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Investigating Signal Recovery Challenges from Cosmic Dawn and Reionisation using SKA-1 Low

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Extended Abstract

The period in the evolution of the universe when the first stars began appearing is called cosmic dawn; these sources generated photons which started ionizing the intergalactic medium (IGM) from almost completely neutral to highly ionized, this is the epoch of reionisation in the history of the universe. One of the key science goals for several existing as well as upcoming telescopes is to probe into this era of the history of the universe. Radio telescopes mainly do this by detecting the redshifted 21-cm hyperfine line of neutral hydrogen (referred to as HI 21-cm line).

The major challenge for detecting the HI 21-cm line from Cosmic Dawn, Epoch of Reionization (EoR) and post-reionization epoch is to mitigate the bright Galactic and extragalactic foregrounds. There are two different approaches to observe this signal: (a) using large interferometric arrays at these low radio frequencies to produce statistical power spectra of the HI 21cm fluctuations (key science goal for projects like MWA, LOFAR, PAPER, GMRT-EoR and Square Kilometer Aarray-low) and possibly using images of the HI 21cm fluctuations or (b) using a single antenna at these low frequencies to detect the “all-sky" averaged HI 21 cm signal as a function of redshift (key science goal for projects like EDGES, SARAS, DARE, LEDA, etc). The foregrounds can be continuum emissions(dominated by synchrotron radiation) as well as discrete point sources. The extraction of the desired signal with reasonable confidence is possible only after proper modelling and removal of these strong foregrounds. The challenges are nearly same for both kinds of observations.

We present initial results of newly upgraded Giant Meterwave Radio Telescope (uGMRT) observation of European Large-Area ISO Survey-North 1 (ELAIS-N1) at 325 MHz with the aim of quantifying statistical fluctuations in diffuse Galactic synchrotron emission (DGSE) in this field. We have found significant improvements in source retrieval after direction-dependent calibration for large field of view at this frequency. We have shown that DGSE dominates the sky, after point source subtraction from the entire FoV for calibration techniques. The statistical fluctuations in diffuse Galactic synchrotron emission (DGSE) has been quantified as a power law of the form $\mathscr{C}_l = Al^{-\beta}$.

We also present simulations done for SKA-low with the GSM of the ELAIS-N1. Taking into account the increased sensitivity parameters of the SKA, it is anticipated to provide better estimate of the statistics of the dominant signals in the field as well as the target signal. Subsequently the signal recovery efficiency of the SKA over the currently existing large aperture arrays can be compared.

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