

Electrostatic Solitary Waves in the Martian Magnetosheath

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We report the first direct observations of electrostatic solitary waves in the Martian magnetosheath. These are observed as bipolar electric field pulses of ~ 0.0003 – 0.001 sec. duration with amplitudes ~ 1 – 10 mV/m by the Langmuir Probe and Waves (LPW) instrument onboard the Mars Atmosphere and Volatile EvolutionN (MAVEN) spacecraft. LPW has two Langmuir probes, which together are capable of measuring one component of the electric field from the potential difference along their separation. Observations of these bipolar electric field pulses occurs when there is a significant component of the magnetic field directed along the line of separation between the two Langmuir probes; consistent with these structures propagating along the magnetic field. The local plasma parameters at the time these structures are observed suggest, under the assumption that they are propagating at the ion acoustic speed in the frame of the plasma flow, that they have spatial scales of ~ 10 – 20 Debye lengths. These are the expected ion hole propagation speed and spatial size respectively. Scale size estimates using the electron thermal speed, at which they would propagate if they were electron holes, yields a spatial size of ~ 100 Debye lengths, which is an order of magnitude larger than would be expected. This consideration suggests that ion holes are a likely candidate to explain these bipolar electric field structures. In addition, these electrostatic solitary waves are observed to occur in association with large amplitude, lower frequency waves, that are left-handed polarized and have a frequency close to that of the local proton gyrofrequency in the spacecraft frame. These properties are similar to those of large amplitude, low frequency waves observed in the foreshock and upstream regions of the Martian space environment. It is thought that the latter waves in the upstream and foreshock region are due to a cyclotron resonance interaction between an ion beam in the solar wind frame, due to either pickup ions, or ions reflected from the Mars bow shock. Electrostatic solitary waves are also known to occur in association with ion beams, and so these phenomenon could be related through the particle populations that drive their generation.