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Cosmology and Astroparticle Physics

AGN Feedback, Energy Deposition Profiles and Entropy Injection in Galaxy Clusters

Studies of non-thermal energy deposition in galaxy clusters, mainly due to AGN feedback, which are crucial for calibration of cluster hydro-simulations, were done. The entropy excess (or reduction at cluster centres due to cooling) 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 the total energy feedback, $E_{Feedback}$, from the AGN's (the central AGN in most cases) was estimated. 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 this 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)]

Cosmology with the Largest Galaxy Cluster Surveys: Going Beyond Fisher Matrix Forecasts

The first detailed MCMC likelihood study of cosmological constraints that are expected from some of the largest, ongoing and proposed, cluster surveys in different wave-bands were done. These were compared with those from prevalent Fisher matrix forecasts. Mock catalogs of cluster counts expected from the surveys eROSITA, WFXT, RCS2, DES and Planck, along with a mock dataset of follow-up mass calibrations were analyzed for this purpose. A fair agreement between MCMC and Fisher results was found only in the case of minimal models. However, for many cases, the marginalized constraints obtained from Fisher and

MCMC methods differed by factors of 30-100%. The discrepancy was shown to be alarmingly large for a time dependent dark energy equation of state, w(a); the Fisher methods under-estimating the constraints by as much as a factor of 4-5. It was demonstrated that Fisher estimates become more and more inappropriate as one moves away from CDM, from a constant-w dark energy to varying-w dark energy cosmologies. Fisher analysis was also shown to predict incorrect parameter degeneracies. It was also shown that the addition of mass-calibrated cluster datasets can improve dark energy and σ_8 constraints by factors of 2-3 from what can be obtained from CMB+SNe+BAO only . Finally, it was shown that a joint analysis of datasets of two (or more) different cluster surveys would significantly tighten cosmological constraints from using clusters only. [Subhabrata Majumdar with Satej Khedekar (MPA, Garching)].

Searching for Systematics in SNIa and Galaxy Cluster Data using the Cosmic Duality Relation

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 to 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)]

Deriving the Velocity Distribution of Galactic Dark Matter Particles from the Rotation Curve Data

The velocity distribution function (VDF) of the hypothetical weakly interacting massive particles (WIMPs), currently the most favoured 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 was shown to strongly 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 ex-

pected 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)].