Remote Sensing of CME Magnetic Field Across the Corona to Heliosphere Using Coordinated Wide Field of View Radio Polarimetric and PUNCH Observations

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Measuring magnetic fields of coronal mass ejections (CMEs) in the outer corona and inner heliosphere through remote sensing is vital for advancing space-weather prediction. While routine white-light coronagraphs and heliospheric imagers provide insights into the geometry of CME magnetized plasma, they are not capable of directly measuring magnetic fields. At radio wavelengths, Faraday rotation (FR) — the polarization angle change of background linearly polarized astronomical sources — can be used to estimate line-of-sight (LoS) integrated magnetic fields when a plasma structure intersects the LoS. However, this technique has traditionally been restricted to coronal heights below 15 ⊙ (R⊙ = Solar radii), utilizing high-frequency telescopes like the JVLA, which have narrower fields of view (FoVs) and reduced sensitivity to magnetic field strength.

In recent years, the advent of new-generation ground-based radio telescopes such as MWA, LOFAR, ASKAP, and MeerKAT has provided a significant opportunity. These instruments, with their wide FoVs and lower observing frequencies, are well-suited for measuring CME magnetic fields from the corona to the inner heliosphere. Despite their potential, challenges remain, including calibration and the need for precise, time-sensitive observations using non-solar-dedicated telescopes during space-weather events. Additionally, extracting magnetic field estimations from radio measurements requires accurate knowledge of the electron density distribution along the LoS to the background radio sources. The PUNCH mission's white-light polarization observations offer a complementary solution by providing electron density measurements from the outer corona to the inner heliosphere. This synergy enables the extraction of magnetic field estimates from wide-FoV radio observations.

This presentation highlights recent successes in detecting FR signatures caused by CMEs from coronal to heliospheric heights, leveraging cutting-edge radio telescopes. These efforts are especially timely as they align with the early operational phase of PUNCH, paving the way for coordinated radio and white-light wide-FoV polarimetric observations to provide complimentary pieces of information to measure CME vector magnetic fields. The ultimate goal is to strengthen space-weather research and improve predictive capabilities by combining these advanced observational techniques.

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