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Redshifted 21 cm HI signal from post-reionization era: 326.5 MHz ORT experiments

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Abstract. Observations of the redshifted 21 cm HI fluctuations promise to be an important probe of the post-reionization era. Here we predict the expected SNR for the upgraded Ooty Radio Telescope (ORT) which operates at frequency 326.5 MHz ($z = 3.35$). Assuming that the visibilities contain only the HI signal and system noise, we show that a 3σ detection of the HI signal ($\sim$ 1 mK) is possible at angular scales $11'$ to 3° with $\approx$ 1000 hours of observation.

Keywords : cosmology: large scale structure of universe -cosmology - diffuse radiation

1. Introduction

Observations of the redshifted 21cm radiation from the large scale distribution of neutral hydrogen (HI) is one of the most promising probes to study the high red-shift Universe (Furlanetto, Oh & Briggs 2006, for detail review). Realizing its great potential, a large number of the recent or upcoming interferometric experiments (GMRT[1], LOFAR[2], MWA[3], PAPER (Parsons et al. 2010) are developed to aim for measuring the 21-cm signal from z $\sim$ 1 to 12. The removal of continuum foregrounds sources is currently one of the largest obstacles for detecting the faint HI signal. Because the foreground sources are expected to be roughly four to five orders of magnitude stronger than the HI signal (Ghosh et al. 2011). The aim of this paper is to present the expected

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[1]http://www.gmrt.ncra.tifr.res.in
[2]http://www.lofar.org/
[3]http://web.haystack.mit.edu/ast/arrays/MWA/

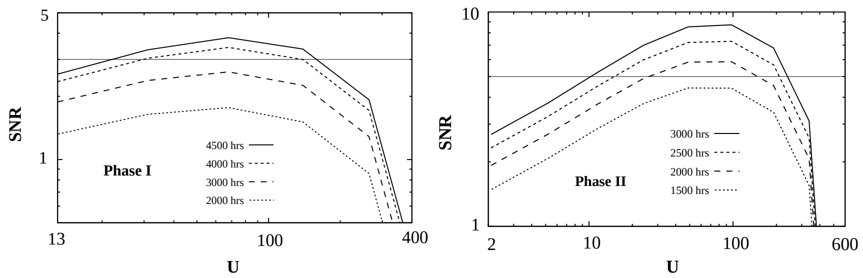

Figure 1. This figure shows the signal to noise ratio (SNR) as function of baseline **U** for different integration times are indicated. The horizontal line is for SNR = 3 (left panel) and SNR = 5 (right panel).

21 cm from $z = 3.35$. and discusses the possibility of its detection with the upgraded ORT. We use the LCDM cosmology with parameters:$(\Omega_{m0}, \Omega_b h^2, \Omega_{\Lambda 0}, h, n_s, \sigma_8) = (0.30, 0.024, 0.7, 0.7, 1.0, 1.0)$. A brief outline of the paper follows. Section 2 introduces the upgraded ORT as a radio interferometer and presents model prediction for the SNR. Section 3 contains the conclusions.

2. The ORT, the measured visibilities and SNR predictions

The upgradation of the Ooty Radio Telescope (ORT), as a Radio interferometer, is being carried out in two different stages with two nearly independent systems, namely **Phase I** and **Phase II** (Ali & Bharadwaj 2013, for detail discussions). ORT baseline distribution is 1-D and we assume that they are along the length of the cylinder (x axis, for our convenience). We then have the baselines $\mathbf{U}_1 = \left(\frac{d}{\lambda}\right)\hat{i}$; $\mathbf{U}_2 = 2\mathbf{U}_1$; $\mathbf{U}_3 = 3\mathbf{U}_1$; ... $\mathbf{U}_{N_A-1} = (N_A - 1)\mathbf{U}_1$ for which the visibilities $V(\mathbf{U}, \nu)$ are recorded. Here d is the two antennas separation in terms of λ. Any baseline $\mathbf{U}_n$ occurs $M_n = (N_A - n)$ times in the array. We have investigated the SNR for detecting the HI signal under the assumption that it is possible to completely remove the foregrounds. We see that for Phase I, a 3σ detection is possible with $\sim 4,000$ hrs of observation and a 5σ detection is possible with $\sim 5,700$ hrs of observation (Figure 1) . A 3σ detection is possible with $\sim 1,000$ hrs of observation with Phase II, and a detection better than $> 5\sigma$ is possible with $\sim 2,000$ hrs of observation.

3. Conclusions

The present paper primarily introduces the ORT as an instrument for exploring the high redshift cosmological HI signal. A preliminary SNR estimates have been presented, and these have been used to estimate the observing time required to detect the HI signal. Phase I and II are both sensitive to the BAO feature and the successive oscillations will be probed by ORT.

References

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Parsons A. R. et al., 2010, AJ, 139, 1468