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Probing coronal magnetic fields using high fidelity spectro-polarimetric low radio frequency observations of the Sun using the Murchison Widefield Array

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Magnetic field measurements at middle and higher coronal heights are challenging using conventional techniques with observations at visible or extreme ultra-violet wavelengths. Low radio frequencies are ideal for probing magnetic fields at higher coronal heights. Polarization properties of solar radio emissions are known to be a rich source of information about the emission mechanisms and magnetic fields of the corona. Nonetheless, largely due to technical challenges, precise polarimetric solar observations at low radio frequencies have remained challenging. The degree of polarization of solar radio emission varies dramatically over time, frequency, and also in morphology, depending on the emission mechanism. The radio bursts show a moderate to a high degree of circular polarization, while the quiet sun thermal emissions show a very low degree of circular polarization (<1%). Once feasible, detection of this very low circular polarisation from quiet Sun thermal emission will be an important tool to measure the quiet Sun coronal magnetic field. Simultaneous measurements of linear and circular polarisation from active emissions are important to understand the quasi-longitudinal and quasi-transverse propagation and will be a direct probe of the magnetic field geometry. According to the conventional views, linear polarization the low-frequency solar emission is expected to be wiped out due to large differential Faraday rotation. Hence, the few polarization studies of the low-frequency Sun in the past many decades have concentrated on measuring only the circular polarization. Nonetheless, we will show a few examples of convincing detections of linearly polarized emission from a variety of active solar emissions using observations from the Murchison Widefield Array (MWA). Perhaps the most rewarding, and also challenging, will be the polarimetric observations of faint gyrosynchrotron or thermal emission from the coronal mass ejection (CME) plasma, which will allow us to model the CME plasma parameters unambiguously at higher coronal heights. We have recently developed state-of-the-art polarization calibration and imaging pipeline for snapshot spectro-polarimetric solar imaging to enable the studies enumerated above and more. Here we summarise its current status and showcase some early science results which challenge the conventional wisdom and open a new window of the polarimetric study of the low-frequency radio Sun. While this pipeline is optimized for the MWA, a Square Kilometer Array (SKA) precursor, it can be adapted for the future SKA-Low and other future solar arrays in a straight

forward manner.