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Foreground simulation and power spectrum estimation for 610 MHz GMRT observations

Samir Choudhuri[1*], Somnath Bharadwaj[1] and Sk. Saiyad Ali[2]
[1]*Department of Physics and Meteorology & Centre for Theoretical Studies, IIT Kharagpur, 721302, India*
[2]*Department of Physics, Jadavpur University, Kolkata 700032, India*

Abstract. Foreground removal is a biggest challenge for a statistical detection of the redshifted 21cm HI signal. They have strength 4-5 order magnitude larger than the faint HI signal. We simulate UV coverage and Galactic diffuse emission at 610MHz for GMRT. We estimate power spectrum of the diffuse emission using two visibility-correlation function. We find that visibility-correlation estimator is consistent with the input power-spectrum which we have used to simulate Galactic diffuse emission.

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

1. Introduction

The Observation of redshifted 21 cm radiation is one of the most promising tool to probe the large scale structure of the Universe from dark ages to present epoch (Furlanetto, Oh & Briggs 2006). The radiation coming from different astrophysical sources, other than the HI signal, contribute to the foreground radiation. They are 4-5 order magnitude larger than the expected 21 cm signal (Ghosh et al. 2011). A details study of the foreground components is required to extract the 21cm signal. Several authors have simulated the properties of the foregrounds in order to develop algorithm to subtract foregrounds from the simulated data (Jelić et al. 2008). The aim of this paper is to present the validate of the foreground simulation. This shows that the simulated power spectrum of the diffuse Galactic emission with a Gaussian random field of a certain power law index is consistent with model prediction based on 150 MHz observation (Ghosh et al 2012) . A brief outline of the paper follows. Section 2

*Email: samir11@phy.iitkgp.ernet.in

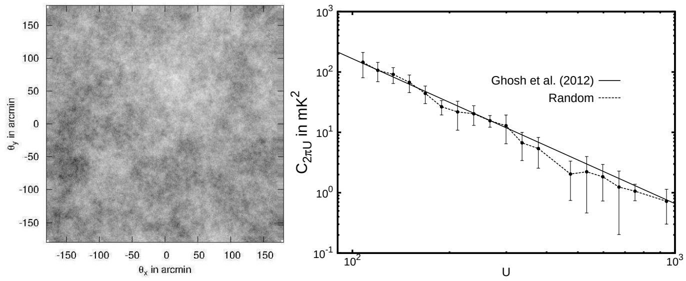

Figure 1. The left panel of the figure shows the simulated map of the diffuse synchrotron emission at 610 MHz. The size of the simulated map is $5^\circ \times 5^\circ$ with $\sim 0.17'$ resolution. The right panel shows the input power spectrum (solid line) and the power spectrum for random UV distribution with $1\,\sigma$ noise (dotted line).

discusses the estimation of power spectrum using simulation. Section 3 contains a summary and the conclusions.

2. Simulation and power spectrum estimation

The observed angular power-spectrum of the diffuse radiation at 150 MHz GMRT observations (Ghosh et al. 2012) can be modelled as $C_{2\pi U} = A_{150}\left(\frac{150}{610}\right)^{2\alpha}\left(\frac{1000}{2\pi U}\right)^{\beta}$ mK^2. Here $A_{150} = 513\,\mathrm{mK}^2, \alpha = 2.8, \beta = 2.34$. The fitting model is used for simulation. We use FFT to simulate diffuse intensity fluctuation in the sky plane (left panel of Fig.1). We simulate visibilities with a noise of variance $\sigma = 1.05\times10^{-1}$ Jy for this foreground component for a random UV distribution of $U_{max} = \pm1000$. The GMRT beam can be well aproximated by a Gaussian $A(\theta) = e^{-\theta^2/\theta_\circ^2}$, where $\theta_\circ = 25.8'$. Using this the visibility correlation (Ghosh et al. 2011) at two different baselines can be written as,

$$V_2(U, U + \Delta U) = \frac{\pi\theta_\circ^2}{2}\Big(\frac{\partial I_\nu}{\partial T}\Big)^2 C_{2\pi U} \tag{1}$$

where $(\partial I_\nu/\partial T)$ is the conversion factor from brightness temperature to specific intensity. Using eq. (1) we estimate power spectrum for a baseline range 100 to 1000 (right panel of Fig.1).

3. Summary and conclusions

We have estimated the power-spectrum of diffuse Galactic emission using the unbiased visibility correlation estimator. The positive noise bias is dropped by correlating different visibilities (self-correlation is avoided). The estimated power-spectrum is consistent with the observed power-spectrum. This validates the visibility based estimator which is used in our analysis.

References

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