Cosmic Microwave Background (CMB) Research

(Manzoor A Malik)

Cosmic Microwave Background (CMB) is credited with bringing out cosmology from speculation to precision science. Exquisite measurements of Cosmic Microwave Background fluctuations over the past three decades provide a unique window to the physics of the early Universe, encoding the nature of the primordial density fluctuations generated during inflation that in turn depends on the ultra-high energy physics operating at that epoch.

In this DST sponsored project titled “Constraining the Cosmological Parameters and the Underlying Theoretical Models with CMB Anisotropy and Polarization Measurements” , we (me in collaboration with Professor Tarun Souradeep (IUCAA, Pune) and Asif Iqbal (JRF)) systematically analyzed the WMAP9 and PLANCK data. In the paper published in JCAP (2015), we have analyzed the low multipole, low power anomaly in the WMAP9 as well as the Planck data. While WMAP shows low power anomaly upto l=4, Planck because of its improved sensitivity and angular resolution shows that the anomaly extends upto l=40. The power law description used in Lambda CDM model is not adequate to account for this anomaly. We have analyzed various models in this work and have shown that a combination of models can account for this anomaly. We find that sharp cut off model gives best likelihood value for the WMAP 9 year data, but is as good as power law model according to AIC. For the joint WMAP 9 + Planck data set, Starobinsky model is slightly preferred by AIC which is also able to produce CMB power suppression up to $l \leq 30$ to some extent. However, using BIC criteria, one finds model(s) with least number of parameters (power law model) are always preferred. In a recent paper that also appeared in JCAP (2017), we had a relook at the anomalously low value of the CMB temperature fluctuations up to multipole l < 40, by investigating case of punctuated inflation scenario. This form of inflation potential is inspired by Minimal Super-symmetric Standard Model (MSSM) wherein suppression of curvature perturbation power at large scales is produced by introducing period of fast-roll phase of the inflation sandwiched between two stages of slow-roll phase. We found that punctuated inflation leads to better fit in CMB data compared to simple power law model and that, for Planck data, punctuated inflation is moderately preferred over a simple power law model.

Together with Subha Majumdar (TIFR), Biman Nath (RRI) and my student, Asif Iqbal, we also studied the excess entropy and non-gravitational energy profiles up to r_{200} for a sample of 17 galaxy clusters using joint data sets of Planck Sunyaev–Zel’dovich pressure and ROSAT/Position Sensitive Proportional Counter gas density profiles. Our results based on the direct probe of the ICM in the outermost regions do not support any significant pre-heating. This work was published in MNRAS Letters (2017). A detailed companion paper was published in MNRAS (2018).

The main outcomes of the project are as follows:

1. Manpower:

Asif Iqbal, who was working as a JRF (later SRF) in the project received his degree of Doctor of Philosophy (Ph. D.). He is now a post doctoral fellow at Raman Research Institute (RRI). Another Ph. D. student (Mussadiq Qureshi) is likely to submit his Ph. D. in 2018 in the same area.

2. Publications: 4 papers (as detailed below) were published in leading international journals:

1. Joint Planck and WMAP Assessment of Low CMB Multipoles
Asif Iqbal, Jayanti Prasad, Tarun Souradeep and Manzoor A. Malik
Journal of Cosmology and Astroparticle Physics (JCAP), JCAP06(2015)014
Astro-ph arXiv:1501.02647 *(Impact Factor: 5.877)*

*2. Little evidence for entropy and energy excess beyond r*500 **-** *An end to ICM preheating*
Asif Iqbal, Subhabrata Majumdar, Biman B. Nath, Stefano Ettori, Dominique Eckert, and Manzoor A. Malik
MNRAS letters, 465, 99, 2017 *(Impact Factor: 5.0)*

3. Low l power suppression in punctuated inflation
Mussadiq Qureshi, Asif Iqbal, Manzoor A. Malik and Tarun Souradeep
Journal of Cosmology and Astroparticle Physics (JCAP), JCAP04(2017)013
Astro-ph arXiv: 1610.05776v2 *(Impact Factor: 5.877)*

*4. Excess entropy and energy feedback from within cluster cores up to r*200
Asif Iqbal, Subhabrata Majumdar, Biman B. Nath, Stefano Ettori, Dominique Eckert and Manzoor A. Malik
MNRAS, 472, 713, 2017 (Impact Factor: 5.0)