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Mesoscale structures in the solar wind and coronal mass ejections (CMEs) are one of the scientific targets of the upcoming PUNCH mission. We do not fully understand what processes form these structures and how they evolve from the outer solar corona through the heliosphere. In anticipation of the high sensitivity large field-of-view PUNCH imaging, MHD simulations capable of modeling the global inner heliosphere while simultaneously resolving structures at mesoscales can help predict what structures we expect to form in certain interaction scenarios. We use an efficiently parallelized and scalable physics-based MHD model with numerical algorithms featuring high resolving power to perform global inner heliosphere simulations with CMEs at a previously unattainable high resolution. Using the GAMERA-Helio inner heliosphere model coupled with the Gibson-Low CME model, we model the evolution of a wide and fast CME flux rope through a realistic solar wind background. The simulation resolves spatial scales down to ~7*10^4 km (or ~0.1 solar radius or 10 Earth radii), enabling, for the first time, to study mesoscale structures that form in the CME-solar wind interaction in a global context. We discuss the development of ripples and irregularities at the CME shock, compressions, and magnetic field fluctuations in the CME-driven sheath and connect these structures with the interaction between the CME and background solar wind structures. By computing synthetic white-light images from high-resolution GAMERA simulations, we show how mesoscale structures that form at the CME-solar wind interface appear in the total and polarized brightness images to be observed by the PUNCH mission.
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