EDGES MEMO #007
RFI MEMO #022

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Subject: Dipole beam change with frequency

The ideal antenna for measuring the EoR global signature would be one whose beam pattern is constant with frequency. A dipole over a ground plane has the analytic frequency dependent beam pattern given in memo #20. Convolving this analytic beam with the sky brightness map of Haslam et al. (1982) gives the LST variation of antenna temperature of zenith pointing antenna at 42.5˚ latitude shown in figure 1. Since the sky map is for 408 MHz I have used the following spectral index weighting function:

$$map\left(\ell,b,f\right)=\left[w(b)(f/408)^{-2.4}+\left(1-w(b)\right)(f/408)^{-2.75}\right]map\left(\ell,b,408\right)$$

where

$$\begin{aligned} w(b) &= \left(\cos(\ell)+1\right)/2 \qquad & |b| \le 10^\circ \\ &= 0 & |b| > 10^\circ \end{aligned}$$

ℓ = galactic longitude
b = galactic latitude
f = frequency in MHz

The convolution method used is similar to that used in Rogers et at. (2004) except that the full frequency dependent analytic expression for a dipole, which is 0.5 λ long and 0.2 λ above a ground plane at 200 MHz, is used. The galactic latitude weighted spectral index is an attempt to account for the difference in spectral index for sources in the plane compared with the "isotropic" sources as discussed by Bridle (1967).

Figure 2 is similar to figure 1 except the dipole is oriented E-W instead of N-S. Figure 3 shows the difference in antenna temperature between an antenna whose pattern follows the analytic function and one whose pattern is fixed to that at 140 MHz. This difference is a function of LST and is shown for 0,6,12 and 18 hours. Figure 4 shows the residuals to the differences shown in figure 3 after removing the best fit polynomial with 7 terms. The peak residuals at 100 MHz given in Table 1 are under 1 mK and become completely negligible if the number of terms in the polynomial is increased to 9.

LST (hr)	Peak residual mK
0	0.17
6	0.06
12	0.16
18	0.75

Table 1. Peak residuals to 7 term polynomial.

These simulations shown that the beam pattern variation with frequency of a small antenna should not mask the ability to observe a global EoR signature in the background a frequency dependence which changes over 10-20 MHz as shown in the simulations of memo #16.

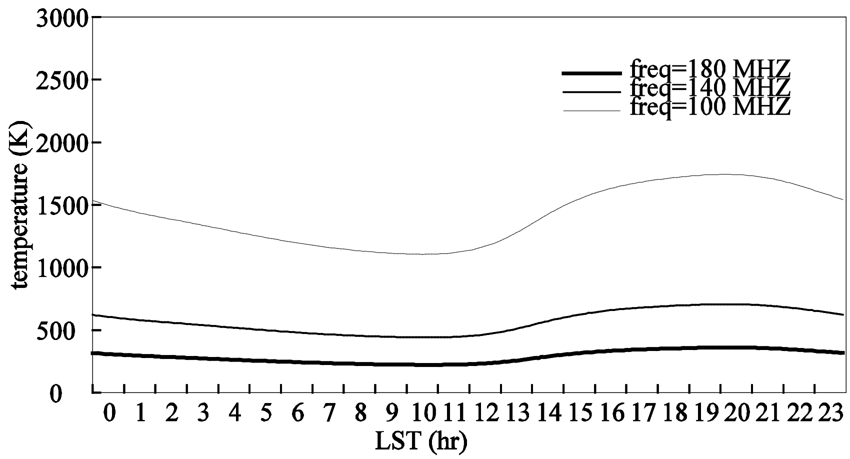

Figure 1. Antenna temperature vs LST N-S for dipole antenna above ground plane.

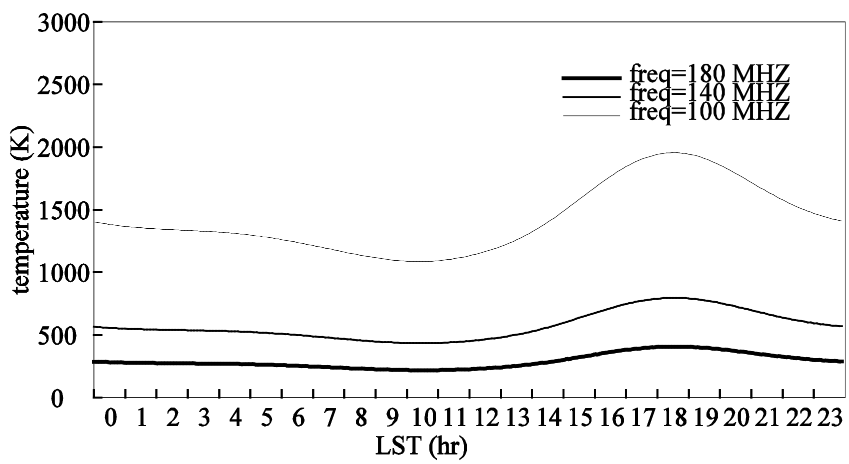

Figure 2. Dipole oriented E-W.

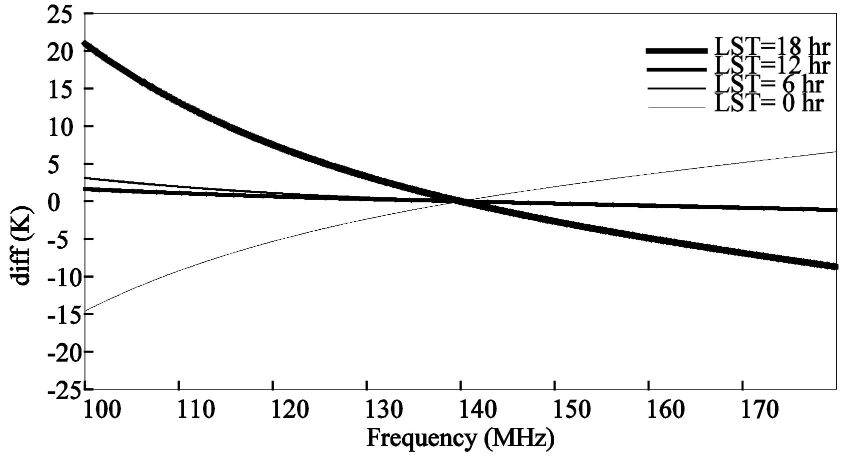

Figure 3. Difference between antenna temperature of dipole and fixed antenna pattern.

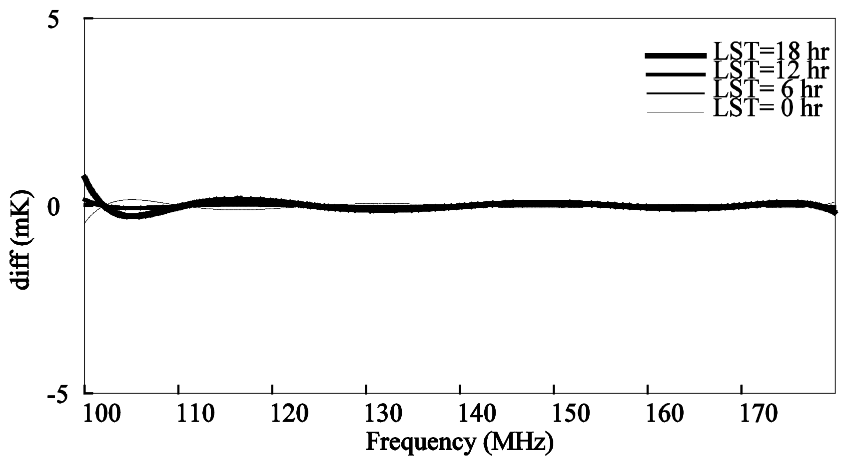

Figure 4. Residuals of difference temperatures to polynomial fit.

References

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