Abstract

This thesis entitled with "**STUDY OF SOME COSMOLOGICAL MODELS IN LYRA GEOMETRY**" comprises of 9 (nine) chapters devoted to the investigation of 8 (Eight) different models of the universe having physical interest in Lyra Geometry, which is nothing but an alternative theory of gravitation.

Chapter-1 is **introductory** in nature where we highlighted the basic idea with the foundation and development of the cosmological problem in relativity. In the light of related works of others, we have described the physical relevance and motivations for the various problems of investigation presented in the following chapters.

In Chapter-2, we studied a problem entitled "**Whether Lyra's Manifold itself is a Hidden Source of Dark Energy**" by considering a five dimensional Bianchi type-I string cosmological model in Lyra manifold with two different cases. In the course of investigation of some interesting cosmic string universes in the five dimensional Lyra manifold it is excitingly found that the geometry itself of Lyra manifold behaves as a new source of dark energy and this energy takes a form similar to that of quintessence in most of the cases, though in one case the dark energy comes out to be that of the cosmological constant type. The behaviour of the universes and their contribution to the process of evolution are examined in details.

The work presented in this chapter has been published in "International Journal of Theoretical Physics" (IJTP), 07 June 2017, with doi:10.1007/s10773-017-3417-4

Chapter 3 deals with the study of "**Five Dimensional String Universes in Lyra Manifold**". Here considering five dimensional plane symmetric metric we discuss a model universe with different situations, by solving the modified Einstein field equations within the framework of Lyra Geometry. In this model universe though both energy density and string tension density are obtained as decreasing functions of time until both of them tend to zero as time tend to infinity but with the advent of time, the density of the string decreases more rapidly than density of the particles attached to them. Thus our universe ultimately becomes a

universe dominated by particles, where strings are becoming invisible in course of time. From this model universe, we see that the special dimensions expand isotropically implying the expansion of our universe which bears testimony to our universe being a realistic one.

Moreover, the expressions of the expansion factor and deceleration parameter explains that our model universe is expanding and the gauge function β^2 is found to be constant at the initial epoch of time and gradually increases with time until it becomes a finite constant $4b_0^2$ at infinite time. Though an anisotropic parameter is produced in this universe, its anisotropy does not promote anisotropy in the expansion but in course of time our universe becomes an isotropic one. Interacting with the pressure less matter here the displacement vector can play the same role as a cosmological constant . Thus it will be nice to study more to be whether the displacement vector plays a role in disturbing the rate of expansion of the universe.

The work presented in this chapter has been published in "International Journal of Astronomy and Astrophysics" (IJAA), 2015, 5, pp. 90-94. doi:10.4263/ijaa.2015.52012

Chapter 4 is devoted to the study of a "**Higher dimensional LRS Bianchi type - I Cosmological Model Universe interacting with perfect fluid in Lyra Geometry**". Exact solutions of the field equations are obtained with certain physical assumptions in two different cases. In Case-I, the displacement vector β is taken as constant whereas, in Case-II, β is considered to be a function of cosmic time t. The physical behavior of the model is also discussed in details. We also discussed different distributions like dust, stiff fluid, disordered distribution and Matter distribution in internabular space and it is observed that our model universe is always an isotropic one which supports the Ade et al.-Plank collaboration-2015.

The work presented in this chapter has been published in "The African Review of Physics" (2016) 11: 0006 pp. 33-38.

Chapter 5: In this chapter we studied the "**Higher dimensional Cosmological Model Universe with Special law of Hubble's Parameter in Lyra Geometry**" by considering five dimensional LRS Bianchi type I metric with special law of variation of Hubble's Parameter given by the relation $H = aR^{-m}$ [Berman (1983) ; Berman and Gomide (1988) ; Ram et al. (2010)], where $a > 0$ and $m \geq 0$, the exact solutions of the field equations are obtained in two different cases corresponding to $m = 0$ and $m \neq 0$. So we obtained two cosmological models in two cases corresponding to $m = 0$ and $m \neq 0$ with constant deceleration parameter. The physical and geometrical behaviors of the models are also discussed in details. In both the cases, the displacement vector β is found to be positive and is a decreasing function of time that tend to zero at infinite time. Characteristically β is similar to that of Λ - term in Einstein's theory of gravity. In all the models β plays the same role as cosmological constant and preserves the same character as Λ - term in Einstein's theory.

Also, since the energy density ρ and pressure p are obtained as positive and negative respectively (in both the cases) so that both of our models reprsentsent dark energy model universes which are isotropic and expanding with accelerations. Thus both model universes satisfy the results of recent cosmological observations like Type SNeIa supernova, CMB anisotropies, the large scale galaxies structures of universe, Baryon Acoustic Oscillations, WMAP, and new data sets like Planck results, ACT and SPT which have measured the CMB temperature and polarisation anisotropies.

This chapter-5 is in communication for publication.

Chapter 6 deals with the study of a "**Higher Dimensional Cosmological Model Universe with Quadratic Equation of State in Lyra Geometry**". In this chapter, we have studied five-dimensional LRS Bianchi type I metric in presence of perfect fluid and study cosmological model in the context of Layra's geometry by using quadratic equation of state. Exact solutions of the field equations are obtained with certain physical assumptions. The physical behavior of the model is also discussed in details. Here, initially when $t \to 0$ then the Hubble's parameter H and expansion factor θ are found to be constants but as the time progresses gradually they decreases and finally when $t \to \infty$ both H and θ become zero, which means that the Universe is expanding with the increase of time but the rate of expansion becomes slow as time increases. Our work analyze the general feature of LRS Bianchi Type-I cosmological model with time dependent displacement vector, so the concept of Lyra geometry is still exist even after the infinite times with different ideas and concepts. So it will be interesting to study the different properties of different topological defects within the framework of Lyra geometry and beneficial for further study to investigate the different models of our universe.

The work presented in this chapter has been published in "Prespacetime Journal", USA, March 2016, volume 7, Issue 3, pp. 499-508

In Chapter 7, this chapter entitled "**On Bianchi type III Cosmological Model with Quadratic EoS in Lyra Geometry**", we investigated for a homogeneous and anisotropic space-time described by Bianchi type III metric in presence of perfect fluid in the context of Lyra geometry. Exact solutions of the Einstein's field equations have been obtained under the assumption of quadratic equation of state (EoS) of the form $p = a\rho^2 - \rho$, where a is a constant and strictly $a \neq 0$. The physical and geometrical behavior of the model is also discussed in details. Interestingly we have obtained the shear free dark energy model universe which expands with acceleration.

This chapter-7 is in communication for publication.

Chapter 8 deals with the "**Bianchi type III Cosmological Model Universe with hybrid scale factor in presence of Van der Waals fluid in Lyra Manifold**". Here we obtain the exact solutions of the field equations by considering the Van der Waal equation of state since from the recent discovery of the accelerated expansion of the universe at late time, the cosmological component enlarged and exotic equation of state were needed to model the acceleration of cosmic expansion. Due to the nonlinearities of such equation of state the cosmological dynamics is usually solved. The variations of the some of the physical parameters with time are also presented in details. Interestingly we found that the initial accelerated epoch is due the Van der Waal fluid which behaves like a scalar field with negative pressure. Also it can stimulate the transition from an inflationary period to a matter field dominated epoch.

This chapter-8 is in process for publication in Astrophysics and Space Science

In the last Chapter 9, entitled "**Could the Lyra Manifold be the hidden source of the dark energy ?**", we considered the five dimensional Locally Rotationally Symmetric (LRS) Bianchi Type I universe with time dependent deceleration parameters in Lyra manifold and the solutions are obtained in 4 (four) different cases viz. (i) Models with Time Dependent Deceleration Parameter, (ii) Models with variable Deceleration Parameter- with three sub-cases (1-3), (iii) Models with Linearly Varying Deceleration Parameter and (iv) Models with special form of Deceleration Parameter. In all the cases the displacement vector β is positive and is a decreasing function of time which tends to zero in infinite time.

In the course of investigation of our present model universe characteristically β is similar with the same role as cosmological constant in Einstein's theory. From all the above different cases we find that the energy density and gauge function are positive and decreasing function of time. We also observed the value of deceleration parameter obtained from all the cases of our model universe are in fair agreement with the result of cosmological observations like Type SNeIa supernova, CMB anisotropies, the large scale galaxies structures of universe, Baryon Acoustic Oscillations, WMAP, and new data sets like Planck results, ACT and SPT which have measured the CMB temperature and polarization anisotropies. From the values of pressure p and critical density ρ we found that our model universe behaves as the dark energy model universe which is accelerated at the late phase of the cosmic dynamics before it might be decelerating at the early phase. Thus, it is seems that the geometry itself of Lyra manifold behaves and consistent with present observational findings for accelerating universe. The behavior of the universes and their contribution to the process of evolution are examined. While studying their physical, dynamical and kinematical properties for different cases it is found that this model is a new and viable form of model universe containing dark energy. It will be very helpful in explaining the present accelerated expansion behavior of the universe.

The work presented in this chapter has been published in "International Journal of Geometric Methods in Modern Physics" (IJGMMP), Vol. 14 (2017), 1750063 (34 pages); doi:10.1142/S0219887817500633 © World Scientific Publishing Company