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# A Bayesian Method to Mitigate the Effects of Unmodelled Time-Varying Systematics for 21-cm Cosmology Experiments

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## 1 Extended Abstract

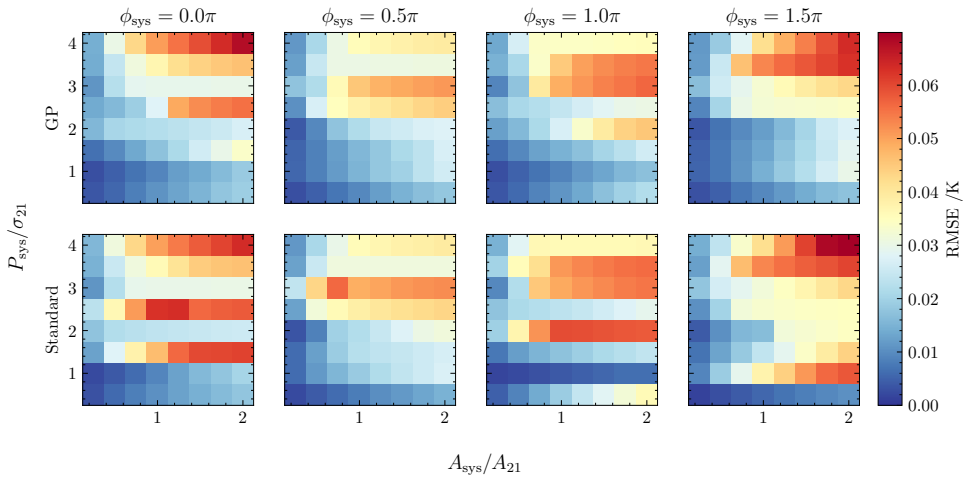


**Figure 1.** Weighted root mean square error of the pipeline fits for the standard REACH pipeline (lower row) [1, 2] and the Gaussian processes pipeline (upper row) for different systematic parameters.

Radio observations of the neutral hydrogen signal from the Cosmic Dawn and Epoch of Reionisation have helped to provide constraints on the properties of the first stars and galaxies. Since this global 21-cm cosmological signal from the Cosmic Dawn is effectively constant on observing timescales and since effects resulting from systematics will vary with time, the effects of these systematics can be mitigated without the need for a model of the systematic.

In this talk we will present a method to account for unmodelled time-varying systematics in 21-cm radio cosmology experiments using a squared-exponential Gaussian process kernel to account for correlations between time bins in a fully Bayesian way. By comparing this with the standard REACH pipeline [1, 2] and varying the model parameters of a simulated systematic we find that the Gaussian process method improves our ability to recover the signal parameters by widening the posterior in the presence of a systematic and reducing the bias in the mean fit parameters.

When varying the amplitude of a model sinusoidal systematic between 0.25 and 2.00 times the 21-cm signal amplitude and the period between 0.5 and 4.0 times the signal width, we find on average a 5% improvement in the root mean squared error of the fitted signal as can be seen in figure 1. We can use the fitted Gaussian process hyperparameters to identify the presence of a systematic in the data, demonstrating the method's utility as a diagnostic tool. Furthermore, we can use Gaussian process regression to calculate a mean fit to the residuals over time, providing a basis for producing a model of the time-varying systematic.

## References

[1] Anstey, D., de Lera Acedo, E., and Handley, W., "A general Bayesian framework for foreground modelling and chromaticity correction for global 21 cm experiments", *Monthly Notices of the Royal Astronomical Society*, **506**, 2, September 2021, pp. 2041–2058, doi:10.1093/mnras/stab1765.

[2] Anstey, D., de Lera Acedo, E., and Handley, W., "Use of time dependent data in Bayesian global 21-cm foreground and signal modelling", *Monthly Notices of the Royal Astronomical Society*, **520**, 1, March 2023, pp. 850–865, doi:10.1093/mnras/stad156.