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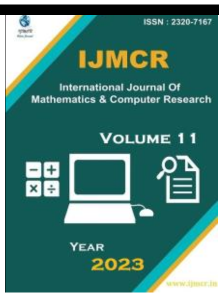


Anisotropic Tilted Spherical False Vacuum Model

R.N.Patra
P.G.Department of Mathematics, Berhampur University, Berhampur-7, (Odisha), India

ARTICLE INFO	ABSTRACT
Corresponding Author: **R.N.Patra**	In this paper, a tilted spherically symmetric cosmological model with perfect fluid distribution along with heat conduction has been considered. To get a generalized solution, I have assumed the model to be False Vacuum (i.e. $p+\rho=0$), where *p* being the isotropic pressure and ρ is the matter density of the fluid. The various physical properties of the model are also discussion as the concluding remark.

KEYWORDS: Tilted spherical cosmological model, False Vacuum model, Perfect fluid.

1. INTRODUCTION

In the recent years, there has been a considerable interest in investigating spatially homogeneous and anisotropic cosmological models, in which matter do not move orthogonally to the hypersurface of homogeneity. These types of models are called tilted cosmological models. The general dynamics of these cosmological models have been studied in details by King and Ellis[1] and they have shown that in such universe, the matter move with non-zero expansion, rotation and shear. Also, Ellis and King[2], Collins and Ellis[3], Ellis and Baldwin[4] have shown that we are likely to be living in a tilted universe and they have indicated that how we may detect it.

The spherically symmetric cosmological models have been studied by several authors. S.N.Jena, R.N.Patra and R.R.Swain[5] have studied inhomogeneous macro model with perfect fluid, R.N.Patra[6,7] has studies in context of the cosmic string model, R.N.Patra et. al. [8, 9] have used spherical metric in presence of perfect fluid and magnetic field for construction of new metrices. U.K.Panigrahi and R.N.Patra and M. Sharma[10] have constructed metric by using new scalar tensor theory of Gravitation.

Now I am motivated by these studies and taken interest to construct a tilted spherically symmetric cosmological model filled with perfect fluid along with heat conduction.

2. THE FIELD EQUATION

We consider the spherically symmetric space-time

$$ds^2 = -e^{\lambda} dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta \, d\phi^2 + e^{\mu} dt^2 , \quad (1)$$

where $\lambda(t)$ and $\mu(t)$ are the cosmic parameter.

The Energy momentum tensor for perfect fluid distribution with heat conduction given by Ellis[10] is given by

$$T_i^j = (p+\rho) v_i v^j + P g_i^j + q_i v^i + v_i q^j \quad (2)$$

together with

$$\left.\begin{aligned} g_{ij} v^i v_j &= -1 \\ q^i q^j &> 0 \\ q_i \; v_i &= 0 \end{aligned}\right\} \quad (3)$$

Here, p is the isotropic pressure, ρ is the matter density, q_i the heat conduction vector orthogonal to v_i. The fluid flow vector v_i has the components $(\sin h\alpha, 0, 0, cash\,\alpha)$ satisfying equation (3), where α being the tilt angle.

The Einstein's field equation

$$R_i^j - \frac{1}{2} R g_i^j = -8\pi \, T_i^j , \; (C = G = 1).$$

The field equation for the line element (1) leads to

$$-\frac{1}{4}\lambda_4^2 e^{\lambda-\mu} - \frac{\lambda_4 \mu_4}{8} e^{\lambda-\mu} = -8\pi\left\{(p+\rho)\sin h\alpha - e^{\lambda} p + 2q_1 \sin h\alpha\right\}$$
(4)

$$-\frac{\lambda_4}{r} = -8\pi\left\{(p+\rho)\sin h\alpha \cos h\alpha + q_1 \cos h\,\alpha + v_1 \frac{\sin h^2\alpha}{\cos h\alpha}\right\}$$
(5)

$$\frac{\lambda_{44}}{2} + \frac{\lambda_4^2}{2} - \frac{\lambda_4\mu_4}{8} = 8\pi\, pe^{\mu} \qquad (6)$$

$$-\frac{1}{4}\lambda_4^2 + \frac{1}{r^2}e^{\mu-\lambda} - \frac{1}{r^2}e^{\mu} = -8\pi\{(p+\rho)\cos h^2\alpha + e^{\mu} p + 2q_1 \sin h\alpha\}$$
(7)

3. SOLUTION TO THE FIELD EQUATIONS

Taking False Vacuum model $(\rho = -p)$, the tilt angle $\alpha = 1$, and the approximate value of $e = 2$, the value of λ from equation (5) is found to be

$$\lambda = 13.6rt\, q_1 .$$

Choosing the value of the heat conduction vector $q_1 = \frac{1}{13.6} = 0.074$, the value of λ becomes

$$\lambda = rt . \qquad (8)$$

Substracting equation (6) multiplied by $e^{\lambda-\mu}$ from equation (4) and using the above values of ρ, α, λ, e and q_1, the value of μ found to be

$$\mu = 3r^3t - 2.4 . \; (9)$$

The heat conduction vectors q_1 and q_4 are found to be in a relation

$$q_4 = 3q_1 \quad (10)$$

$$q_1 = 0.074, \; so\; q_4 = 0.222 .$$

From equation (6), the value of the isotropic pressure is found to be

$$p = \frac{4r^2 - 3r^4}{201e^{3r^3t-2.4}} . \; (11)$$

Using the values of λ and μ, the new form of the space-time
becomes

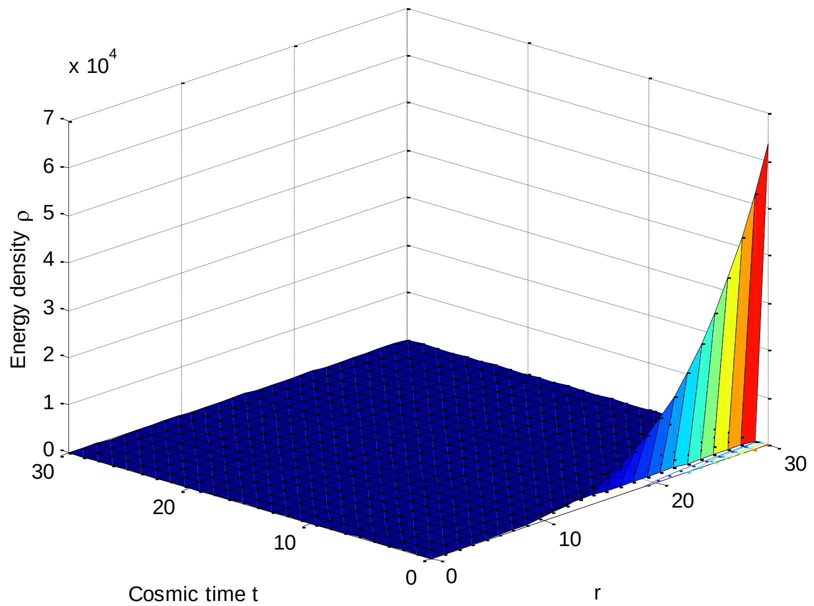
$$ds^2 = -e^{rt}\, dr^2 - r^2\, d\theta^2 - r^2 \sin^2\theta d\phi^2 + e^{3r^3t-2.4} dt^2 .$$

4. PHYSICAL PROPERTIES

1. Assuming the heat conduction vector along the fourth co-ordinate to be thrice of that along the first co-ordinate, the isotropic pressure and the matter density of the space-time with perfect fluid distribution as in equation (11) is

$$p = -\rho = \frac{4r^2 - 3r^4}{201\, e^{3r^3t-2.4}} .$$

When $t - \infty$ then $\rho \to 0$ with a negative pressure. The variation of ρ w.r.t 't' has been shown in the graph, where ρ is a decreasing functions of time.



2. Taking the value of the tilt angle $\alpha = 1$ and the approximate value of $e = 2$, the fluid flow and the heat conduction vectors are found to be

$$v_1 = \sin h\alpha = 0.75$$

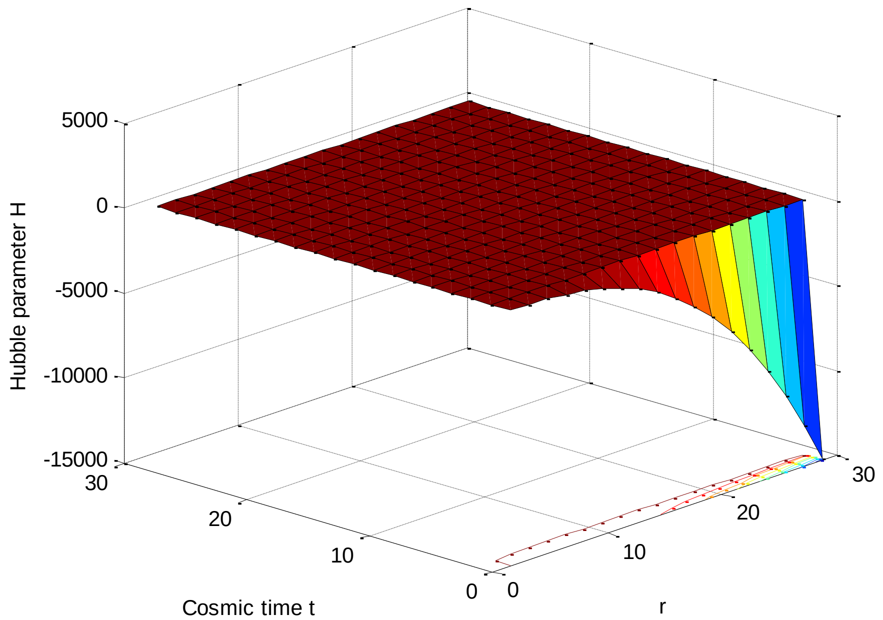
$$v_4 = \cos h\alpha = 1.25$$

$$q_1 = 0.074 \; and \; q_4 = 0.222 .$$

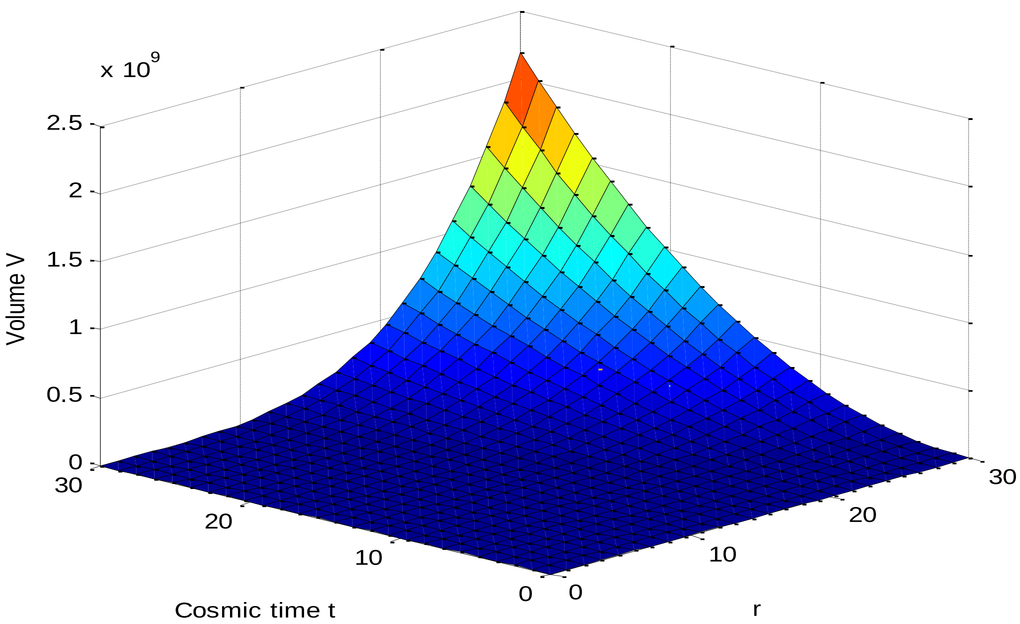
As the tilt angle is independent of time, the velocity components are found to be constant, that means the flow is uniform.

3. The Hubble parameter $H = \frac{2r^3t + 3r^4 - 2.4}{2r(3r^3t - 2.4)}$ is a function of 'r' and 't'.

The $H \sim t$ graph has been shown below.



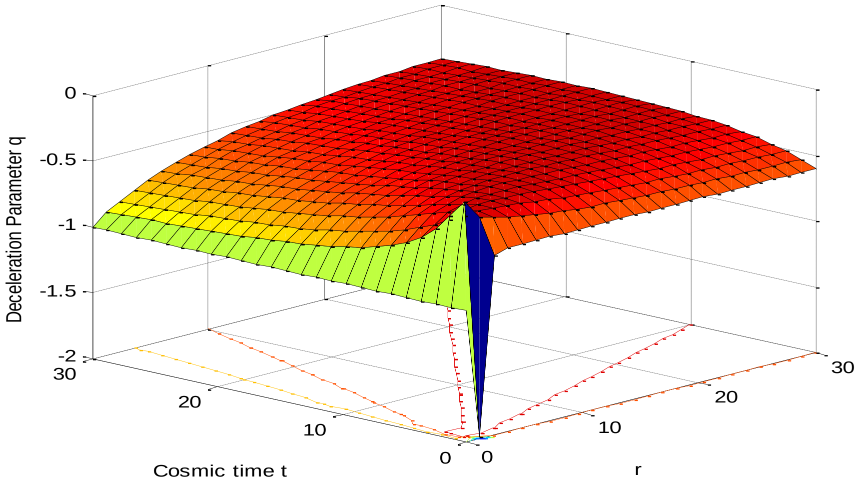
4. The cosmic scale factor $R = \lambda^{\frac{1}{2}}$ and the volume $V = R^2 = \lambda\mu$ i.e. $V = 3r^4t^2 - 2.4rt$. So $V \to \infty\, as\; t \to \infty$ and $V \to 0\; as\; t \to 0$ that means the universe expands with the increase of cosmic time and may blow up in near future which has been shown in the graph.



5. The deceleration parameter $q = \frac{d}{dt}\left(\frac{1}{H}\right) - 1$ is found to be

$$q = \frac{(3r^4 + 3r^3t - 2.4)\,6r^4 - r^4(14.4r^4 - 6t)}{(3r^4 + 3r^3t - 2.4)^2} - 1$$

i.e. $q < 0$, which shows the accelerating nature of the universe. The graph of deceleration parameter q has been shown in the graph given below.



6. The mean anisotropy parameter

$$A = \frac{1}{2}\left(\frac{\Delta H_1}{H} + \frac{\Delta H_2}{H}\right) \neq 0$$

That means the model of the universe is found to be anisotropic.

5. CONCLUSION

The false vacuum model $(p = -\rho)$ applied to the universe filled with perfect fluid and heat conduction is found to be anisotropic with expansion in volume as the deceleration parameter $q < 0$. Taking the tilt angle $\alpha = 1$, the flow of the fluid is found to be uniform. The matter density of the model decreases sharply with increase in cosmic time and the isotropic pressure becomes less negative gradually. Taking the approximate value of $e = 2$, the heat conduction vectors are found to be in a relation $q_4 = 3q_1$.

REFERENCES

1. A.R.King and G.F.R Ellis: Comm. Math. Phys, Vol.31, pp.209-242(1973).
2. G.F.R. Ellis and A.R.King: Comm. Math. Phys., Vol.38, No.2, pp.119-156(1974).
3. C.B. Collins and G.F.R Ellis: Phys., Rep., Vol.56, pp.65-105(1979).
4. G.F.R. Ellis and J.E. Baldwin: Mon. Not. Roy Astron. Soc. Vol.206, pp.379-381(1984).
5. S.N.Jena, R.N.Patra and R.R.Swain: Inhomogeneous macro model with perfect-fluid. International Journal of Innovative Science, Engineering and Technology, Vol.2, Issue.4, pp.421-429(April 2015).
6. R.N.Patra: Anisotropic Cosmological Model of Cosmic String with Bulk Viscosity in Lyra Geometry-IJMTT, Vol.48, Number.3, pp.147-151,(Aug. 2017).
7. R.N.Patra: String Cosmological Model in New Scalar Tensor Theory of Gravitation, IJMTT, Vol.48, No.2, pp.152-154.
8. R.N.Patra, R.C.Sahu and R.R.Swain: Identification of scalar meson field with perfect fluid in Bimetric Theory for a spherically symmetric cosmological model-IJETER, Vol.3, Issue-3, pp.41-43,(Dec. 2015).
9. S.N.Jena, R.N.Patra and R.R.Swain: Non-existence of String Cosmological Models in presence of Magnetic Field in Bimetric Theory, IJISET, Vol.2, Issue-6, pp.721-727(June, 2015).
10. U.K.Panigrahi, R.N.Patra, M.Sharma: Higher Dimensional Symmetric Metric Models in A New Scalar Tensor Theory of Gravitation, IJMR, Vol.7, No.1, pp.1-6(2015).