1 TIFR Annual Report (2011-12) - Department of Theoretical Physics

2 Highlights

Cosmology and Astroparticle Physics

Current and future observational constraints on the thawing class of scalar field models, proposed to explain the late-time acceleration of the universe, were studied along with other widely studied dark energy and modified gravity models.

Using the large scale structure data on X-Ray clusters observed by XMM-Newton, a 'universal entropy injection' prescription was developed justifying the need to put in both extended preheating and core AGN heating when modelling clusters as cosmological probes.

Using the observed 'entropy profiles' of clusters from the REXCESS survey, the first estimate of the total, as well as radial, non-gravitational energy deposition for a large, nearly flux-limited, sample of clusters. This provided a crucial ingredient for simulating clusters for cosmology.

TEXT

Cosmology and Astroparticle Physics

Constraining thawing quintessence

Current and future observational constraints on the thawing class of scalar field models proposed to explain the late-time acceleration of the universe were studied using the recently introduced 'Statefinder hierarchy. Especially, thawing class of models were compared with other widely studied dark energy (and modified gravity) models to check the underlying parameter degeneracies. Constraints were put on the deviations of these thawing models from the canonical Λ cold dark matter model using a large class of observational data, e.g. the Type Ia supernova (SN) data, the baryon acoustic oscillation data, the cosmic microwave background data and data from the measurements of the Hubble parameter using red-envelope galaxies. Forecasting constraints using a simulated data set for the future Joint Dark Energy Mission (JDEM) SN survey was also done. The study showed that, although with current data it is difficult to distinguish different thawing models from CDM, a future JDEM-like mission would be able tell apart thawing models from CDM for currently acceptable values of Ω_0. [Subhabrata Majumdar with Gaveshna Gupta and Anjan A. Sen (JMI, New Delhi)]

Universal entropy injection profile for galaxy clusters

Based upon the recently determined universal pressure profile, the effect of additional entropy contributions to intra-cluster medium (ICM) was studied. Beginning with a power-law entropy profile that is expected in the absence of any feedback, it was shown that a simple universal prescription of entropy injection results in the final, observed universal pressure profile. The proposed prescription consists of two components, one associated with an overall increase in entropy and another associated with injection in the central parts of the cluster. Importantly, both the components of entropy injection are needed to produce the final universal pressure profile. This is indicative of a need of both pre-heating the ICM as well active galactic nuclei in the cluster core. The effect of entropy injection on the evolution of cluster scaling relations was studied making the proposition testable with upcoming data. It was pointed out that the self-similar evolution of the universal pressure profile is equivalent to a negative evolution of entropy injection with redshift, with a scaling $S_{inj} \propto (1+z)^{-0.8} S_{inj}(z=0)$. Finally, it was shown the current observational data are indicative of the entropy injection decreasing with redshift. [Subhabrata Majumdar with Biman B. Nath (RRI)]

Energy deposition profiles and entropy in clusters

Study of non-thermal energy deposition in galaxy clusters, for better calibration of these objects to be used as cosmological probes, was carried out. To this end, the results of a study of fractional entropy enhancement in the intra-cluster medium (ICM) of the clusters from the representative XMM-Newton cluster structure survey (REXCESS) were reported. The observed entropy profile of these clusters with that expected for the ICM without any feedback, as well as with the introduction of preheating and entropy change due to gas cooling were compared. The first estimate of the total, as well as radial, non-gravitational energy deposition up to r_{500} for a large, nearly flux-limited, sample of clusters was done. It was found that the total energy deposition corresponding to the entropy enhancement is proportional to the cluster temperature (and hence mass), and that the energy deposition per particle as a function of gas mass shows a similar profile in all clusters, with its being more pronounced in the central region than in the outer region. These results support models of entropy enhancement through AGN feedback and can act as crucial inputs to hydro-simulations of galaxy clusters. [Subhabrata Majumdar with Anya Chaudhuri (DAA/TIFR) and Biman B. Nath (RRI)]