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Bayesian Identification of Global 21cm Signal Depth Origin

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1 Extended Abstract

The Global 21cm signal represents one of the most promising methods for providing direct measurements of the intermediate stages of the development of the Universe, in particular the Cosmic Dawn and Epoch of Reionisation. The maximum possible depth of this signal is determined by the difference between the brightness temperature of the cosmic radio background and the physical temperature of the hydrogen gas in the Intergalactic Medium (IGM). Standard astrophysics predicts a maximum signal depth of approximately 200 mK [1]. However, many theories have been proposed that could enhance the signal depth, predominantly by either increasing the radio background brightness or enabling additional cooling of the gas. It will potentially be difficult to determine which of these is the origin of an abnormally deep 21cm signal measurement based on the detected signal alone. However, a deep signal due to excess radio will also contain that excess radio as a component of the foreground.

As a result, we present a method by which the origin of a deep signal can be determined based on Bayesian model fits using a physically motivated foreground. By utilising the radio foreground model developed for the Radio Experiment for the Analysis of Cosmic Hydrogen (REACH) [2], coupled with models of excess radio contributions and the corresponding 21cm signals, provided by training the GLOBALEMU emulator [3] on simulations of the EoR made using 21cmSPACE [4], we will demonstrate that these deep signal origins can be confidently and reliably distinguished based on the Bayesian evidences of the model fits of foregrounds, as shown in Table 1.

References

[1] I. Reis, A. Fialkov, and R. Barkana "The subtlety of Ly α photons: changing the expected range of the 21-cm signal" *MNRAS*, **506**, October 2021, pp. 5479-5493.

[2] D. Anstey, E. de Lera Acedo, and W. Handley, "A General Bayesian Framework for Foreground Modelling and Chromaticity Correction for Global 21cm Experiments", *MNRAS*, **506**, September 2021, pp. 2041-2058.

[3] H. T. J. Bevins, W. J. Handley, A. Fialkov, E. de Lera Acedo, and K. Javid. "GLOBALEMU: a novel and robust approach for emulating the sky-averaged 21-cm signal from the cosmic dawn and epoch of reionization" *MNRAS*, **508**, December 2021, pp. 2923-2936.

[4] I. Reis, A. Fialkov, and R. Barkana "High-redshift radio galaxies: a potential new source of 21-cm fluctuations" *MNRAS*, **499**, December 2020, pp. 5993-6008.

Table 1. Bayesian evidences of fits of simulated 21cm data that include excess background or excess cooling, to models that differ in the 21cm signal included, the foreground included, or both.

Distinguishing Test	Data Type	Model		
		Excess Background $\log \mathscr{L}$	Excess Cooling $\log \mathscr{L}$	Correct Identification $\Delta \log \mathscr{L}$
Signal Only	Excess Background	226.1 ± 0.6	227.6 ± 0.6	-1.5
	Excess Cooling	231.7 ± 0.8	233.7 ± 1.2	2
Foreground Only	Excess Background	260.1 ± 0.3	-26673.6 ± 0.4	26933.7
	Excess Cooling	264.7 ± 0.3	275.5 ± 0.3	10.8
Joint Foreground and Signal	Excess Background	296.8 ± 0.3	-30280.1 ± 0.4	30576.9
	Excess Cooling	243.3 ± 0.4	297.0 ± 0.3	53.7