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Title of the thesis: Issues of Accelerating Universe in Particle Physics and Cosmology.

ABSTRACT

At present, research in particle physics and cosmology is going through an exciting period when surprising data and observation results are revolutionizing cosmology. At the same time, advances in string theory brought it into closer contacts with low energy physics and gravitation. It is now widely believed that our Universe has two periods of accelerated expansion in its history of cosmic evolution. This has been supported by a variety of observational data like Supernova Type Ia, Cosmic Microwave Background Radiations (CMBR) as well as the data from large scale red shift surveys. All these have made the accelerated expansion of the universe as one of the most challenging subjects of investigation in cosmology. The accelerated expansion in the early Universe, termed as Inflation, plays an important role in solving the major problems in standard cosmology like horizon, flatness and monopole problems. It also provides a mechanism to produce a nearly scale-invariant primordial fluctuations that behaves as a seed for the structure formations in the universe. On the other hand, it is believed that our universe is currently going through a second accelerated expanding period and has been first verified by Type Ia Supernova measurements. To discover the nature of driving force behind the late time acceleration of the universe is one of the most important tasks in cosmology today. The aim of the thesis is to build possible models to explain both the accelerations and to constrain these models using the available observational data.

In particular, we have studied different cosmological and astrophysical aspects of scalar field models. We have studied the primordial power spectrum generated by non-canonical scalar fields having the kinetic term of the Dirac-Born-Infield (DBI) type and investigated their consistency with the WMAP-7 data. In doing this, we have modified the presently available "MODECODE" package to include the non-canonical scalar fields. One interesting outcome of this study is the fact that the non-canonical scalar fields with $\Lambda\phi^4$ potential is consistent with WMAP-7 data unlike its canonical counterpart.

In another work, we have considered non-minimally coupled scalar fields with non-canonical kinetic energy where the kinetic term is of DBI form. We have studied the early evolution of the universe when it is sourced only by the k-field, as well as late time evolution when both the matter and k-field are present. After considering the k-field with constant potential as well as potential inspired from Boundary String Field Theory (B-SFT), we have shown that it is possible to have inflationary solution in early epoch as well as late times accelerations. The solutions also exhibit attractor properties. We also constrained these models with astrophysical observation namely the Solar systems test. Using the PPN parameter γ, we calculated the time delay $\Delta\tau$ produced due to the gravitational field of Sun, for the signal to travel the round trip distance between a ground based antenna and a reflector placed in a spacecraft. We used the $\Delta\tau$ to compare our result with that obtained by the Cassini mission and derived the constraints on the model parameters.

Further in this thesis, we studied the non-linear structure formation in presence of thawing scalar field models and looked for the signatures by which these models can be distinguished from standard ΛCDM model. We calculated the density contrast at the time of virialization, the number density of galaxy clusters and the total cluster number counts considering different dark energy models and found that some of the models may have significant deviation from the ΛCDM. We also constrained these models using presently available data for cluster number counts of massive X-ray clusters. The results showed that current cluster data is not suitable enough for constraining potentials for the thawing scalar fields as well as for other cosmological pramaters like n_s. But we got significant constraint for the parameter σ_8 and a lower bound on Ω_{m0}.

Modifying the Einsteins gravity at large distance scales being an interesting proposal to explain the late time acceleration of the universe, we have studied the scaling solutions in modified gravity models where the Universe is sourced by a background matter fluid together with a tachyon type scalar field and calculated the scaling potentials and the scale factors for specific cases of the modifications.

To conclude, accelerated expansion in both early and late time Universe is an active field of research in cosmology as well as in particle physics. In this thesis some challenging issues in this field have been studied and addressed.