Summary

The Minor Research Project (UGC Approval File No: 47-751/13 (WRO), Date: 21/05/2014) entitled **"Study Of Cosmological Models In Creation Field Theory Of Gravitation"** sanctioned by University Grant Commission, New Delhi consist of four chapters.

The chapter I is "Introduction". This chapter content literature survey, previous research work data carry out on this topic. Here the brief information related to the topics is given.

The Chapter II is "Bianchi Type-III Domain Walls with Variable Deceleration Parameter in Creation Field Cosmology".

In this chapter Bianchi type-III metric has considered in the form of

$$ds^2 = dt^2 - a_1{}^2 dx^2 - a_2{}^2 e^{-2mx} dy^2 - a_3{}^2 dz^2 ,$$

where metric potentials a_1, a_2 and a_3 are functions of cosmic time t only.

The Einstein field equations modified by Hoyle and Narlikar by introducing a massless scalar field called as creation field *viz.* C - Field were given by

$$R_{ij} - \frac{1}{2} R g_{ij} = -8\pi G \left({}^{m}T_{ij} + {}^{c}T_{ij} \right),$$

where ${}^{m}T_{ij}$ and ${}^{c}T_{ij}$ are matter tensor of Einstein's theory and C-field theory respectively.

A thick domain walls can be viewed as soliton-like solution of the scalar field equations

We assume the energy momentum tensor in the form

$${}^{m}T_{ij} = \rho(g_{ij} + \omega_i \omega_j) + p\omega_i \omega_j \quad ,$$

where ρ is the energy density of the wall, p is the pressure in the direction normal to the plane of the wall and ω_i is a unit space-like vector in the same direction which obeys the relation $\omega^i \omega_j = -1$. To study the thick domain walls in Creation field theory of gravitation. In the co-moving co-ordinate system, we have from above equation

$$T_1^1 = T_2^2 = T_4^4 = \rho , \quad T_3^3 = -p \quad \text{and} \quad T_i^j = 0 \quad \text{for } i \neq j .$$

Here pressure is taken in the direction of z axis. The quantities ρ and p depends on t only.

The ${}^{c}T_{ij}$ is matter tensor due to creation field given by

$$ {}^{c}T_{ij} = -f\,(c_i c_j - \frac{1}{2} g_{ij} C^{\alpha} C_{\alpha}), $$

where $f > 0$ is the coupling constant between matter and creation field. It is assumed that creation field C is a function of time t only *i.e.* $C(x,t) = C(t)$.

In order to determinate solution, we use variable deceleration parameter q as

$$ q = -\frac{a\ddot{a}}{\dot{a}^2} = -\left(\frac{\dot{H} + H^2}{H^2}\right) = b(t) $$, where a is mean scale factor of the universe.

Also, we assume that the scalar expansion (θ) in the models is proportional to the shear scalar (σ^2). This condition leads to

$a_1 = a_3{}^{n}$, where n is a constant.

After finding scale parameter, Bianchi type-III cosmological models with domain walls in Hoyle-Narlikar's creation field theory of gravitation written as

$$ ds^2 = dt^2 - \ell_1{}^2 \sinh^{\frac{6n}{2n+1}}(\beta T) dx^2 - \ell_2{}^2 \sinh^{\frac{6n}{2n+1}}(\beta T) e^{-2mx} dy^2 - \ell_3{}^2 \sinh^{\frac{6}{2n+1}}(\beta T) dz^2 . $$

From Physical parameter of cosmological model, it is observed that

1. The deceleration parameter (q) decreases very rapidly and reaches up to value -1 and then after it remains constant $(i.e. -1)$ like de-Sitter universe.
2. The cosmological model has singularity at $T = 0$. It starts with big bang from its singular state at $T = 0$ and continues to expand till $T = \infty$. At $T = 0$, the energy density (ρ) and Pressure (p) are infinite and they become negligible for large values of T.
3. The mean anisotropy parameter (A_h) is found to be constant. Also, the ratio $\frac{\sigma^2}{\theta^2} =$ constant $(\neq 0)$ indicating that the model approaches to anisotropic throughout the evolution. The study on domain walls successfully describes the various features of the universe.
4. The creation field C is directly proportional to time t. Hence the creation of matter increases as time increases which follows the results obtained by Hoyle and Narlikar.

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The Chapter III, is **"LRS Bianchi Type-V Cosmological Model For Barotropic Fluid Distribution With Bulk Viscosity And Decaying Vacuum Energy Λ(t) In Creation Field Theory of Gravitation"**

In this chapter we consider LRS Bianchi type-V metric in the form of

$$ds^2 = dt^2 - A^2dx^2 - B^2e^{-2mx}(dy^2 + dz^2) \ ,$$

where A and B are scale factors which are function of cosmic time t and m is a constant.

The Einstein field equations modified by Hoyle and Narlikar (1964) by introducing a massless scalar field called as creation field *viz*. *C*-field were given by

$$R_i^j - \frac{1}{2}Rg_i^j = -8\pi G\left[\underset{(m)}{T_i^j} + \underset{(c)}{T_i^j}\right] - \Lambda g_i^j \, .$$

The energy momentum tensor $\underset{(m)}{T_i^j}$ for viscous and $\underset{(c)}{T_i^j}$ for creation field are given by

$$\underset{(m)}{T_i^j} = (\rho + p)v_i v^j - pg_i^j - \xi\theta(v_i v^j - g_i^j)$$

and $$\underset{(c)}{T_i^j} = -f\left(C_i C^j - \frac{1}{2}g_i^j C^\alpha C_\alpha\right).$$

Here ρ is the energy density of massive particles and p is the pressure. v_i are co-moving four velocities which obey the relation $v_i v^j = 1, v_\alpha = 0, \alpha = 1, 2, 3$. ξ is the coefficient of bulk viscosity and θ is the expansion. The coupling constant between matter and creation field is greater than zero. It is assumed that creation field C is a function of time only i.e. $C(x,t) = C(t)$.

For deterministic model, we assume that the coefficient of bulk viscosity (ξ) is inversely proportional to the expansion (θ). This condition leads to (Yadav & Yadav, 2013)

$$\xi\theta = \text{Constant} = \beta \text{ (say)}.$$

From above equations, we get

$$\underset{(m)}{T_i^j} = (\rho + p)v_i v^j - p g_i^j - \beta(v_i v^j - g_i^j).$$

The conservation equation

$$\left(8\pi G T_i^j + \Lambda g_i^j\right)_{;j} = 0$$

leads to

$$8\pi\dot{G}\left(\rho - \frac{1}{2}f\dot{C}^2\right) + 8\pi G\left(\dot{\rho} - f\dot{C}\ddot{C}\right) + 8\pi G\left[3\rho\frac{\dot{A}}{A} - 3\beta\frac{\dot{A}}{A} - 3f\dot{C}^2\frac{\dot{A}}{A} + 3p\frac{\dot{A}}{A}\right] + \dot{\Lambda} = 0.$$

Following Hoyle and Narlikar, the source equation of *C*-field: $C^i_{;i} = n/f$ leads to $C = t$, for large values of r. Thus $\dot{C} = 1$. We assume that the universe is filled with barotropic perfect fluid i.e. $p = \gamma\rho$, where p being isotropic pressure & ρ is the matter of density.

To get deterministic solution in terms of cosmic time t, we assume that $\Lambda = \frac{1}{A^2}$, where A is scale factor. {Chen & Wu (*Phys. Rev. D*, 41:695,1990)}.

Thus, LRS Bianchi Type-V Cosmological Model For Barotropic Fluid Distribution With Bulk Viscosity And Decaying Vacuum Energy Λ(t) in Hoyle-Narlikar's creation field theory of gravitation leads to

$$ds^2 = dt^2 - (\delta\sinh^2 t)\left[dx^2 - e^{-2mx}(dy^2 + dz^2)\right].$$

From Physical parameter of cosmological model, it is observed that

The universe starts evolving with zero volume at $t = 0$ and expands infinitely with the increase in cosmic time t. The scale factor A increases exponentially with time indicating inflationary scenario in the model.

The values of expansion scalar θ tend to infinity for large values of t $(t \to \infty)$ showing that the universe is expanding with increase of time. The mean anisotropy parameter is found to be zero. Also, the ratio $\frac{\sigma}{\theta} = 0$ indicating that the model is isotropic throughout the evolution.

The energy density ρ is always positive and decreases as time increases for all these models. The creation field C is proportional to the time t i.e. the creation of matter increases as time increases as obtained by Hoyle and Narlikar.

The cosmological term Λ is initially infinite for all these models. It is decreasing function of time and approaches to zero at late time which is supported by recent result from the observations of type Supernovae explosion (SNIa).

It is observed that q decreases very rapidly and reaches to value -1. Then after it remains constant -1 (like de-sitter universe). The model has accelerated expansion at early stages and at present as well showing that the universe is inflating.

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The chapter IV contents the references of above all chapters.