MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

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Telephone: 781-981-5407
Fax: 781-981-0590

To: EDGES Group

From: Alan E.E. Rogers

Subject: Temperature contribution of ionosphere to the sky noise spectrum

The attenuation through the ionosphere has been measured at 18 MHz by Steiger and Warwick (1961) by observing the sky noise vs sidereal time for a little more than a year. The antenna was well calibrated dipole array looking at zenith. The maximum measured attenuation was 20 dB while a mean value at night was about 1 dB at 18 MHz. If we assume the value of 1 dB for nighttime observation with EDGES and an inverse wavelength squared dependence the noise contribution from the ionosphere is about 30 K at 50 MHz dropping to 7.5 K at 100 MHz. This contribution from the ionosphere along with the effect of the attenuation will change the measured spectral index from 2.50 to 2.45 and after fitting for the best spectral index the residual signature is shown in Figure 1. The signature has a rms of 4K which is more than an order of magnitude above that expected for the EoR signature. Possible solutions are to solve for the ionosphere attenuation or to make a correction based on the TEC and /or measurement made with a riometer.

The following function is sufficient to solve the ionosphere and electron temperature:

$$T = T_0 f^{-\beta} - T_0 (1-L) f^{-\beta-2} + T_e (1-L) f^{-2}$$

Where $f = frequency / f_0$

β = sky noise spectral index

L = ionosphere loss factor at f_0 (L = 1 = zero loss)

T_e = electron temperature $\approx 10^3\ K$

T_a = sky temperature at f_0

f_0 = reference frequency

The loss in dB is approximately given by

$$\left(1.6\times10^{-6} / f^2\right) \int N\nu\, ds$$

Where N is the electron density and ν is the collision frequency. To first order ν is proportional to N so that the absorption increases by N^2 so that the day/night ratio is a factor of 10 or more. An assessment of the impact of having to solve for the ionosphere was made by comparing the theoretical error from the covariance matrix in the case of adding the $f^{-\beta-2}$ and f^{-2} terms to a solution for an EoR signature in addition to the following:

1] Spectral index
2] Slope in spectral index vs frequency
3] A constant to represent the uncertainty in ground loss

For a Gaussian EoR signature of 25 MHz full width at half power centered at 75 MHz the 1σ error in EoR is 100 mK for noise of 20 mK/MHz. Without the need to solve for the ionosphere the error in Eor is 50 mK.

The rms of the ionosphere signature is reduced from 4 K to 140 mK rms for EDGES observation in the 100 to 200 MHz range so the ionosphere is much less of a concern in this frequency range..

Steiger, W.R. and Warwick, J.W. "Observations of Cosmic Radio Noise at 18 Mc/s in Hawaii," *JGR*, **66**, 1, pp57-66, 1961.

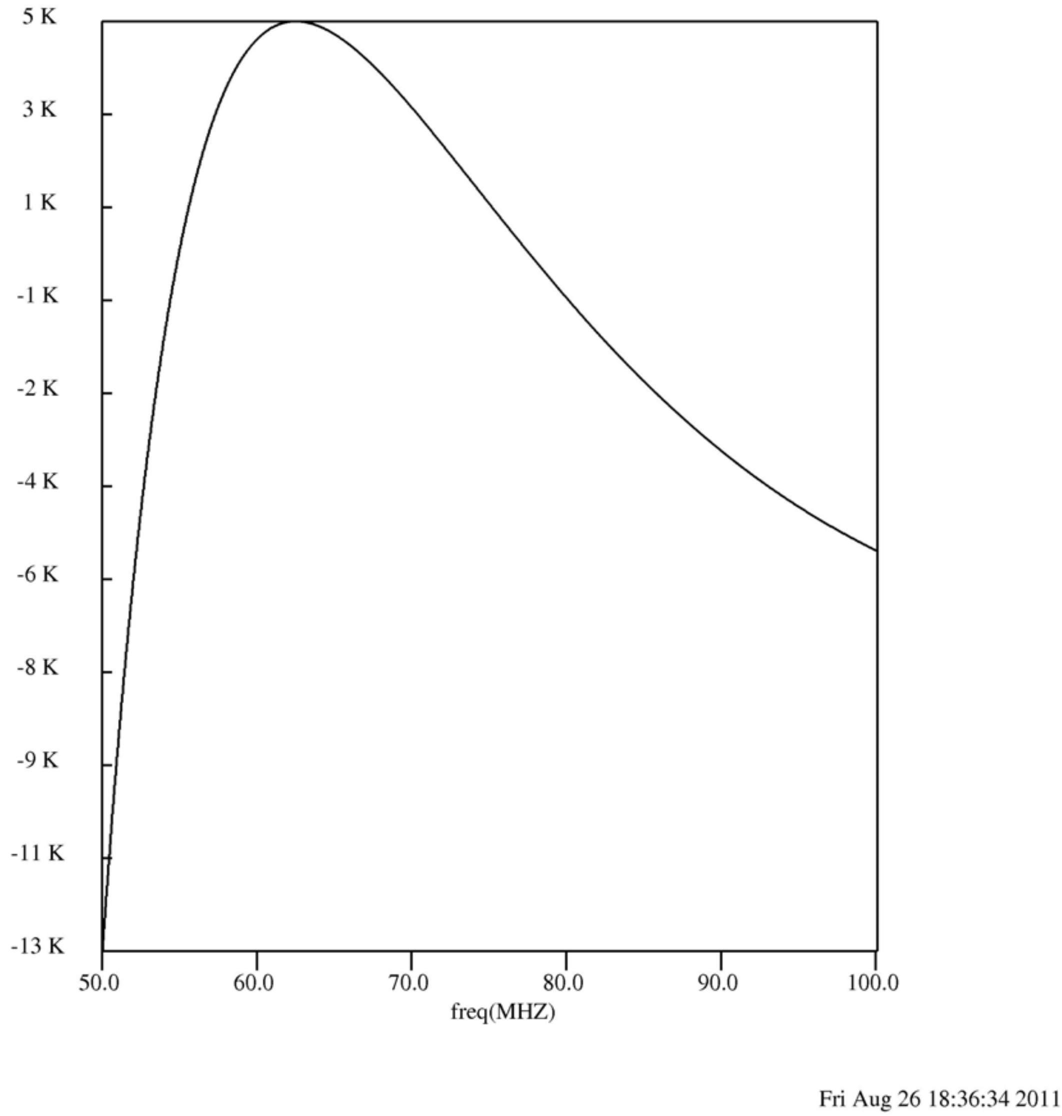

Figure 1. Residual signature from ionosphere