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Abstract

The recent observational probes have confirmed that our Universe is undergoing an accelerated phase of expansion around the present epoch. The mysterious negative pressure fluid which drives this acceleration is dubbed as dark energy. This thesis deals with the issues of late time acceleration by studying the different classes of scalar field models for dark energy. We have studied the cases in which scalar field is minimally as well as non-minimally coupled to the gravity sector. We have utilized the latest observational data to constrain the scalar field models.
We looked at observational constraints on the thawing class of scalar field models, proposed to explain the late time acceleration of the Universe. We compared these thawing class of models with other widely studied dark energy and modified gravity models, using the recently introduced 'Statefinder Hierarchy', to check the underlying parameter degeneracies. We have also studied the constraints on deviations of these thawing models from canonical ΛCDM model using large class of observational data, for instance the Supernova Type Ia, the BAO data, the CMB data and data from the measurements of the Hubble parameter using red-envelope galaxies. We also forecast constraints using a simulated dataset for the future JDEM SNe survey. Our study showed that, although with current data it is difficult to distinguish different thawing models from ΛCDM, a future JDEM like mission would be able to furnish reasonable insight in distinguishing thawing models from ΛCDM.

We further studied the observational constraints for the axion models in string theory which can sucessfully act as quintessence. The evolution of the Universe in such model was truly sensitive to the initial value of the axion field. In a way, the initial value of the axion field controlled the deviation of cosmic evolution from the ΛCDM behavior. Using the latest data related with the background cosmology such as Union2 Supernova Type Ia dataset as well as data from BAO measurements, the WMAP measurement of the shift parameter and the H(z) measurements we showed that, the reconstructed equation of state of the axion field had extremely small deviation from the cosmological constant $w = -1$ even at 2σ confidence level. Yet another outcome of this investigation was that we could put bound on the supersymmetry (SUSY) breaking scale using cosmological measurements assuming the values of different string related parameters and vice-versa.
We also studied the linear growth function f of the large scale structures in a cosmological scenario where Generalised Chaplygin Gas (GCG) served as the dark

energy candidate. In doing so, we parametrized the growth index parameter as a function of redshift and did a comparative study between the theoretical growth rate and the proposed parametrization. Moreover, with the new parametrization, we demonstrated the growth rate of a wide range of dark energy models and compared their actual behaviour with our proposed parametrization. We have shown that our proposed parametrization accurately represented the growth rate for a number of different dark energy models. We then compiled a data set consisting of 28 datapoints within redshift range (0.15-3.8) to constrain the growth rate. It includes direct growth data from various projects/surveys including the latest data from the Wiggle-Z measurements. It also includes data constraining growth indirectly through the rms mass fluctuation $\sigma_8(z)$ inferred from Ly-α measurements at various redshifts. By fitting our proposed parametrization for f with these data, we showed that the growth history of the large scale structure of the Universe although allowed a transient acceleration but it cannot be distinguished from an eternally accelerated Universe.
We have discussed the dark energy models in a scenario, where the scalar field is non-minimally coupled to the gravity sector. We have investigated both quintessence and phantom dark energy scenarios, in which the scalar fields evolve in nearly flat potentials and are non-minimally coupled to gravity. We showed that all such models converge to a common behavior and provided the corresponding approximate analytical expression for $w(a)$. From our study, we found that non-minimal coupling leads to richer cosmological behavior compared to its minimal counterpart. In addition, comparison with Baryon Acoustic Oscillation and latest Supernovae data revealed that agreement can be established more easily and with less strict constraints on the model parameters.
Next we considered Brans-Dicke type non minimally coupled scalar field as a candidate for dark energy. In the conformally transformed Einstein's frame, our model is similar to coupled quintessence model. In such models, we considered potentials for the scalar field which satisfy the slow-roll conditions. For such potentials, we showed that the equation of state for the scalar field can be described by a universal behaviour, provided the scalar field rolls only in the flat part of the potentials where the slow-roll conditions are satisfied. We have also studied the observational constraints on the model parameters considering the Supernova and BAO observational data.

From our study, it can be inferred that the current observational data although strongly supports the fiducial ΛCDM model, but it can still accommodate the scalar field dark energy models. The models considered so far in our investigation seemed to be consistent with the present day observational datasets. Also, our model parameters are well constrained with the available cosmological data.