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SVD/MCMC pipeline for separating the global 21-cm signal from foregrounds/systematics

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For precision measurements of the highly redshifted sky-averaged 21-cm spectrum of neutral hydrogen during Cosmic Dawn, we are developing a full data analysis pipeline. This consists of three distinct steps. First, using a pattern recognition code, pylinex (now publicly available; for details see Tauscher, Rapetti, Burns & Switzer, 2017), we extract in a model-independent fashion the signal from large beam-weighted foregrounds and instrument systematics. For this, we account for the Stokes parameters of the polarization induced by a large beam interacting with spatially-varying foregrounds (Nhan, Bradley & Burns, 2017), providing us with key separation power between the latter and the isotropic signal. To optimize the characterization of each component, we employ Singular Value Decomposition (SVD) of training sets to produce signal and systematics basis functions specifically suited to each theoretical modelling and observation, respectively. We then perform a weighted least square fit of the corresponding coefficients and select the number of modes to employ by minimizing the Deviance Information Criterion (DIC), which we find to most consistently yield unbiased fits compared with the other information criteria we have tested.

Second, we employ a multidimensional interpolation technique to translate the extracted signal into a chosen physical parameter space, from which we initiate the final step of the pipeline, a Markov Chain Monte Carlo (MCMC) exploration of the probability distribution in that space. This sequence allows us to circumvent the fact that current theoretical models of the imprint of the first stars, galaxies and black holes, the nature and duration of reionization, and the presence/absence of exotic physics on the 21-cm spin-flip temperature vary widely, making finding the starting point for an MCMC analysis of critical importance for an efficient search. To demonstrate the ability of the pipeline, we generate simulated data from which we successfully recover and constrain the inputted astrophysical parameters.

1. K. Tauscher, D. Rapetti, J. O. Burns, and E. Switzer, "Global 21-cm signal extraction from foreground and instrumental effects I: Pattern recognition framework for separation using training sets", *Astrophysical Journal* (accepted), 2018, eprint arXiv:1711.03173.

2. B. Nhan, R. Bradley, J. O. Burns, "A Polarimetric Approach for Constraining the Dynamic Foreground Spectrum for Cosmological Global 21 cm Measurements", *Astrophysical Journal*, **836**, 90, 2017, doi: 10.3847/1538-4357/836/1/90.