ABSTRACT

The thesis titled "**Dark Energy in Higher Dimensional Spherically Symmetric Space-time**" consists of 9 chapters, for which the abstracts of each chapter is given below.

Chapter 1 is an introductory chapter. The chapter explains the motivation for conducting the research and introduces the works presented in the thesis. In this chapter, we provide the basic idea of the foundation and formulation of cosmological problems of general relativity. We also present the brief highlights of various concepts, space-time, and theories of gravitations discussed in the following chapters of the thesis. We also present the review of various literature from different sources to obtain a better grasp of the past and present works.

Chapter 2 presents the research method and methodology employed to acquire knowledge and data to answer the research problem. The logic behind the method used to acquire and analyse the results of the study is discussed in this chapter.

Chapter 3 presents a research problem titled "**Higher dimensional phantom dark energy model ending at a de-Sitter phase**". The work discussed in this chapter is published in **Chinese Journal of Physics, 77 (2022) 1732-1741, DOI: 10.1016/ j.cjph.2021.05.022 (IF-3.237)**. In this chapter, using a spherically symmetric metric, we investigate a minimally interacting holographic dark energy model within the framework of Saez-Ballester Theory. We predict that the dark energy component dominating the universe is of phantom type, which will lead the model universe to cosmic doomsday (big rip singularity). As big rip and holographic dark energy are incompatible with each other, we employ a higher dimensional scenario so that the cosmic doomsday is replaced by the de-Sitter phase. The model expands with a slow and uniform change of size during the early evolution, whereas the change becomes faster, agreeing with the present observation of the accelerated expansion. The present values of Hubble parameter and the dark energy EoS parameter are measured to be $H = 67$ and $\lambda = -1.00011$, which agree with the respective values $H_0 = 67.36 \pm 0.54 kms^{-1} Mpc^{-1}$ and $\lambda = -1.03 \pm 0.03$ of the most recent Planck 2018 result. Discussions on the parameters obtained are also presented in details with graphs.

Chapter 4 presents a research problem titled "**Vacuum energy in Saez-Ballester Theory and stabilization of extra dimensions**". The work discussed in this chapter is

is published in **Universe, 8 (2022) 60, DOI: 10.3390/universe8020060 (IF-2.278)**. In this chapter, we study a spherically symmetric metric in 5D within the framework of Saez-Ballester Theory, where minimal dark energy-matter interaction occurs. We predict that the expanding isotropic universe will be progressively DE dominated. We estimate few values of the deceleration parameter, very close to the recently predicted values. We obtain the value of the DE EoS parameter as $\omega = -1$. Additionally, we measure the value of the overall density parameter as $\Omega = 0.97 (\approx 1)$, in line with the notion of a close to or nearly (not exactly) flat universe. We predict that the model universe starts with the Big-Bang and ends at the Big Freeze singularity. In general, we cannot find conditions for stabilization of extra dimensions in general relativity, and all dimensions want to be dynamical. Here, we present two possible conditions to solve this stabilization problem in general relativity.

Chapter 5 presents a research problem titled "**A higher dimensional cosmological model for the search of dark energy source**". The work discussed in this chapter is published in **International Journal of Geometric Methods in Modern Physics, 18 (2021) 2150026, DOI: 10.1142/S0219887821500262 (IF-1.874)**. In this chapter, with due consideration of reasonable cosmological assumptions within the limit of the present cosmological scenario, we analyse a spherically symmetric metric in 5D setting within the framework of Lyra manifold. The model universe is predicted to be a DE model, dominated by vacuum energy. The model represents an oscillating model, each cycle evolving with a big bang and ending at a big crunch, undergoing a series of bounces. The universe is isotropic and undergoes super-exponential expansion. The value of Hubble parameter is measured to be $H = 67.0691$ which is very close to $H_0 = 67.36 \pm 0.54 kms^{-1}Mpc^{-1}$, the value estimated by the latest Planck 2018 result. A detailed discussion on the cosmological parameters obtained is also presented with graphs.

Chapter 6 presents a research problem titled "$f(R,T)$ **gravity model behaving as a dark energy source**". The work discussed in this chapter is published in **New Astronomy, 84 (2021) 101542, DOI: 10.1016/j.newast.2020.101542 (IF-1.325)**. In this chapter, within the limits of the present cosmological observations in $f(R,T)$ gravity theory, we analyse a spherically symmetric space-time in 5D setting. The field equations have been carefully studied considering reasonable cosmological assumptions to obtain exact solutions. It is predicted that the isotropic model universe behaves like a dark energy (vacuum energy) model. In the present scenario, the model evolves with a slow and uniform change of shape. It is observed that the universe is close to or nearly flat. The model is free from initial singularity and is predicted to approach the de-Sitter phase dominated by vacuum energy or cosmological constant in the finite-time future. A comprehensive discussion on the cosmological parameters obtained in view of the recent studies is presented in detail with graphs.

Chapter 7 presents a research problem titled "**Scale Covariant Theory as a dark energy model**". The work discussed in this chapter is under review at **International Journal of Geometric Methods in Modern Physics**. In this chapter, we study a spherically symmetric space-time in 5D with the consideration of Scale Covariant Theory. The Scale Covariant Theory model is found to be isotropic and behaves as a phantom dark energy model, which tends to the de-Sitter phase avoiding finite time future singularity (big rip). The gravitational constant G decreases with a variation of -7.2×10^{-11} yr^{-1} and the Hubble's parameter is estimated to be $H = 68$. A detailed interpretation of the cosmological findings is also provided with graphical representations.

Chapter 8 presents a research problem titled "**Dark energy on higher dimensional spherically symmetric Brans-Dicke universe**". The work discussed in this chapter is published in **Chinese Journal of Physics, 60 (2019) 239-247, DOI: 10.1016/j.cjph.2019.05.003 (IF-3.237)**. In this chapter, we present a cosmological model in 5D spherically symmetric space-time with energy momentum tensors of minimally interacting fields of dark matter and holographic dark energy in Brans–Dicke Theory. Under some realistic assumptions in consistent with the present cosmological observations, we have analyse the field equations to obtain their exact solutions. With particular choices of the constants involved, the values of the overall density parameter and the Hubble parameter are obtained to be very close to the latest observational values. We obtain a model universe which will be increasingly dark energy dominated in the far future. A comprehensive presentation of the physical as well as kinematical aspects of the parameters, including future singularity, in comparison with the present observational findings is also provided.

Chapter 9 is a concluding chapter. This chapter aims to provide a thorough summary of the major findings and the arguments of the research. The chapter summarizes the works presented in the thesis and conveys the relevance of the research. The chapter also explains what new knowledge has been brought to light and suggests future research ideas on the subject.