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Effect of Earth's Ionosphere on the ground based HI 21cm signal observation

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The formation of the universe in its first billion years was characterized by two significant stages, the Epochs of Reionization (EoR) and Cosmic Dawn (CD), that played a vital role in shaping the structure of the universe during this period. The characteristics of the Intergalactic Medium (IGM) during the EoR and CD have yet to be firmly established through observation [2]. One of the primary objectives of current and upcoming radio telescopes such as EDGES, SARAS, MWA, and SKA is to detect the redshifted HI 21-cm signal. This signal can either be measured with an interferometer or by using a single radio telescope to survey the entire sky. Despite this, detection of the 21-cm signal presents a challenge due to the bright foreground signals from the galaxy and beyond. Additionally, at lower frequencies, the Earth's Ionosphere also significantly distorts the signal by creating directional-dependent effects [4, 1]. Hence, it is essential to understand the impact of each corrupting term in signal detection using parametric and non-parametric approaches such as machine learning (ML) or Bayesian statistics. This talk is divided into two parts:

i) I will present an Artificial Neural Network (ANN) that has been developed 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. The current ANN model shows 96 to 97 % accuracy in recovering the signal parameters from Cosmic Dawn (CD) and Epoch of Reionization (EoR) using the synthetic observations of global signal experiments [3].

ii) I will also present an end-to-end pipeline that has been developed to study the effect of bright foreground, primary beam, Ionosphere and other systematics on the extraction of the redshifted HI 21cm signal from forthcoming interferometric experiment observation such as SKA-1 Low. This pipeline has incorporated several signal extraction methods, specifically focused on power-spectrum estimation. We use simulation to understand and quantify how different ionospheric scale structures impact the precision of 21-cm signal power spectrum estimation with synthetic observation with SKA1-Low.

References

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