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Probing the First Structures with the SKA

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Extended Abstract

The first stars in the universe started to appear at redshifts z ~30, the epoch of Cosmic Dawn. The IGM during this period was almost completely neutral. However since these structures were sources of ionizing radiation, the neutral IGM was converted into a highly ionized one, between z ~15 to z ~6 - the Epoch of Reionisation or EoR. Any detection of cosmological signal from this era can give valuable insights into characteristics of the first stars. Thus one of the major targets of the upcoming Square Kilometer Array (SKA) is to probe for the cosmological signals from this epoch. The main target signal for the SKA-low, the proposed low frequency SKA array, is the redshifted 21cm hyperfine spectral line of neutral hydrogen atom.

Most challenging part of the signal recovery comes in the form of extremely strong foregrounds present in any part of the sky observed.The SKA by virtue of its large collecting area would be very sensitive to the signal fluctuations for both the target signal as well as the foregrounds. In this work we present the challenges in the recovery of the EoR power spectrum in terms of foreground model accuracy by using SKA.

We develop the initial stage of the simulation using the OSKAR simulation package developed by the Oxford e-Research Centre. This package uses the Radio Interferometer Measurement Equation (RIME) formalism to generate visibilities from a given sky model. The basic advantage of RIME is its use of linear algebra. This requires incorporation of the various changes undergone by the sky signal (in its passage from the origin to the raw output of the telescope) in the form of a series of multiplicative Hermitian matrices. This method dramatically reduces the computation requirement of the telescope- a huge advantage for a large aperture array like the SKA. Thus both the direction dependent and independent effects can be incorporated for extracting the expected signal from the observed one. In this work we explore the minimum requirements for development of an end to end pipeline, which could efficiently perform a real time calibration to remove "obvious" foregrounds without loss of any real signal. This would be essential for large observation time required for EoR signal detection, since the data volume is expected to be overwhelmingly large for the SKA.

References

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