Tomographic Inversion of Synthetic White-Light Images: Observing Coronal Mass Ejections in 3D

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Forecasting the arrival of Coronal Mass Ejections at Earth depends on accurate characterisation of their three-dimensional structure and kinematics. This is usually achieved via forward-modelling; applying an assumed model of the CME structure to white-light observations, which may be achieved using a small number of observing spacecraft. An alternative approach is inverse modelling, whereby white-light images are treated as two-dimensional projections of the Thomson-scattered light from the 3D plasma distribution. Inversion of images taken from multiple vantage points is purely mathematical and allows the three-dimensional CME density structure to be constrained. However, the method requires multiple observing spacecraft and, to-date, it has enjoyed limited success when applied to CMEs.

We establish the effectiveness of the tomographic inversion method using synthetic imagery produced by state-of-the-art magnetohydrodynamic simulations using the COROnal HELiospheric (CORHEL) model. This is performed for a fleet of spacecraft, such that various combinations can be combined and used to perform tomography on the synthetic imagery, with the goal of establishing the minimum requirements for successful 3D CME reconstruction. We demonstrate how the number of observing spacecraft influences the solution, how well the technique is augmented using polarised brightness measurements and the optimal orbital configuration, including out-of-ecliptic observers.

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