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Coronagraphic observations enable direct monitoring of coronal mass ejections (CMEs) through scattered light from free electrons, but inferring the 3D plasma distribution from 2D images remains a major challenge due to the optically thin medium and the complex image formation processes.

We present a new deep learning framework for 3D tomographic reconstructions of the corona and heliosphere from multi-viewpoint coronagraphic observations, using a neural representation to estimate the evolving electron density and CME structure. By explicitly modeling Thomson scattering and incorporating physics-based constraints on plasma flow and propagation, the method can robustly recover CME morphology, propagation direction and speed even from a limited number of viewpoints.

Using synthetic CME observations, we demonstrate that reliable CME kinematics can be obtained from only two viewpoints, and that additional viewpoints significantly improve the reconstruction of the 3D plasma distribution. We further present first applications to observational data, including intrinsic modeling of instrumental calibration differences, stray-light effects, and F-corona contributions.

This work demonstrates the potential of physics-informed, data-driven tomography for improved CME characterization and space weather forecasting. This approach directly capitalizes on PUNCH polarimetric imaging and multi-viewpoint geometries, unlocking new capabilities for 3D reconstructions of CMEs throughout the inner heliosphere.

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