



Modelling a hot horizon in global 21-cm experimental foregrounds

Joe H.N. Pattison^{(1) (2)}, Dominic J. Anstey^{(1) (2)}, and Eloy de Lera Acedo^{(1) (2)}

(1) Astrophysics Group, Cavendish Laboratory, J.J. Thomson Avenue, Cambridge, CB3 0HE, UK

(2) Kavli Institute for Cosmology, Madingley Road, Cambridge, CBG3 0HA, UK

The 21-cm signal from cosmic hydrogen is one of the most propitious probes of the early Universe. The detection of this signal would reveal key information about the first stars, dark matter, and early structure formation. We explore the impact of an emissive and reflective, or ‘hot’, horizon on the recovery of this signal for global 21-cm experiments.

Using an expanded version of the REACH Bayesian analysis pipeline [1] it is demonstrated that when using physically motivated foreground models to recover the sky-averaged 21-cm signal one must accurately describe the horizon around the radiometer. Not accounting for the horizon will lead to a signal recovery with residuals an order of magnitude larger than the injected signal, with a log Bayesian evidence of 1600 lower than when one does account for it. Signal recovery is sensitive to incorrect values of soil temperature and reflection coefficient in describing the horizon, with a 10 per cent error in reflectance causing twofold increases in the root mean square error (RMSE) of a given fit.

These parameters may be fitted for using Bayesian inference to mitigate these issues without overfitting and mischaracterizing a non-detection. Accurate signal recovery is sensitive to errors in measurements of the horizon projection onto the sky, but fitting for soil temperature and reflection coefficients with priors that extend beyond physical expectation can resolve these problems. An overestimation in the height of the horizon may be corrected for with an increased reflection coefficient in the foreground model, and an underestimation may be corrected for with an increased horizon temperature. We show that using an expanded prior range can reliably recover the signal even when the height of the horizon is mismeasured by up to 20 per cent, decreasing the RMSE from the model that does not perform this fitting by a factor of 9.

1. Anstey D.J. et al, “A general Bayesian framework for foreground modelling and chromaticity correction for global 21 cm experiments,” *MNRAS*, **506**, 2, June 2021, pp. 2041-2058, doi: 10.1093/mnras/stab1765