Opening a new window of spectro-temporal polarimetric imaging study of low frequency radio Sun using SKA precursor

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Polarisation of the low-frequency Sun

- Thermal bremsstrahlung from quite Sun corona (Stokes V $\sim$ 1%; Sastry et al. 2009).
- Coherent plasma emission from radio bursts (Stokes V $\sim 20 - 90\%$).
- Gyrosynchrotron emission from coronal mass ejections (CMEs). Emissions are very faint.

Importance

- Polarisation properties of the low-frequency radio emissions provide robust constraints on the emission mechanisms of different types for solar radio bursts.
- Polarisation observations at low-frequency are a direct measurement tool for coronal magnetic fields at middle and higher coronal heights.
- Low levels of circular polarisation (<1%) from quiet Sun thermal emission are a direct probe for large scale magnetic fields of the quiet corona.
- Break the degeneracy between magnetic field strength and line of sight angle for gyrosynchrotron emission from CMEs.

Status till recently

- Most polarisation studies used non-imaging instruments – unable to provide information about spatial structure.
- Most of the imaging instruments rely on Earth rotation synthesis imaging – unable to provide high fidelity spectroscopic snapshot images.

Robust polarisation calibration

- Fully automated robust unsupervised polarisation calibration algorithm : "Polarimetry using Automated Imaging Routine for Compact Arrays of the Radio Sun (P-AIRCARS)" (Kansabanik et al., in prep.)
- Produce images with dynamic range $\sim 10^2 - 10^5$.
- Residual polarisation leakages – Stokes Q & U : <1%, Stokes V : <0.3%, similar to that for astronomical observations.

Preliminary science results

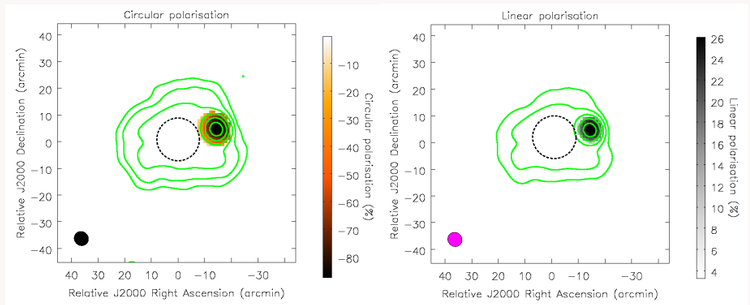

Figure: Left panel : Circular polarisation; Right panel : Linear polarisation from Type-I noise storm at 119 MHz.

- First ever linearly polarised emission detected from low-frequency solar emission with spectroscopic imaging over 40 kHz bandwidth.
- Faraday rotation measurements of the linearly polarised emission can be a novel tool for measuring coronal magnetic fields and understanding emission mechanisms.

Polarisation from quiet Sun thermal emission

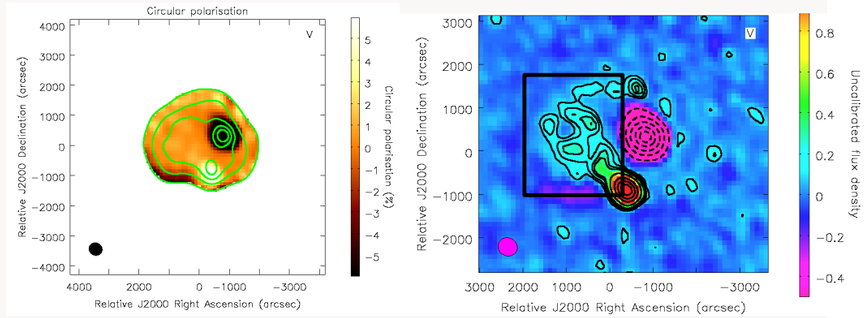

Figure: Left panel : Fractional circular polarisation (Stokes V) image at 80 MHz. Contours show Stokes I emission. Right panel : Zoomed in Stokes V image showing the first ever detection of weak circular polarisation from quiet Sun thermal emission (black box).

- Average fraction circular polarisation of the quiet Sun region $\sim$ 0.5%, residual leakage < 0.07%.

Summary and conclusion

- P-AIRCARS implements a state-of-the-art robust polarisation calibration algorithm for low-frequency radio solar observations.
- It achieves similar level of residual leakages as typically obtained for astronomical observations.
- Early results from P-AIRCARS are already leading to new discoveries – (1) first detection of linear polarised emission and (2) first detection of weak circular polarisation from the quiet Sun.
- Suitable for future SKA-Low and opening a new window for high fidelity spectro-polarimetric snapshot imaging studies of the low-frequency radio Sun.

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MWA MURCHISON WIDEFIELD ARRAY