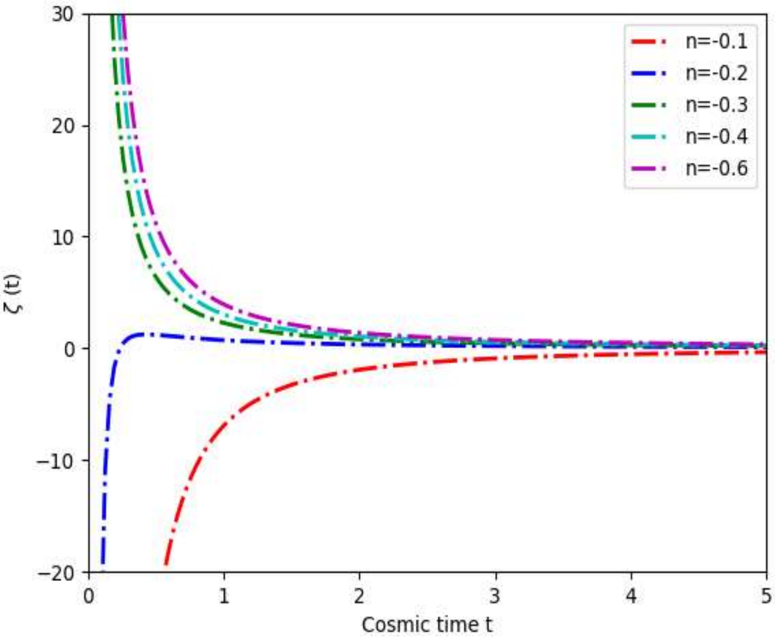

Fig.3: Variation of coefficient of viscosity versus time.

III. CONCLUSION:

In this paper we have studied Bianchi type-I space-time with string particle density in the context of Einstein theory. Here we have considered the volume of the universe as a function of cosmic time and assumed it as an n^{th} power of cosmic time. To obtain a more general model we assumed shear scalar is proportional to expansion scalar. The cosmological constant term obtained as a function of time and during initial epoch it is diverging in nature and later it approaches to zero which matches to the recent astrophysical data. The coefficient of bulk viscosity is initially diverging and behaves as a decreasing function of time, later it get vanishes hence we obtained an inflationary model.

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