EPSC Abstracts
Vol. 8, EPSC2013-681, 2013
European Planetary Science Congress 2013
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MESSENGER Observations of Plasmoid-type Flux Ropes in Mercury's Magnetotail

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Abstract

Magnetic field observations by the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft during passes through Mercury's plasma sheet frequently contain signatures of large-scale magnetic reconnection in the form of magnetic flux ropes. These flux ropes form in the cross-tail current sheet, separating the north and south lobes of the magnetotail, due to reconnection at two or more X-lines. The flux ropes are then convected either toward or away from the planet by the Alfvénic-flow emanating from the X-lines. Flux ropes are identified in the magnetic field data on the basis of their helical structure as a bipolar variation in the north–south magnetic field coincident with a strong core field in the east–west direction. Here we survey seven "hot seasons," when periapsis is on Mercury's dayside and apoapsis is in the tail, to select a total of 49 such flux ropes for which minimum variance analysis indicates that the spacecraft passes near the central axis of the structure. During these intervals, it is not uncommon to identify multiple events on a single orbit. The locations of the selected flux ropes range between 1.7 and 2.8 R_M (where R_M is Mercury's radius, or 2440 km) down the tail from the planet with typical durations of ~1–2 s. From plasma measurements, we determine densities between ~2 and 10 cm^{-3} in the plasma sheet, from which we calculate local Alfvén speeds of approximately 250–650 km s^{-1}. Under the assumption that flux ropes travel at the Alfvén speed, their diameters range from 0.1 to 0.5 R_M. The strong core fields in the flux ropes also cause the total magnetic field magnitude to increase by a factor of ~2 relative to the background field in the tail lobes. These events indicate that intense magnetic reconnection occurs frequently, not only at the dayside magnetopause but also in the cross-tail current layer of this small but extremely dynamic magnetosphere.