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Solar Science and Space Weather with the Murchison Widefield Array

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The two key phenomenon involved in Space Weather - magnetic reconnection and particle acceleration at shocks and magnetic reconnection sites - are both yet to be understood in sufficient detail. Due to the nature of the emission mechanisms involved, radio observations, especially at metric wavelengths, are sensitive to the local magnetic fields, carry information about particle acceleration sites and shocks where they are produced, and originate at coronal heights which are hard to probe by most other means. Radio observations are unique in that they have they can be used to study the precursors, the drivers as well as the consequences of Space Weather events. The pre-eruption phase of a coronal mass ejection (CME) is often associated with the type III solar bursts. The CME shock location, motion and morphology can be studied using the type II emission. The gyrosynchrotron emission from the accelerated electrons trapped in the CME plasma allow us to estimate the CME magnetic field, among other parameters. Due to Faraday rotation, the CME plasma leaves an imprint of its magnetic topology on the linearly polarised light from background radio sources. A large number of such observations sampling many lines of sight through the CME as it traverses the vast interplanetary space can, in principle, allow to us estimate the 3D magnetic field configuration of the CME, eventually leading to robust Space Weather prediction. Upon arrival on Earth, the terrestrial impact of the CMEs can also be measured using ionospheric observations.

In spite of the well recognised unique strengths of solar radio observations and the complementarity they offer to our other sources of information, it has remained hard to use them to their to true potential. The primary underlying reason is that much of this science requires spectroscopic imaging with high time and frequency resolution, and a high imaging dynamic range and fidelity. For the Fourier imaging technique of radio interferometry, which conventionally relies on time and frequency synthesis to build its image fidelity, this has been a long standing challenge. This is now changing with the advent of the new generation of capable and versatile low frequency interferometers like Murchison Widefield Array (MWA), the LOw Frequency Array (LOFAR) and the Long Wavelength Array (LWA). Of these instruments, the MWA design is particularly well suited for solar and heliospheric science studies of interest from a space weather perspective. We have been working systematically on building the tools needed to enable the scientific exploration of these fine-grained high-SNR data and pursue science opportunities with them. The techniques developed range from a robust flux calibration and an imaging pipeline optimised for spectroscopic imaging of the Sun to algorithms for quantifying the strength and prevalence of weak impulsive nonthermal emissions. Here we will briefly discuss the opportunity presented by the new generation low radio frequency arrays, share some examples to illustrate the current status of our efforts and, mention the challenges ahead, with an emphasis on Space Weather considerations.