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MESSENGER observations of statistical flow braking and flux pile-up in Mercury's magnetotail

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Abstract

Similar to Earth, Mercury's magnetotail experiences frequent dipolarization of the magnetic field. These rapid (~2 s) increases in the northward component of the tail field ($\Delta B_z \sim 30$ nT) at Mercury are associated with fast sunward flows (~300 km/s) that enhance local magnetic field convection and plasma transport, similar to dipolarizations in the Earth's magnetotail. Differences between the two magnetospheres, namely Mercury's smaller tempro-spatial scales and lack of an ionosphere, result in differences in the dynamics of dipolarizations in these magnetotails. At Earth, for example, the braking of these fast flows as they approach the inner magnetosphere accumulates (or "piles up") magnetic flux and plays an important role in developing the substorm current wedge. At Mercury, flow braking and flux pile-up in the near magnetotail remain open questions. We develop an automated algorithm to identify dipolarizations in the magnetic field, allowing for statistical examination of flow braking and flux pile-up. We find a significant decrease in dipolarization frequency associated with the inner edge of the plasma sheet (Figure 1), indicative of braking. Dipolarizations inside this boundary exhibit prolonged statistical flux pile-up. However, due to the close proximity of the plasma sheet to Mercury's surface, we estimate ~20% of dipolarizations may impact the planet, generating substantial plasma deposition to the nightside surface. The existence of flow braking and flux pile-up at Mercury suggests a current wedge may form. The possible impacts of the shorter substorm timescales at Mercury and the smaller height-integrated electrical conductance provided by Mercury's crust and iron core relative to Earth's ionosphere will be discussed.

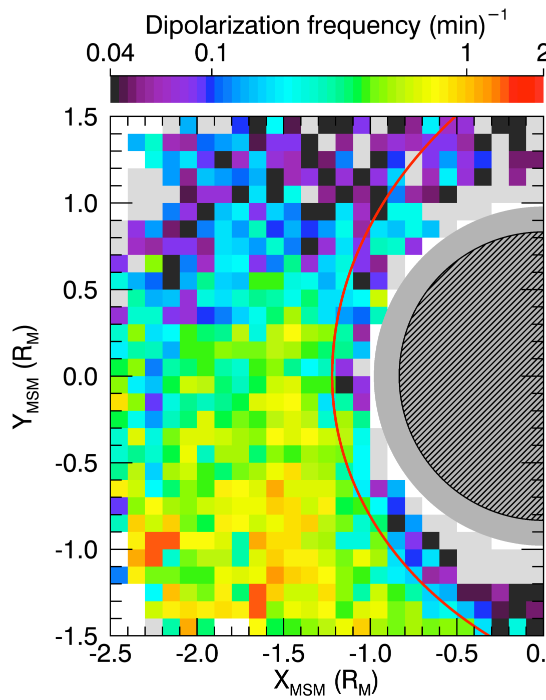

Figure 1: Spatial frequency of dipolarizations near the magnetic equator. White indicates regions with insufficient spacecraft sampling; light grey indicates regions with sufficient sampling but no observed dipolarizations. The dark grey marks the nightside planetary surface, and the hashed region marks Mercury's conducting core. The red line marks the typical inner edge of the plasma sheet.