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Solar and Heliospheric Science from the New Generation Radio Telescopes: Status and Opportunities

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1 Extended Abstract

Active solar radio emissions usually arise from processes complementary to those giving rise to emissions at other wavebands. The polarization of solar radio emissions not only carries detailed information about the intrinsic emission mechanism but also the strength and topology of the coronal magnetic fields. As these emissions make their way through to the observer, they get imprinted with signatures of the turbulent birefringent magnetized coronal plasma they traverse due to propagation effects. Radio observations also provide one of the few means to probe the vast coronal and heliospheric medium via studies of the propagation effects imprinted on the radio emission from background sources as they traverse the magentized and turbulent medium. All of these make radio observations an excellent probe of the solar coronal and heliospheric regions which provide information complementary to what can be obtained from other means.

In practice, however, a mix of instrumental and algorithmic limitations has kept the promise of solar radio observations from being realized. This is now set to change. Several new-generation radio interferometers have recently become available, and more are expected in the near future. These are the many precursors and pathfinders of the Square Kilometre Array Observatory (SKAO) and the SKAO itself (expected first-light 2029). The vastly improved observational abilities of these instruments are very well aligned with the needs of solar and heliospheric physics. Between the various instruments and available techniques, they can be used to study regions from the base of the corona to beyond an AU and address a large variety of science targets. However observing the Sun with instruments optimized to observe galactic and extra-galactic sources which are multiple orders of magnitude fainter imposes additional non-standard requirements. In addition the extreme difference between the flux densities of the Sun and typical calibrator sources require us to develop alternative flux density and polarization calibration strategies for solar observations. There is yet another aspect to contend with – some of the most interesting times for observing the Sun are during periods of solar activity. Solar activity, however, is inherently unpredictable and this makes “blind observing" very inefficient at capturing episodes of solar activty. On the other hand, observing time on these versatile instruments is precious and only limited amounts are expected to be available for solar observing. It is hence essential to develop triggered observing mechanisms which can monitor solar activity in real-time and initiate solar observations when suitable solar activity is detected.

For over a decade now, we have devoted considerable work towards enabling solar and heliospheric science with these instruments. Much of our work has been with the Murchison Widefield Array (MWA), though lately we have also been working with Low Frequency Array (LOFAR), MeerKAT and the upgraded Giant Metrewave Radio Telescope (uGMRT). This talk will showcase some example science areas where considerable progress has been made, share the status and near-term plans for radio solar and heliospheric observations with these new-generation instruments and the science opportunities they present.