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MESSENGER Observations of Showers of Flux Transfer Events at Mercury

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1. Introduction

The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft entered orbit about Mercury on March 18, 2011 [1]. Mercury's magnetic field is dipolar and possesses the same polarity as that of Earth [2,3]. Magnetic reconnection occurs at the magnetopause when there is a component of the interplanetary magnetic field opposite to that of the magnetospheric field, but at a markedly faster rate than at Earth, probably due to the stronger interplanetary magnetic field (IMF) in the inner solar system [4].

Reconnection at the dayside magnetopause and near the magnetic cusps at Earth often connects well-defined, discrete bundles of planetary magnetic flux to the IMF. These flux transfer events (FTEs) contribute to the transfer of magnetic field from the dayside magnetosphere to the magnetotail, which drives convection in Earth-like magnetospheres. Such events are identified primarily by their characteristic magnetic flux-rope topology with the cylindrical outer wraps compressing the axial core fields [5]. FTEs at Mercury were first reported in the Mariner 10 flyby observations [6]. MESSENGER flyby magnetic field measurements yielded many more examples of FTEs and led to the determination that their relative magnetic flux content was much greater than at Earth [7].

Here we present an initial survey of flux transfer events at Mercury using magnetic field and plasma measurements from the orbital phase of the MESSENGER mission.

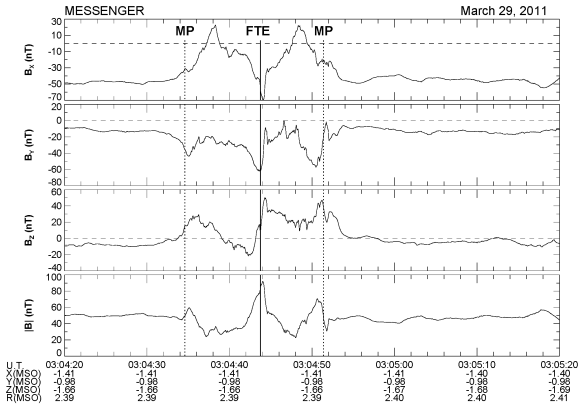

Figure 1. Magnetic field measurements of a ~ 2-s-long FTE (dark vertical line) with flux rope topology on March 29, 2011. The magnetic field and spacecraft position data are displayed in Mercury solar orbital (MSO) coordinates. X_{MSO} is directed from the center of the planet toward the Sun, Z_{MSO} is normal to Mercury's orbital plane and positive toward the north celestial pole, and Y_{MSO} completes this right-handed orthogonal system. Dashed vertical lines mark the inner edge of the compression that moved the magnetopause (MP) inward and placed MESSENGER briefly in the magnetosheath.

2. Mercury Flux Transfer Event

An example of an FTE observed on March 29, 2011, just 30 s prior to MESSENGER exiting the southern lobe into the magnetosheath is displayed in Figure 1. MESSENGER started and ended the interval moving southward through the outer portion of the southern lobe of Mercury's magnetotail. As shown, a transient compression of the tail, almost certainly due to the FTE, caused the magnetopause to be displaced inward and briefly placed MESSENGER in the

magnetosheath between 03:04:34 and 03:04:52 UTC, where it encountered an FTE at 03:04:44 UTC. The FTE is identified by its clear flux-rope topology with bipolar B_Z and strong core field (peak intensity ~ 85 nT) in the B_X and B_Y components [*6,7*]. The duration of the FTE is ~ 2 s, which, for an assumed 400 km/s magnetosheath flow speed, implies a diameter of 800 km or 0.33 R_M (R_M = 2440 km). This FTE appears very similar to those observed in the equatorial magnetosheath during the MESSENGER flybys [*7*].

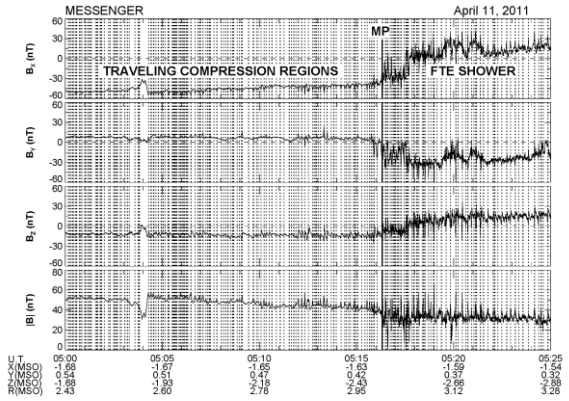

Figure 2. Magnetic field measurements over a 25 min interval spanning the outer portion of the southern lobe of Mercury's magnetotail, the magnetopause, and the nearby magnetosheath. Vertical dashed lines mark the TCRs and FTEs that occur every ~ 8 – 10 s.

3. April 11, 2011, FTE Shower

MESSENGER's orbit provides relatively long dwell times in the southern lobe of the magnetotail and the adjacent magnetosheath below and just downstream of Mercury. As an example, 25 min of magnetic field observations in the southern lobe and magnetosheath collected on April 11, 2011, are shown in Figure 2. The location of the magnetopause is marked with a heavy vertical line. In the magnetosheath, a series of 65 FTEs are identified with vertical dashed lines. Their durations are 1 - 2 s, and the mean time between events is 8.3 s. We term this extended interval of periodic FTE encounters an "FTE shower."

Remarkably, these FTEs were also clearly being sensed by MESSENGER in the tail lobe prior to the magnetopause crossing in the form of traveling compression regions (TCRs). TCRs are compressional perturbations in the magnetic field observed in the tail lobes. They are usually seen in relatively close proximity to the plasma sheet during plasmoid ejection [4]. However, TCRs have also been observed when the tail is compressed by short-duration enhancements of solar wind pressure, for example, as a result of small magnetic flux ropes embedded in the solar wind as it moves around the Earth's magnetosphere [8].

In Figure 2 a total of 96 ~ 2-s-long TCRs are identified in the MESSENGER magnetic field measurements prior crossing the magnetopause. The mean separation in time between events was 9.5 s, in close agreement with the magnetosheath FTE results. Hence, a total of 65 + 96 = 161 FTEs are inferred to have been generated during this single 25 min shower event at Mercury. Further analyses of the properties of the individual FTEs and the shower events observed during the first tail season of the MESSENGER mission is underway with a special emphasis on the role of these shower events on the magnetic flux transfer cycle and the access of solar wind ions to Mercury's surface.

References

[1] S. C. Solomon et al., MESSENGER mission overview, *Space Sci. Rev.*, *131*, 3–39, 2007.

[2] B. J. Anderson et al., The structure of Mercury's magnetic field from MESSENGER's first flyby, *Science 321*, 82–85, 2008.

[3] B. J. Anderson et al., The magnetic field of Mercury, *Space Sci. Rev.*, *152*, 307–339, 2010.

[4] J. A. Slavin et al., MESSENGER observations of magnetic reconnection in Mercury's magnetosphere, *Science*, *324*, 606–610, 2009.

[5] L. Trenchi et al., TC-1 observations of a flux rope: Generation by multiple X line reconnection, *J. Geophys. Res.*, *116*, A05202, doi:10.1029/2010JA015986, 2011.

[6] Russell, C. T., and R. J. Walker, Flux transfer events at Mercury, *J. Geophys. Res.*, *90*, 11,067–11,074, 1985.

[7] J. A. Slavin et al., MESSENGER observations of large flux transfer events at Mercury, *Geophys. Res. Lett.*, 37, L02105, doi:10.1029/2009GL041485, 2010.

[8] M. B. Moldwin, et al., On the origin of reverse polarity TCRs, *Geophys. Res. Lett*., *28*, 1925–1928, 2001.