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Department of Theoretical Physics

Cosmology and Astroparticle Physics

Probing the circumgalactic baryons

The Sunyaev-Zel'dovich (SZ) distortion of the cosmic microwave background radiation from extensive circumgalactic gas (CGM) in massive galactic haloes was studied specially from the hot gas in those galactic haloes in which the gas cooling time is longer than the halo destruction time-scale. It was shown that the SZ distortion signal from the hot gas in these galactic haloes at redshifts z $\approx$ 1-8 can be significant at small angular scales, and dominate over the signal from galaxy clusters. The integrated Compton distortion from the warm O VI absorbing gas was estimated to be $y \sim 10^{-8}$, which could potentially be detected by experiments planned for the near future. Finally, the detectability of the SZ signal from circumgalactic gas in two types of surveys, a simple extension of the South Pole Telescope survey and a more futuristic cosmic-variance-limited survey were studied. With the help of a Fisher matrix analysis, it was found that it will be possible for these surveys to constrain the gas fraction in CGM, after marginalizing over cosmological parameters, to 33 per cent, in case of no redshift evolution of the gas fraction.
[Subhabrata Majumdar with P. Singh (RRI), B. B. Nath (RRI), and J. Silk (IAP, Paris)]

Using cross-correlation to probe cosmic baryons

The cross-correlation of distribution of galaxies, the Sunyaev-Zel'dovich (SZ) and X-ray power spectra of galaxies from current and upcoming surveys were shown these to be excellent probes of the nature, i.e. extent, evolution and energetics, of the circumgalactic medium (CGM). A Fisher matrix analysis found that the gas fraction in the CGM can be constrained to a precision of $\sim 34\%(23\%)$ by the SPT-DES and $\sim 23\%(14\%)$ by the eROSITA-DES surveys in the presence (absence) of an unknown redshift evolution of the gas fraction. It was also demonstrated that the cross-correlated SZ-galaxy and X-ray-galaxy power spectrum can be used as powerful probes of the CGM energetics and potentially discriminate between different feedback models recently proposed in the literature; for example, one can distinguish a 'no AGN feedback' scenario from a CGM

energized by 'fixed-velocity hot winds' at greater than 3σ.
[Subhabrata Majumdar with P. Singh (RRI), B. B. Nath (RRI), A. Refregier (ETH, Zurich) and J. Silk (IAP, Paris)]

Dark energy constraints after Planck

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.
[Subhabrata Majumdar with D. K. Hazra (APCTP, Korea), S. Pal (ISI, Kolkata), S. Panda (IOP, Bhubaneswar) and A. A. Sen (JMI, Delhi)].

Can Effective Field Theory of Inflation Generate Large Tensor-to-Scalar Ratio within Randall Sundrum Single Braneworld?

A methodology was established for generating sub-Planckian field excursion along with large tensor-to-scalar ratio in a single brane RS braneworld scenario for a generic model of inflation. This scenario was investigated by incorporating various parametrization in the primordial power spectrum for scalar and tensor modes as well as in the tensor-to-scalar ratio as required by the recent observational probes. Using the proposed technique further stringent constraints were derived on positive brane tension, cut-off of the quantum gravity scale and bulk cosmological constant to get sub-Planckian field excursion along with large tensor-to-scalar ratio, which is consistent with the upper bound of Planck (2013 and 2015) data and Planck+BICEP2+Keck Array joint constraint.
[S. Choudhury]