Title: ML-Enhanced Foreground Removal Methods for 21-cm Experiments Preparing for the SKA Era

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Abstract: The redshifted 21-cm signal from the Cosmic Dawn and Epoch of Reionization provides a unique probe of the early Universe, but its detection is challenged by bright astrophysical foregrounds and complex instrumental systematics. As current interferometers (LOFAR, MWA, NenuFAR, HERA) reach increasing sensitivity, foreground mitigation has become the dominant limitation.

We present ML-GPR, a Bayesian framework based on Gaussian Process Regression that exploits the distinct spectral correlations of foregrounds and the cosmological signal. The method is enhanced by physically motivated priors learned from simulations using generative models, enabling robust and flexible component separation. ML-GPR now forms a core element of the LOFAR and NenuFAR analysis pipelines, contributing to the latest constraints on the 21-cm signal.

We further present recent extensions to the time domain, leveraging the partial temporal decorrelation of contaminants to improve robustness against systematics. These developments will be discussed in the context of current experiments and future SKA observations.