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An End-to-end Pipeline for HI 21cm Cosmological Observations

Aishrila Mazumder*(1), Abhirup Datta(1), Arnab Chakraborty(1)
(1) Department of Astronomy, Astrophysics and Space Engineering, Indian Institute of Technology Indore, Indore 453552, India

1 Extended Abstract

Radio interferometer like the upcoming Square Kilometre Array (SKA) has the potential to detect the redshifted 21-cm signal from the early stages of the universe. The most effective way to study the effects of the various foregrounds and systematics that obscure the signal is to simulate such observation for the instrument in question using realistic conditions. This work presents an initial report on the development of an end-to-end pipeline which will also allow to simulate radio interferometric observations using realistic sky model and telescope observing parameters. The pipeline developed for future SKA1-low telescope uses the OSKAR simulator tool. This pipeline is capable of using input sky models and different radio interferometric array layout to produce synthetic observations. The observing parameters can be set by the user of the e2e pipeline. The input sky model has flexibility for both point source and diffuse emission models. To understand and analyze the relative performance of different array specifications in optimal observing strategy of the HI cosmology this e2e pipeline is critical. Besides SKA1-low, this pipeline can also include other array configurations like the HERA and the MWA. The synthetic observations with different array configurations are used for further extraction of the faint cosmological signal. This pipeline includes few signal extraction techniques related to the power-spectrum estimation. Here, we only present the very first functionality of the pipeline for the signal extraction case in presence of different array specifications. Simulated redshifted HI 21cm signal brightness temperature is generated from 21cmFAST [1], which is then used to predict observed visibilities for different array specifications. The power spectrum is estimated from the synthetic visibilities. Figure 1 shows the spherically averaged power spectrum for a mock observation with pure HI 21cm signal. In order to include variation in the signal model, we have used ReionYuga [2] to generate more HI 21-cm signal model. Here, we present the first results from the e2e pipeline. This is just a proof of concept. In Mazumder et al. (2021, in prep.) we will present detailed study from this pipeline in presence of foregrounds and imperfect sky/telescope models. In future, this pipeline can be used to study effects of different telescope parameters like the array geometry, primary beam, observation strategies etc in the optimal extraction strategy of the faint redshifted HI 21cm signal. This is one of the key science goal for the upcoming SKA.

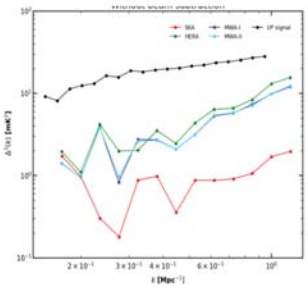

Figure 1. The Spherically averaged Signal Power Spectrum of as observed with SKA-1 Low (red), HERA (green), MWA Phase-I (blue) and MWA Phase-II (cyan). The black curve is the power spectrum for the input signal.

References

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[2] S. Majumdar, G. Mellema, K. K. Datta, H. Jensen, T. Roy Choudhury, S. Bharadwaj, M. M. Friedrich "On the use of seminumerical simulations in predicting the 21-cm signal from the epoch of reionization" *Monthly Notices of the Royal Astronomical Society*, **443**, 4, October 2014, pp. 2843–2861, doi:10.1093/mnras/stu1342