Contribution ID: **89**   Type: **Talk**

Reionisation time fields reconstruction from 21 cm signal maps

Friday, December 1, 2023 5:00 PM (15 minutes)

During the Epoch of reionisation, the intergalactic medium is reionised by the UV radiation from the first generation of stars and galaxies. One tracer of the process is the 21 cm line of hydrogen that will be observed by the Square Kilometre Array (SKA) at low frequencies, thus imaging the distribution of ionised and neutral regions and their evolution.

To prepare for these upcoming observations, we investigate a deep learning method to predict from 21 cm maps the reionisation time field treion, i.e. the time at which each location has been reionised. treion encodes the propagation of ionisation fronts in a single field, gives access to times of local reionisation or to the extent of the radiative reach of early sources. Moreover it gives access to the time evolution of ionisation on the plane of sky, when such evolution is usually probed along the line-of-sight direction.

We trained a convolutional neural network (CNN) using simulated 21 cm maps and reionisation times fields produced by the simulation code 21cmFAST . We also investigate the performance of the CNN when adding instrumental effects.

Globally, we find that without instrumental effects the 21 cm maps can be used to reconstruct the associated reionisation times field in a satisfying manner: the quality of the reconstruction is dependent on the redshift at which the 21 cm observation is being made and in general it is found that small scale features are smoothed in the reconstructed field, while larger
scale features are well recovered. When instrumental effects are included, the scale dependance of reconstruction is even further pronounced, with significant smoothing on small and intermediate scales.

The reionisation time field can be reconstructed, at least partially, from 21 cm maps of IGM during the Epoch of reionisation. This quantity can thus be derived in principle from observations and should then provide a mean to investigate the effect of local histories of reionisation on the first structures that appear in a given region.

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Session Classification: Contributed talks

Track Classification: Paris