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MESSENGER Observations of Mercury's Magnetosphere Dynamics: A Review (Invited)

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MESSENGER magnetic field and plasma observations of Mercury's magnetospheric dynamics are reviewed. The combination of Mercury's weak, intrinsic magnetic field and intense solar wind forcing of the inner heliosphere creates a small, but highly dynamic, magnetosphere. In this active environment, frequent magnetic reconnection is responsible for the transport of plasma and magnetic flux with Dungey cycle times that are 30 times faster than at Earth. At the dayside magnetopause, reconnection occurs for all orientations of the interplanetary magnetic field, independent of shear angle, as a direct consequence of the low plasma beta, the ratio of plasma to magnetic pressure, in the inner heliosphere. The mean magnetopause reconnection rate of 0.15 is $\sim$3 times higher than average values at Earth. Flux transfer events, with core field strengths reaching values of 250 nT and higher, have durations of $\sim$2-3 s and $\sim$8-10 s separations. Observations of Mercury's plasma mantle in the high-latitude magnetotail provide direct measurements of solar wind transport into the magnetosphere. The cross-magnetosphere electric potential, calculated from plasma mantle and magnetopause structure, is $\sim$30 kV. Also in the magnetotail, Earth-like dipolarization events are reported as rapid increases in the field magnitude (40-50 nT) followed by slow, $\sim$10 s, decays in the north-south component of the magnetic field. Substorm-like loading/unloading of magnetic flux in Mercury's tail is observed to have $\sim$2-3 min durations with field magnitude increases of $\sim$30-50%. Multiple X-line reconnection in the cross-tail current sheet creates flux ropes with similar magnetic variations to those observed at Earth, but the timescales are 40 times shorter at Mercury. Plasma sheet heating, resulting as a consequence of this intense reconnection in Mercury's magnetotail, is a topic for further investigation. Overall, Mercury's magnetosphere is a dynamic environment with constant plasma and magnetic flux circulation as a result of frequent magnetic reconnection.