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Predicted appearance of Magnetic Flux Rope and Sheared Magnetic Arcade Structures before a Coronal Mass Ejection via three-dimensional radiative Magnetohydrodynamic Modeling

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Magnetic Flux Ropes (MFRs) are free-energy-carrying, three-dimensional magnetized plasma structures characterized by twisted magnetic field lines and are widely considered the core structure of Coronal Mass Ejections (CMEs) propagating in the interplanetary space. The way MFRs form remains unclear as different theories predict that either MFRs form during the initiation of the CME or pre-exist the onset of the CME. The term "pre-existing structure" is synonymous with "filament channels." On the one hand, the theories predicting on-the-fly MFR formation require Sheared Magnetic Arcades (SMAs; low twist but stressed magnetic structures) for the filament channel/pre-existing magnetic structure of CMEs. On the other hand, a growing number of works using SDO/AIA observations (combined with non-linear force-free extrapolations; NLFFF) suggest that MFRs may be the form of filament channels, therefore pre-existing the CME eruption. However, due to the inability to routinely measure the 3D magnetic field in the solar atmosphere, we cannot unambiguously interpret optical and EUV imaging observations as projected on the plane of the sky. Therefore, a raging debate on the nature of the pre-eruptive structure continues. It is also possible that the filament channel/pre-eruptive structure evolves from SMA to MFR slowly, further complicating the distinction between these two types of structures in the solar observations. This work presents realistic simulated EUV observations synthesized on a time-evolving radiative MURaM MHD model along the slow evolution of an SMA converting to an MFR. We discuss the implications of our results in the context of filament channel formation and CME initiation theory.

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