Geophysical Research Abstracts
Vol. 17, EGU2015-2582, 2015
EGU General Assembly 2015

MESSENGER Observations of Cusp Plasma Filaments at Mercury

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The MESSENGER spacecraft, in orbit about Mercury, has documented highly localized, ∼1-2-s-long reductions in the dayside magnetospheric magnetic field of the planet with amplitudes up to 90% of the ambient intensity. These magnetic field depressions which we have termed cusp filaments are observed from just poleward of the magnetospheric cusp to mid-latitudes, i.e., from ∼55 to 85^{o}N. Minimum variance analysis and superposed epoch analysis of the Magnetometer (MAG) data indicate that the filaments are simple two dimensional flux tubes. If the filaments move over the spacecraft at the polar convection speed, then these filaments have a mean diameter of ∼230km, which is an order of magnitude larger than the gyro-radius of a 1 keV H^+ ion, i.e., ∼ 23 km. During these events, MESSENGER's Fast Imaging Plasma Spectrometer (FIPS) measured H^+ ions with magnetosheath-like energies consistent with the view that the magnetic field depressions are diamagnetic and most probably the low-altitude extensions of flux transfer events (FTEs) that form at the magnetopause as a result of reconnection. Here we analyze 349 filaments identified in MESSENGER magnetic field and plasma data to determine the physical properties of these structures. MESSENGER observations during the spacecraft's final low-altitude campaign confirm that these cusp filaments extend down to very low altitudes. We calculate an average particle precipitation rate onto the surface from all of the filaments at any given time of $\sim 2\text{x}10^{25}$ #s^{-1}. This precipitation rate is comparable to published estimates of the total precipitation rate in the cusp proper. The existence of these cusp filaments has important implications for surface sputtering and our understanding of Mercury's northern cusp. Overall, the MAG and FIPS observations analyzed here appear consistent with an origin for cusp plasma filaments by the inflow of magnetosheath plasma associated with the localized magnetopause reconnection process that produces FTEs at higher altitudes.