URSI AP-RASC, Sydney, Australia, 17 – 22 August 2025

Impact of calibration errors and instrumental noise for SKA1-Low on HI 21 cm maps from the Epoch of Reionization

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The Cosmic Dawn (CD) and the Epoch of Reionization (EoR) represent a crucial phase in cosmic evolution, marking the emergence of the first luminous source that ionized the intergalactic medium (IGM). Interferometric 21 cm experiments are designed to probe the redshifted 21 cm signal from neutral hydrogen during CD/EoR epochs to infer about the early universe. The upcoming SKA1-Low is expected to make tomographic images of this epoch. The SKA1-Low is under construction. It is essential to need an image analysis tool to extract the significant amount of information from such future observations. A significant amount of work has been done based on the percolation theory that tracks the time evolution of the reionization history of the 21 cm field during EoR using simulated tomographic images.
Our aim is to track the history of reionization by quantifying the morphology of the development of the ionized regions during different stages of EoR. In order to investigate the time evolution of ionized reionization, we use a novel statistical tool called the “Largest Cluster Statistics" (LCS). Our analysis of the LCS of the redshifted 21 cm signal from the EoR has demonstrated to be a robust metric for studying the history of reionization. We analyze how the convolution of the telescopic synthesized beam of SKA1-Low with the 21 cm signal introduces bias in the history of reionization using LCS [1]. In addition, we test the robustness of LCS analysis in the presence of antenna-based calibration errors and the instrumental noise for SKA1-Low via synthetic observations simulated by the 21CME2E pipeline [2]. This study allows us to draw an inference about the history of reionization from synthetic EoR observations with the SKA1-Low AA4 telescope.

References

[1] Dasgupta, S., “Interpreting the HI 21-cm cosmology maps through Largest Cluster Statistics. Part I. Impact of the synthetic SKA1-Low observations”, JCAP, vol. 2023, no. 5, Art. no. 014, IOP, 2023. doi:10.1088/1475-7516/2023/05/014.

[2] Pal, S. K., Dasgupta, S., Datta, A., Majumdar, S., Bag, S., and Sarkar, P., “Interpreting the HI 21-cm cosmology maps through Largest Cluster Statistics. Part II. Impact of the realistic foreground and instrumental noise on synthetic SKA1-Low observations”, arXiv e-prints, Art. no. arXiv:2503.00919, 2025. doi:10.48550/arXiv.2503.00919.