Probing cosmological dark matter and dark energy using post reionization neutral intergalactic medium

Ashis Kumar Pal
Department of Physics
BITS Pilani, Pilani-Campus

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Chapter 7

Conclusion and scope for future study

This thesis investigates the possibility of using the tracers of the post-reionization matter density field towards improving our understanding of the dark sector of the total matter energy budget. The post-reionization epoch is characterized by the absence of the complex astrophysical processes that in the epoch of reionization caused the Universe to become largely ionized by $z \sim 6$. As a good tracer of the underlying distribution of dark matter the clustering of the H I brightness temperature fluctuations imprint both the background cosmological evolution and the growth of cosmological structures. Our analysis has focussed on two very important astrophysical systems namely the Lyman-α forest and the Damped Lyman α systems, the latter being the dominant source of the redshifted 21-cm signal. The investigation focused on the use of the H I 21-cm maps with the Lyman-α forest. The cross-correlation signal apart from being independent probe also helps to mitigate the issues "foregrounds" in H I 21 cm observations and other systematics.

The thesis, in the very beginning discusses the post-reionization epoch and the two tracer systems that are of interest to us. The cross-correlation between the redshifted 21-cm signal and the Lyman-α forest is then formulated and its detection investigated. The first part of the thesis is devoted to the dark matter sector and its imprint on the cross-power spectrum. Here, we consider the free-streaming effect of neutrinos and then warm dark matter. The suppression of the cross-power spectrum is then used to constrain the masses of the particles. In our study of dark energy, we considered two model independent parametrizations of a dynamic dark equation of state. Constraints on the dark energy parameters are then obtained through the detection of BAO features in the cross-correlation power spectrum.

7.1 Scope for Future Work

Investigations are aimed towards some of these issues

- Preliminary Fisher matrix analysis shows that the Lyman-α forest and 21 cm cross-correlation signal can be used to constrain dark energy parameters with good precision. We aim to follow this up with detailed and more realistic experimental conditions.
- Detection of the cross-correlation power spectrum shall probably allow a true ascertainment of the comsic H I signal. Optimal observation strategies and telescope design needs to be studied for more realistic projections.
- BAO features on the cross-power spectrum has to used in a tomographic manner for constraining the dark energy equation of state.
- The physics involved behind the observed Lyman-α forest and 21-cm signal involves non linear effects on small scales. Our linear theory analysis needs to be justified using non-linear theories like the Halo model, or through simulations.
- Cross-Bispectrum and higher order statistics needs to be investigated.
- General relativistic effects appearing on Horizon scales maybe studied to understand relativistic effects on cosmological scales.