EDGES MEMO #278

# MASSACHUSETTS INSTITUTE OF TECHNOLOGY
## HAYSTACK OBSERVATORY

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To: EDGES Group

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Subject: Absorption profile fitting tests on data release.

1] Fitting "5-physical terms" when the calibrated data figure1_plotdata.csv is available from loco.lab.asu.edu/edges/edges_data_release/ is processed using standard weighted least squares to find the best fit using the 5 physical terms given in equation (1) of the methods. The best fit coefficients obtained from a grid search in center frequency and width are

| $a_0$ | $a_1$ | $a_2$ | $a_3$ | $a_4$ |
|---|---|---|---|---|
| -10523.1 | -5867.9 | -1891.9 | 155.3 | 12118.4 |

using frequency normalized by 75 MHz and the best fit absorption model with fixed flattened Gaussian with $\tau = 7$ has the following parameters:

| center (MHz) | width (MHz) | depth (K) |
|---|---|---|
| 78.1 | 18.7 | 0.53 |

and an rms after fit of 0.024K.

While the 5 functions are called "physical functions" the individual values obtained in the best fit do not represent physical quantities instead the sum given by equation (2) of the methods section represents the best fit to the foreground and the individual values of the best fit coefficients will change significantly with the frequency $\nu_c$ chosen to obtain the normalized frequency $(\nu/\nu_c)$.

2] An alternate "polynomial" given by

$$P_i(f) = a_i f^{-2.55} \left(\log(f)\right)^i$$

where $f$ is the normalized frequency gives a "more" physical meaning because with this polynomial the spectral index of the best fit is given by $\left(a_1/a_0 - 2.55\right)$ and the best fit parameters are

| $a_0$ | $a_1$ | $a_2$ | $a_3$ | $a_4$ |
|---|---|---|---|---|
| 1750.8 | -31.8 | -71.6 | 37.8 | 150.2 |

with

| center (MHz) | width (MHz) | depth (K) | rms (K) |
|---|---|---|---|
| 78.1 | 18.7 | 0.57 | 0.024 |

and spectral index from $a_0$ and $a_1$ is -2.568

This polynomial, fits the foreground and any instrumental effects, which result from imperfect calibration etc. It can also be extended to more than 5 terms for tests of the effect of any structure in the data not modeled with 5 terms.

3] Tests of the effects of the ionosphere

The effects of adding or subtracting 40 parts per 1000 of ionospheric absorption are given in the following table where 5a in the last column used 5-physical terms, 5b used 5-terms of the alternate polynomial. A test with the addition or subtraction of ionospheric emission with opacity of 40 parts per 1000 and an electron temperature of 800 K had a negligible effect on the best fit absorption parameters.

| Center (MHz) | Width (MHz) | Depth (K) | Rms (K) | | |
|---|---|---|---|---|---|
| 78.5 | 18.8 | 0.53 | 0.023 | Add | 5a |
| 78.1 | 18.7 | 0.57 | 0.025 | Subt. | 5a |
| 78.1 | 18.7 | 0.52 | 0.023 | Add | 5b |
| 78.1 | 18.7 | 0.62 | 0.025 | Subt. | 5b |

The choice of 40 parts per thousand is an approximate estimate of the average over 24 hours for data taken over a year without excluding daytime data. A typical value of 0.015 dB at night to 0.1 dB during the day at 150 MHz from Evans and Hagfors (1968) Radar Astronomy is assumed.

The 5 physical basis function terms given in equation (1) of the methods can be expanded to more terms using the terms of the alternate polynomial for additional terms beyond the fifth physical term. Tests on the sensitivity to ionospheric absorption show that this choice of basis functions is better than the general polynomial in equation (2)