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From Coronal Heating to Space Weather : Progressing solar physics using the Murchison Widefield Array

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The confluence of the dense Fourier sampling provided by the data from the Murchison Widefield Array (MWA) [1] and the end-to-end interferometric imaging pipeline optimized for solar imaging with arrays with a compact core developed by the MWA solar group [2] have lead to a significant improvement in the state-of-the-art in fidelity and dynamic range of metrewave solar radio imaging. The considerable improvement in the imaging quality has brought within reach novel science capabilities. This paper will present the current status and near term plans for two exciting examples of this nature which are briefly discussed below.

The gyrosynchrotron emission from the coronal mass ejection (CME) plasma has long been regarded as a valuable diagnostic coronal magnetic fields. However, detecting and imaging this intrinsically low brightness temperature emission, especially given the usual presence of much brighter active emissions during CME times is a challenging prospect. Consequently there have been only been a few successful detections of CME gyrosynchrotron emission. The first successful detection and modeling of CME gyrosynhrotron emission from the MWA has recently been reported [3]. Subsequent work has led to successful detection of such emission in all three CMEs where this has been attempted yet. These are also the weakest and the farthest detections of such emissions, to the best of our knowledge. The routine detection of this emission from unremarkable CMEs suggests that the imaging capabilities achieved by the MWA is usually sufficient to meet this challenge.

The search for Parker's "nanoflares" has remained an important and challenging aspect in the quest to understand coronal heating. The nonthermal electrons produced by these nanoflares are expected to give rise to emission in the metrewave radio band. By pushing the detection threshold of nonthermal emission by about two orders of magnitude lower than previous studies, we have uncovered ubiquitous impulsive nonthermal emissions from the quiet sun [4]. We refer to them as Weak Impulsive Narrowband Quiet Sun Emissions (WINQSEs) and are actively pursuing a multi-pronged approach to characterise and understand them in greater detail. These include studying them across multiple epochs; developing machine learning algorithms to identify WINQSEs in radio images and characterise their morphologies; exploring the ability of the present generation EUV and X-ray instruments to estimate the energy corresponding to the brightest of WINQSEs; attempting very high time resolution imaging to explore their temporal structure; initiating a project to simulate the process of energization of charged particles through magnetic reconnection and eventually model the radio emission they give rise to; and better understanding their relationship to magnetic switchbacks recently reported by Solar Orbiter.

References

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