21-cm power spectrum analyses of the 3c196 flanking field

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The 3c196 field is one of the main fields observed by the Low Frequency Array (LOFAR) for the 21-cm power spectrum Epoch of Reionisation analyses. The brightness of 3c196 complicates the task of calibration. Therefore, LOFAR multi-beam observations were performed with one beam on a flanking field of 3c196, thereby attenuating the bright source 3c196 by the primary beam. The suitability of this field for EoR power-spectrum properties are analyzed. Initially, six bright sources, were used for bootstrapping. A single night of data with a bandwidth of 12MHz covering a redshift range of z=10.01 – 11.12 was used to carry out the power spectrum analysis. We adopted a novel automated technique of foreground removal that entails deconvolving the manually modelled sources and then executing the WSClean multiscale cleaning option on a deeply (0.5σ) cleaned image cube with automated masking starting at 8σ, resulting in ~1200 sources. Modelling the few bright sources of the field is essential, given that a reduction of 70% in power was observed in the power spectrum before and after the subtraction of the 6 source sky model. After subtraction of all 1200 WSClean sources the spherically-averaged power spectrum of this single night of observation reduces to $2\text{x}10^3$mK at k=0.1 hMpc^{-1} and is similar to the level at which the main field of 3c196 is currently cleaned to. The subtracted image is seen to have artefacts corresponding to ionosphere and beam which contributes power to the power spectrum. Direction dependent calibration was chosen to remove such effects. Using Sagecal, sources are subtracted with separate solutions in 25 directions. This led to power reducing to $0.75\text{x}10^3$mK at k=0.1 hMpc^{-1} and also approaching the LOFAR systemic noise level at high k values. A novel foreground removal technique called Gaussian Process Regression is successfully used to bring to power spectrum near the thermal noise.

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