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A census of ionospheric activity observed by the Murchison Widefield Array

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The Murchison Widefield Array (MWA) is a low-frequency radio telescope located in the Western Australian desert. While it was designed for broad astrophysics, including to make a statistical detection of the HI spectral line from the Epoch of Reionisation (EoR), the MWA has proven its ability to detect and even image ionospheric structures above it.

In [1], 927 observations were used to build an understanding of (1) how the ionosphere manifests, (2) how frequently each "type" of ionosphere was identified, and (3) how ionospheric conditions affect the quality of MWA EoR data. These results have provided a powerful proof-of-concept that radio telescopes can act as unique probes of high spatial and temporal resolution ionospheric activity, which has multiple benefits beyond radio astronomy. Since that publication, other ionospheric phenomena have been identified in MWA EoR data, which appear to be triggered but still lack any explanation (see Figure 1).

For radio astronomy, as our instruments become more capable, identifying and treating the effect of the ionosphere becomes increasingly important. Efforts have been made to build a database of ionospheric activity on top of the original 927 observations, but this has proven extremely challenging. Ultimately, the software that was used to identify ionospheric activity was deemed no longer fit for purpose and needed to be replaced. Using the new *hyperdrive* calibration software, we present the results of tens of thousands of observations' worth of ionospheric activity, as well as other interesting "one off" phenomena identified along the way.

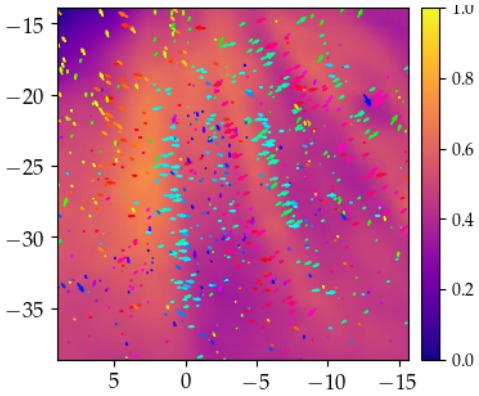

Figure 1. An example of "strong" ionospheric activity detected within MWA EoR data. Each coloured point is a vector and corresponds to a calibrator source, typically a radio galaxy, which is a measurement from our data. The colour of these vectors indicates its direction, and the magnitude is proportional to its size. The background image is a mathematical reconstruction of the STEC that yields these vectors. Several "tubular" structures are visible across the field of view.

References

[1] C. H. Jordan et al., "Characterization of the ionosphere above the Murchison Radio Observatory using the Murchison Widefield Array", *Monthly Notices of the Royal Astronomical Society*, **471**, 4, July 2017, pp. 3974-3987, doi: 10.1093/mnras/stx1797.