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Computer Simulated Studies of the Tomographic Reconstruction of Interplanetary CMEs using Wide Angle Heliospheric Imagers

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The multiple, spatially-separated, vantage points afforded by the STEREO and SOHO missions provide us with a means to infer the three-dimensional structure of the solar corona via tomographic imaging. This method incorporates information from multiple projections of the optically-thin plasma to constrain its three-dimensional density structure. The technique has regularly been applied to the low corona using data from the STEREO and SOHO coronagraphs, however, it is also applicable at much larger, interplanetary distances using wide-angle imagers. Only very limited, large-scale structure may be inferred from the two viewpoints provided by the STEREO Heliospheric Imagers (HIs), however, the upcoming Solar Orbiter and Parker Solar Probe missions will carry wide-angle imagers at additional vantage points in the heliosphere. Beyond these current, and upcoming missions, there is the potential for future instrumentation (such as at L1 and L5) to increase our coverage of the heliosphere further still.

The work presented here is done so with the aim of assessing our ability to improve the tomographic reconstruction of heliospheric plasma densties, including CMEs, by using data from an increased number of vantage points. This is achieved by applying the technique to simulated HI data from multiple spacecraft. We produce simulated solar wind densities using the Graduated Cylindrical Shell (GCS) model based on CMEs from the Coronal Mass Ejection Kinematic Database (KINCAT). These are then used to compute HI observations at different positions in heliosphere via Thomson scattering. These simulated observations are in turn used to perform tomography with differing numbers of spacecraft in order to assess our ability to faithfully reconstruct plasma densities within the CME. We exploit this information to investigate the optimal orbital characteristics, such as spacecraft number, separation, inclination and eccentricity, necessary to perform the technique with HIs. Further to this, we produce simulated observations from HIs capable of polarisation measurements with which we show that the resulting tomographic reconstructions may be improved further. This work has obvious space weather applications, serving as a demonstration for potential future missions, e.g. L1 or L5, and will prove timely in fully exploiting the science return from the upcoming Solar Orbiter and Parker Solar Probe missions.