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Observations and Analyses of Heliospheric Faraday Rotation of a Coronal Mass Ejection (CME) Using the LOw Frequency ARray (LOFAR) and Space-Based Imaging Techniques

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Geomagnetic storms of the highest intensity are general driven by coronal mass ejections (CMEs) impacting the Earth's space environment. Their intensity is driven by the speed, density, and, most-importantly, their magnetic-field orientation and magnitude of the incoming solar plasma. The most-significant magnetic-field factor is the North-South component (Bz in Geocentric Solar Magnetic - GSM - coordinates). At present, there are no reliable prediction methods available for this magnetic-field component ahead of the in-situ monitors around the Sun-Earth L1 point. Observations of Faraday rotation (FR) can be used to attempt to determine average magnetic-field orientations in the inner heliosphere. Such a technique has already been well demonstrated through the corona, ionosphere, and also the interstellar medium. Measurements of the polarisation of astronomical (or spacecraft in superior conjunction) radio sources (beacons/radio frequency carriers) through the inner corona of the Sun to obtain the FR have been demonstrated but mostly at relatively-high radio frequencies. Here we show some initial results of true heliospheric FR using the Low Frequency Array (LOFAR) below 200 MHz to investigate the passage of a coronal mass ejection (CME) across the line of sight. LOFAR is a next-generation low-frequency radio interferometer, and a pathfinder to the Square Kilometre Array (SKA) – LOW telescope. We demonstrate preliminary heliospheric FR results through the analysis of observations of pulsar J1022+1001, which commenced on 13 August 2014 at 13:00UT and spanned over 150 minutes in duration. We also show initial comparisons to the FR results via various modelling techniques and additional context information to understand the structure of the inner heliosphere being detected. This observation could indeed pave the way to an experiment which might be implemented for space-weather purposes that will eventually lead to a near-global method for determining the magnetic field throughout the inner heliosphere.