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Using Bayesian data analysis to model systematics and inform experiment design in Global 21cm experiments

Dominic Anstey*(1), Eloy de Lera Acedo(1), and Will Handley(1) (2)
(1) Astrophysics Group, Cavendish Laboratory, J. J. Thomson Avenue, Cambridge, CB3 0HE, UK
(2) Kavli Institute for Cosmology, Madingley Road, Cambridge, CB3 0HA, UK

Neutral hydrogen will absorb from the cosmic radio background at 21cm. This 21cm absorption provides one of the most promising methods for probing the periods of Cosmic Dawn and the Epoch of Reionisation. One way of measuring this 21cm signal is through global experiments, which use individual wide-beam antennae to measure the sky-average of the signal. We will discuss one such global experiment: REACH, the Radio Experiment for the Analysis of Cosmic Hydrogen [1].

One of the primary challenges in global 21cm experiments is due to the presence of extremely bright radio foregrounds that can exceed the signal by around four orders of magnitude [2]. Distinguishing the signal from these foregrounds is made more difficult by their coupling to chromatic variations in the antenna beam, which distorts the data in a non-trivial manner. Accurately explaining systematics such as this using detailed physical modelling is a primary principle of REACH. We will therefore discuss the REACH's Bayesian data analysis pipeline, which uses physical sky models and antenna simulations of tuneable complexity to model these foregrounds and chromatic distortions, using the Bayesian evidence to choose the required complexity of the model [3].

We will also discuss how simulations in this data analysis pipeline can be used to inform the design of a global 21cm experiment, such as the required integration times and the design of the antenna. This is achieved by simulating a global 21cm experiment under a range of conditions, for a wide range of possible 21cm signals and analysing the results with the Bayesian pipeline. This demonstrates which antenna designs and experimental conditions allow which 21cm signals to be accurately detected, which can then be used to inform the design of the experiment.

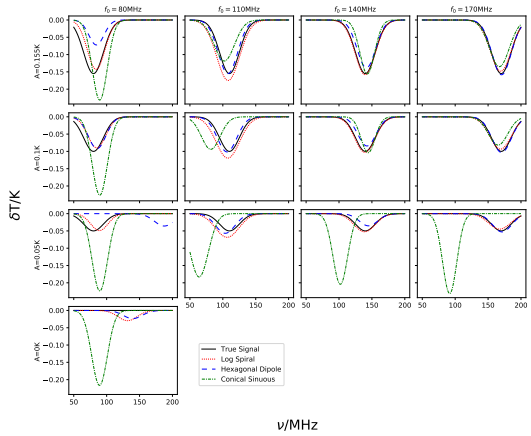

Figure 1. Plot of the signals recovered by the REACH pipeline compared the the signals inserted into the simulated data for a range of REACH antenna prototypes.

References

[1] E. de Lera Acedo, "REACH: Radio Experiment for the Analysis of Cosmic Hydrogen" in *2019 International Conference on Electromagnetics in Advanced Applications (ICEAA)*, pp. 0626-0629.

[2] P. A. Shaver, R. A. Windhorst, P. Madau and A. G. de Bruyn, "Can the reionization epoch be detected as a global signature in the cosmic background?" *Astronomy & Astrophysics*, **345**, May 1999, pp. 380-390.

[3] D. Anstey, E. de Lera Acedo, and W. Handley, "A General Bayesian Framework for Foreground Modelling and Chromaticity Correction for Global 21cm Experiments", arXiv e-prints, arXiv:2010.09644, 2020.