DTP Annual report 2013-2014

A. Cosmology and astro-particle physics

1. *Post Planck dark energy constraints*

Constraints were put on plausible dark energy models, parametrized by multiple candidate equations of state, using the recently published Cosmic Microwave Background (CMB) temperature anisotropy data from Planck together with the WMAP-9 low-ℓ polarization data and data from low redshift surveys. To circumvent the limitations of any particular equation of state towards describing all existing dark energy models, three different equation of state covering a broader class of dark energy models were used, hence providing more robust and generic constraints on the dark energy properties.It was shown that a clear tension exists between dark energy constraints from CMB and non-CMB observations when one allows for dark energy models having both phantom and non-phantom behavior; while CMB is more favorable to phantom models, the low-z data prefers model with behavior close to a Cosmological Constant. Further, the equation of state of dark energy as a function of redshift was reconstructed using the results from combined CMB and non-CMB data and it was found that the Cosmological Constant lies outside the 1σ band for multiple dark energy models allowing phantom behavior. A considerable fine tuning was needed to keep models with strict non-phantom history inside 2σ allowed range. This result motivated one to construct phantom models of dark energy,which is achievable in the presence of higher derivative operators as in string theory. However, disallowing phantom behavior, based only on strong theoretical prior, leads to both CMB and non-CMB datasets agree on the nature of dark energy, with the mean equation of state being very close to the Cosmological Constant. Finally, to illustrate the impact of additional dark energy parameters on other cosmological parameters, the cosmological parameter constraints for different dark energy models were provided. [Subhabrata Majumdar with Dhiraj Kumar Hazra (APCTP, Korea), Supratik Pal (ISI, Kolkata), Sudhakar Panda (IOP, Bhubaneswar) and Anjan A. Sen (JMI, Delhi)].

2. *Non-gravitational energy from AGN feedback*

Studies of non-thermal energy deposition in galaxy clusters, mainly due to AGN feedback, crucial for calibration of cluster hydro-simulations were done. The entropy excess (or reduction at cluster centres due to cooling) for in the intra-cluster medium (ICM) of the clusters from the representative XMM-Newton cluster structure survey (REXCESS) were reported. The entropy change was used to estimate the non-gravitational feedback from cluster centre up to r_{500} for a large, nearly flux-limited, sample of clusters. Adding the radiative energy losses we estimate the total energy feedback, $E_{Feedback}$, from the AGN's (the central AGN in most cases). It was found that the total energy deposition corresponding to the entropy enhancement is proportional to the cluster temperature (and hence mass). The NRAO/VLA Sky Survey (NVSS) source catalog was utilized to determine the radio luminosity, L_R, at 1.4 GHz of the central source(s) of our sample. $E_{Feedback}$ showed a strong correlation with L_R, with different normalizations for cool core and non cool core clusters above $T > 3$ keV, indicating that AGN feedback from the central galaxies may provide a significant component of the energy feedback. The properties of the brightest central galaxy (BCG) was also studied and a mild correlation was found between the BCG heating rate and the feedback energy. [Subhabrata Majumdar with Anya Chaudhuri (DAA/TIFR) and Biman B. Nath (RRI)]

3. *Milky Way Dark Matter phase-space distribution*

The velocity distribution function (VDF) of the hypothetical weakly interacting massive particles (WIMPs), currently the most favored candidate for the dark matter in the Galaxy, was determined directly from the circular speed (rotation) curve data of the Galaxy assuming isotropic VDF. This was done by invertingusing Eddingtons methodthe Navarro-Frenk-White universal density profile of the dark matter halo of the Galaxy, the parameters of which were determined by using the Markov chain Monte Carlo technique from a recently compiled set of observational data on the Galaxys rotation curve extended to distances well beyond the visible edge of the disk of the Galaxy. The derived most-likely local isotropic VDF strongly was shown to differ from the Maxwellian form assumed in the standard halo model customarily used in the analysis of the results of WIMP direct-detection experiments. A parametrized (non-Maxwellian) form of the derived most-likely local VDF was proposed. The astrophysical g factor that determines the effect of the WIMP VDF on the expected event rate in a direct-detection experiment was shown to be lower for the derived most-likely VDF than that for the best Maxwellian fit to it by as much as 2 orders of magnitude at the lowest WIMP mass threshold of a typical experiment. [Subhabrata Majumdar with Pijushpani Bhattacharjee (SINP, Kolkata), Soumini Chaudhury (SINP, Kolkata) and Susmita Kundu (SINP, Kolkata)].

4. Using the Cosmic Duality Relation to probe systematics in SNe cosmology

Two different probes of the expansion history of the universe, namely, luminosity distances from type Ia supernovae and angular diameter distances from galaxy clusters, were compared using the Bayesian interpretation of Crossing statistic in conjunction with the assumption of cosmic duality relation. The analysis was conducted independently of any a-priori assumptions about the nature of dark energy. The model independent method was shown to search for inconsistencies between SNIa and galaxy cluster data sets. If detected such an inconsistency was shown imply the presence of systematics in either of the two data sets. By simulating observations based on expected WFIRST supernovae data and X-ray eROSITA + SZ Planck cluster data, it was demonstrated that the method allows one to detect systematics with high precision and without advancing any hypothesis about the nature of dark energy. [Subhabrata Majumdar with Arman Shafieloo (APCTP, Korea), Varun Sahni (IUCAA, Pune) and Alexei Starobinsky (LITP, Moscow)].