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MHD Simulation of Solar Prominence Formation and Eruption

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Solar prominences, the dense and cool materials embedded in the hot and tenuous corona, are intriguing structures in the solar atmosphere. To investigate the formation mechanisms of solar prominences, we reproduce two potential models, i.e., the levitation model and the reconnection and condensation model, by 2.5-dimensional magnetohydrodynamic (MHD) simulations in a chromosphere-transition-corona setup. In the levitation model, the initial arcade-like linear force-free magnetic field is driven by an imposed slow motion converging towards the magnetic inversion line at the bottom boundary. A magnetic flux rope (MFR) is formed by magnetic reconnection and eventually erupts as a coronal mass ejection (CME). An embedded prominence also gets formed directly by levitating material from the chromosphere. Synthetic images and light curves of the seven SDO/AIA channels and thermal X-ray are obtained with forward modeling analysis. In the reconnection and condensation model, a pre-existing MFR in the lower corona suddenly erupts due to catastrophe. The erupting MFR stretches the magnetic field lines, and a current sheet (CS) is formed. Multiple magnetic islands appear in the CS after plasmoid instability occurs. These magnetic islands carry mass from the chromosphere to the MFR. The dense and cool mass carried by the islands accumulated in the bottom of the MFR, forming a prominence. The condensation starts as the MFR rises. The coronal plasma continuously condenses into the prominence due to the thermal instability. We also study the dynamics and physical properties of the magnetic islands.

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