ABSTRACT

The well-known ΛCDM (cosmological constant Λ + cold dark matter) model, known as the standard cosmological model, is remarkably successful to explain the dynamics and observed features of the present Universe such as the accelerated expansion, large scale structure formation and many more. It also finds an excellent fit to various observational data from different sources: cosmic microwave background, large scale structures and baryonic acoustic oscillations are to name a few. This remarkably successful cosmological model is founded on two unknown and major energy ingredients, accounting for around 95% to the total energy budget of the Universe. One is the cosmological constant Λ, mimicking the simplest form of dark energy and responsible for cosmic acceleration whereas the second one is cold dark matter, a pressureless matter, responsible for structure formation in the Universe. Despite the ability of the ΛCDM model in successfully describing the Universe, the major challenge is to understand the precise nature/behavior of both the dark sector components. The hunt for unfolding the mysteries of dark matter and dark energy is on via various ongoing and future experiments. Consequently, a large number of precise observational data from various observational sources are pouring in. Soon, it is expected that these data would be able to pinpoint the precise nature/role of dark matter and dark energy in the dynamics and evolution of the Universe. Hence, the dark matter and dark energy model building and observational constraints acquire special importance in cosmology, which is the main goal of this thesis work. It also deserves to mention that the ΛCDM model is plagued with several theoretical and observational issues. So in this thesis, we study observational constraints on some physically realistic extensions of the standard cosmological model to explore the nature/behavior of dark matter and dark energy while looking for possible solutions to some issues (tensions) of the standard model.

This thesis contains total six chapters. Chapters 1 and 2 are introductory and contain necessary and basic information to understand the forthcoming chapters, objectives, and motivation of the research work carried out in this thesis. **Chapter 1** begins with ba-

sic cosmology including perturbation equations and ends with the description of some major issues with the standard model. **Chapter 2** describes some preliminary Bayesian statistics, observational data sets, and the methodology used in this thesis work. In the last section of this chapter we have discussed minimal set of parameters of the standard model and the constraints on the those parameters from Planck-2018 final data release. In **Chapter 3**, an extension of the ΛCDM model is investigated where we assume that dark matter decays into photons in the presence of a constant as well as time-varying dark energy. The observational constraints on the model parameters are presented, and the possible consequences of decay of dark matter into photons are discussed. In **Chapter 4**, the warmness of dark matter is tested by assuming a time-varying equation of state of dark matter and a constant non-zero sound speed. This scenario is studied by considering a cosmological constant as well as time-varying dark energy. In **Chapter 5**, a model allowing the interaction between dark matter and dark energy is investigated with the recent observational data, and the possible consequences of this dark sector interaction are explored. **Chapter 6** presents overall summary and future scope of the research work carried out in the thesis.