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Extracting the HI 21cm signal from CD/EoR using Artificial Neural Networks

Anshuman Tripathi*(1) and Abhirup Datta (1)
(1) Department of Astronomy, Astrophysics and Space Engineering, IIT Indore, Simrol, Indore, 453552, Madhya Pradesh, India, e-mail: phd2001121001@iiti.ac.in; abhirup.datta@iiti.ac.in

The Epochs of Reionization (EoR) and Cosmic Dawn (CD) are two crucial epochs in the structure formation of the Universe's first billion years. The properties of the Intergalactic Medium (IGM) during these two epochs have not yet been observationally constrained [3]. Detection of redshifted HI 21-cm signal is one of the key scientific goals of ongoing/upcoming radio telescopes like EDGES, SARAS, MWA, SKA, and a potential probe for exploring these epochs. The HI signal can be measured using an interferometer or by averaging across the whole sky using a single radio telescope. However, detection of 21-cm is an observational challenge due to the much brighter foreground of the galactic and extragalactic sources. At low frequency, Earth's ionosphere also distorts signal significantly by introducing directional dependent effects [2, 4]. Hence, it is essential to understand the impact of each corrupting term in signal detection using non-parametric approaches such as machine learning or Bayesian statistics.

Our study uses the Artificial Neural Networks (ANNs) to extract the global 21-cm signal parameters from the composite all-sky averaged signal, containing foreground and ionospheric effects. Here to model the ionospheric effects, we have considered mainly three effects that are induced as a resultant: refraction, absorption, and thermal emission, and all of these are directly proportional to the electron density and temperature of the electrons at various layers of the Ionosphere.

Without any observational constraint, the signal parameter space is enormously huge. In order to train our input datasets or priors for 21cm signal extraction, it is crucial to sample it effectively by generating a representative subsample. Often, such non-parametric techniques do not cover the entire parameter space, resulting in a bias in the resulting inferences. We also build the data set with several realizations of the Global 21cm signal by sampling the whole parameter space. We are picking relevant samples from the parameter space using different sampling approaches to minimize the computational cost of training the ANNs model and obtain more accuracy in parameter extraction from the Global Signal. We are analyzing the outcomes of three sampling techniques: random, stratified, and quasi-Monte Carlo. This trained model can assist us in producing better findings from ground-based data. Our initial findings demonstrate a substantial accuracy in retrieving the signal parameters from CD and EoR utilizing the synthetic data of global signal experiments.

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