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Mass Cycle and Dynamics of a Virtual Quiescent Prominence

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The mass cycle of solar prominences or filaments is still not completely understood. Researchers agree that these dense structures form by coronal in-situ condensations and plasma siphoning from the underlying chromosphere. In the evaporation-condensation model siphoning arises due to evaporation of chromospheric plasma from localised footpoint heating but this is challenging to justify observationally. Here, we simulate the reconnection-condensation model at extreme-resolutions down to 20.8 km within a three-dimensional magnetohydrodynamic coronal volume. We form a draining, quiescent prominence and associated coronal rain simultaneously. We show that thermal instability –acting as a trigger for local condensation formation – by itself drives siphoning flows from the low-corona without the need of any localised heating. In addition, for the first time we demonstrate through a statistical analysis along more than 1000 magnetic field lines that cold condensations give rise to siphoning flows within magnetic threads. This siphoning arises from the strong pressure gradient along field lines induced by thermal instability. No correlation is found between siphoning flows and the prominence mass, making thermal instability the main in-situ mass collection mechanism. Our simulated prominence drains by gliding along strongly sheared, asymmetric, dipped magnetic arcades, and develops natural vertical fine-structure in an otherwise horizontal magnetic field due to the magnetic Rayleigh-Taylor instability.By synthesising our data, our model shows remarkable agreement with observations of quiescent prominences such as its dark coronal cavity in extreme-ultraviolet emission channels, fine-scale vertical structure and reconnection outflows which, for the first time, have been self-consistently obtained as the prominence evolves.

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