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Topic : **Dark Energy and Modified Gravity**

Late time cosmic acceleration of the Universe is one of the biggest and most interesting discovery of our time. It is supported by a number of observational investigations such as Type Ia supernova, cosmic microwave background radiation, surveys of large scale structure, and PLANCK 2013 results. In the standard framework based upon Einstein gravity, cosmic acceleration can be explained by an exotic fluid with large negative pressure filling the Universe, dubbed '*dark energy'*. The simplest candidate for dark energy− the cosmological constant Λ is plagued with difficult theoretical issues such as its fundamental origin and cosmic coincidence problems. Why the vacuum energy is so small? why are the densities of dark energy and dark matter nearly equal at present, while their time evolution is much different? To sort out these problems, different theories have been given in the literature, namely, supersymmetric, coupled dark energy (i.e. the interaction between dark energy and dark matter) and so on.

Alternatively, cosmic acceleration can also be mimicked by the large scale modification of gravity. Though, the late time cosmic acceleration is considered to be an established phenomenon at present, its underlying cause remains uncertain. A large number of models, within the framework of standard lore and modified theories of gravity can explain the said phenomenon. It is therefore important to find ways to discriminate between various competing models. To this effect, important geometrical diagnostics have been recently suggested in the literature such as statefinder, statefinder hierarchy, Om and $Om3$. Statefinders use the second, third and higher order derivatives of the scale factor with respect to cosmic time whereas Om relies on first order derivative alone. Consequently Om is a simpler diagnostic when applied to observations.

Om has two excellent features. First, it can discriminate dynamical dark energy models from ΛCDM (a model in which the Universe contains Λ, associated with dark energy, and cold dark matter), in a robust way, even if the value of the matter density is not precisely known. Secondly, it can provide a null test of ΛCDM hypothesis, i.e., $Om(z)$ - Ω_{0m}=0, if dark energy is a cosmological constant. Also Om has zero, negative and positive curvatures for ΛCDM, quintessence and phantom models respectively.

The thesis consists of seven chapters, first chapter is an introductory part of cosmology which includes a brief outline of my actual work. The next five chapters are based on my research work and the last chapter carries brief summary of the obtained results. At the end of the thesis, we put bibliography and list of publications. The thesis is organized as follows:

Chapter 1 gives a quick introduction and background to the field of cosmology and discusses the observational evidences for late time cosmic acceleration. Theoretically, late time cosmic acceleration can be explained either by an exotic fluid with large negative pressure, dubbed 'dark energy' or by the large-scale modification of gravity. Both approaches to cosmic acceleration has been discussed. We also focus on the applications of supernova (SN) data, cosmic microwave background (CMB) distance information, baryon acoustic oscillation (BAO) and the data of Hubble parameter in constraining the model parameters.

In **Chapter 2**, we investigate the cosmological dynamics of non-minimally coupled scalar field system described by $F(\phi)R$ coupling with $F(\phi) = (1-\xi\phi^N)R(N \geq 2)$ and the field potential, $V(\phi) = V_0\phi^n$, R is the Ricci scalar. We also carry out comparison of the model with other competing models of dark energy such as Dvali-Gabadadze and Porrati (DGP), galileon modified gravity and others by statefinder diagnostic.

In **Chapter 3**, we use Statefinder hierarchy method to distinguish between bimetric theory of massive gravity, galileon modified gravity and DGP models applied to late time expansion of the universe. We also carry out comparison between bimetric and DGP models using Statefinder pairs $\{r, s\}$ and $\{r, q\}$. We show that statefinder diagnostic can differentiate between ΛCDM and above mentioned cosmological models of dark energy, and finally show that Statefinder S_2 is an excellent discriminant of ΛCDM and modified gravity models.

In **Chapter 4**, we study Galileon scalar field model by considering the lowest order Galileon term in the lagrangian , $(\partial_\mu\phi)^2\Box\phi$ by invoking a field potential. We use Statefinder hierarchy to distinguish the light mass galileon models with different potentials amongst themselves and from the ΛCDM behaviour. The Om diagnostic is applied to cosmological dynamics and, observational constraints on the model parameters are studied using SN+Hubble+BAO data.

In **Chapter 5**, we apply the Om diagnostic to models for dark energy based on scalar fields. In case of the power law potentials, we demonstrate the possibility of slowing down the expansion of the Universe around the present epoch for a specific range in the parameter space. For these models, we also examine the issues concerning the age of Universe. We use the Om diagnostic to distinguish the ΛCDM model from non minimally coupled scalar field, phantom field and generic quintessence models. Our study shows that the Om has zero, positive and negative curvatures for ΛCDM, phantom and quintessence models respectively. We use an integrated data base (SN+Hubble+BAO+CMB) for observational analysis and demonstrate that Om is a useful diagnostic to apply to observational data.

In **Chapter 6**, we investigate coupled quintessence with scaling potential assuming specific forms of the coupling and present phase space analysis for three different interacting models. We focus on the attractor solutions that can give rise to late time acceleration with the ratio Ω_{DE}/Ω_{DM} of order unity in order to alleviate the coincidence problem.

Chapter 7 provides a summary of the results obtained in this thesis and a brief possible future prospects of diagnostics.