A STUDY ON SOME BIANCHI TYPE COSMOLOGICAL MODELS IN GENERAL THEORY OF RELATIVITY

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CHAPTER-9

FINDINGS AND SUGGESTIONS

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In this Thesis, we have considered some four and five dimensional Bianchi types (Type-I, Type-III, Type-V) cosmological models in GR to study the Universe and its behavior. There is an individual conclusion in each chapter of the Thesis, though in this chapter, we have summarized them accordingly.

In Chapter-1**,** the definition and history of the cosmology, cosmological models, general relativity and Einstein's field equations, some topic related Principles and laws, the fate of the Universe, different cosmological parameters, some candidates for dark energy, some cosmological problems have been explained. Further, the objectives, Methodology used and Summary of the research work are also presented. Also, various related topics already done research works of several authors have been reviewed. Chapter 2 deals with the construction of a Bianchi type-I string cosmological model in GR with bulk viscosity and a constant DP. The model is expanding, non-shearing, anisotropic throughout the evolution for $n \neq 1$. The existing Universe originates with Big-Bang at $t = 0$ (initial epoch) with zero volume and expands with acceleration with the passes of time, rather the rate of expansion of the Universe slackens with increase of time. The tension density decreases faster than the particle density, indicating that particles dominate the current Universe. In Chapter-3, the field equations obtained for Bianchi type-III Universe in Lyra geometry is derived and solved by using the law of variation of Hubble's parameter H that yields constant deceleration parameter. The model is an anisotropic, expanding, accelerating, non-shearing, inflationary and admits initial singularity at $t = 0$, that begins at $t = 0$ with volume 0 and expands with acceleration until the strings vanish, leaving only the particles in the late Universe, resulting in a particle-dominated Universe that agrees with current observations. In Chapter-4, a five dimensional Bianchi type-I string cosmological model in the context of GTR has been investigated. The isotropic string model doesn't survive in general relativity but anisotropic string model survive. The model represents an expanding Universe that starts at the time $t = 0$ with a volume $V = 0$ and expands with acceleration after an epoch of deceleration. The model is anisotropic, shearing and satisfies the energy conditions $\rho \geq 0$ and $\rho_p \geq 0$. The DP "q" is decelerating at the initial stage of the evolution and then accelerates after some finite time because of the cosmic recollapse, indicating inflation in the model after an epoch of deceleration which is in accordance with the present-day observational scenario of Universe as claimed by SNe Ia [Riess et al.(1998) and Perlmutter et al.(1999)]. In Chapter-5, the exact solution of five dimensional Bianchi type-III string cosmological models with bulk viscous fluid has been obtained. The model may be free from initial singularity at $t = 0$ and we have the expectation that spatial volume may increase with time supporting the accelerated expansion of the Universe. The strings may disappear during the evolution of the Universe, leaving only the particles, which describes the accelerated expansion of the Universe. In Chapter-6, a 5-dimensional LRS Bianchi type-I String cosmological model in GTR in presence of bulk viscous fluid has been investigated. The model is anisotropic, expanding and decelerating at first, then accelerating in the late Universe, resulting the inflationary model Universe. In Chapter-7, we look at a Bianchi type-V cosmology with quadratic EoS direct interaction with perfect fluid in 5-dimensional space-time. The general solutions of EFE were obtained under the assumption of quadratic EoS $p = \alpha\rho^2 - \rho$, where $\alpha \neq 0$ is an arbitrary constant when the DP is treated as a constant quantity. The resulting model expands with accelerated motion, which corresponds to the most recent observational data. The model remains isotropic, non-sharing and free of the initial singularity throughout its evolution. Isotropic pressure (p) is a negative quantity that decreases as time t passes. Such solutions are consistent with recent observational data such as SNe Ia. The negative pressure may be a possible cause of the accelerated expansion of the Universe. In Chapter-8, a five dimensional Bianchi type-I model in the context of GTR have been investigated by considering bulk viscosity as (i) constant quantity and (ii) functions of cosmic time. In both cases the model represents an exponentially expanding and accelerating that starts with volume 0 and stops with infinite volume. The model has an initial singularity and will eventually approach the de-Sitter phase $(q = -1)$. It also satisfies the energy conditions $\rho \geq 0$ and $\rho_p \geq 0$. The strings disappear during the evolution of the Universe, leaving only the particles. The model is anisotropic one and shearing throughout its evolution for $n \neq 1$ but approaches to small isotropy whenever $n = 1$.

From our studies, we have concluded that the present Universe is dominated by particles since the tension density vanishes more rapidly than particle density. The entire models show the expansion of our Universe with acceleration. The models show that the present Universe starts with Big-Bang at initial epoch at $t = 0$ with zero volume and as the time passes it expands with acceleration and the rate of expansion of the Universe slows down with increase of time. The bulk viscosity coefficient plays a great role in the cosmological consequences.

Finally, we may conclude that all the above solutions and results presented in the different chapters in the thesis are new, are in good agreement with the present day cosmological observations and useful for a better understanding of the evolution of the Universe in Bianchi type space-time in GR. These studies are likely to be useful for the analysis of different kinds of Bianchi Models in various space-times. The model needs further deep study in higher dimensional space time considering all the observational findings, which will be supportive for clearing up the current accelerated expansion activities of the Universe and it will be our upcoming work. Through this thesis, with the help of Bianchi type-universes in GR and modified gravity theories, we hope to present a better understanding of the cosmological evolution of the present Universe.

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