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MHD Simulation of Periodic Plasmoid Ejections in Saturn's Magnetotail

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We study large-scale mass loading and plasma loss phenomena in Saturn's magnetosphere by means of global single-fluid MHD simulations (BATS-R-US). The major internal plasma sources, the rings, the icy satellites and Titan are incorporated as mass loading source terms in the MHD equations. We find that even under steady solar wind conditions, large plasmoids are pinched off quasi-periodically along a reconnection line in the dawn side of the magnetotail. Similar plasmoids have been recently observed, with a repetition period of 2-3 days, in Jupiter's magnetotail by the New Horizons spacecraft. In our simulations, the characteristic frequency of plasmoid ejections is decreasing and the size of the plasmoids is increasing with decreasing solar wind dynamic pressure. This can be explained in terms of the Vasyliunas cycle. If the scale size of the magnetosphere is larger due to a lower solar wind dynamic pressure, more time is needed to fill up a recently emptied flux tube with plasma of internal origin. The excessive mass stretches the tailward convected flux tubes until reconnection occurs along an X-line and a plasmoid is pinched off. For medium and low solar wind dynamic pressures, the characteristic period of plasmoid ejections in Saturn's magnetotail varies in the range between 20 and 70 hours. For higher than average solar wind dynamic pressures, however, large plasmoids cannot be observed any more in the simulations, and the loss of plasma in the tail becomes more or less continuous. Interestingly enough, the characteristic frequency of plasmoid ejections becomes lower for larger axial tilts, which means that besides the mass loading rate and the size of the magnetosphere, the geometry of the internal plasma sources also plays an important role in the formation of plasmoids. We demonstrate the periodic formation of plasmoids and the related inner magnetospheric dynamics with 2-D and 3-D animations for different steady solar wind conditions and different axial tilt angles. We conclude that Saturn's magnetosphere behaves Jupiter-like for low and medium solar wind dynamic pressures and more Earth-like for high dynamic pressure.