A SECOND TOPSIDE IONOSPHERIC LAYER

The first report of a topside ionospheric layer was made by Gurnett et al. (2008). This study revealed that a layer regularly appeared at an altitude well above the 130-140 km altitude of the photoelectron peak. This “transient layer” was studied in detail by Kopf et al. (2008), who determined, among other things, that the layer:

• Is at an altitude near 200 km
• Has a density between 2 and 4 x 10^9 cm^-3
• Is seen more prominently at low solar zenith angles, away from the terminator

Due to the high-altitude orbit of Mars Express (MEX), no in situ measurements could be made, limiting the ability to define the structure and origin of the layer.

MAVEN allows for near-simultaneous measurements of the ionosphere with Mars Express. Their orbital paths cross twice per orbit, allowing for correlated observations of the ionosphere. In order to identify useful cross-references, a series of criteria were imposed:

• The orbits cross on the day side of Mars to allow for MEX-MARSIS observations.
• MAVEN is in the ionosphere, at an altitude less than 400 km.
• MARSIS is in ionospheric sounding mode, with MAVEN NGIMS measuring ions.

A few features do not fit the observations of this layer. A rotation is seen, depending on its position. The observations could be a result of how close MAVEN flew to any particular peak.

Some possible explanations:

• Kelvin-Helmholtz Instability – This process occurs where a velocity shear exists between two fluids or plasmas. However, cases analyzed so far show no conclusive evidence of any velocity gradient, and it is unclear why such a shear would exist at this altitude. MAVEN could observe this at several orientations at the same vortex, depending on its position. The observations could be a result of how close MAVEN flew to any particular peak.

• Flux Ropes – A few features do not fit the observations of this layer. A rotation is seen, as expected, but an axial field should also be present, causing an increase in magnetic field. MAVEN should observe a decrease in magnetic field. The reason for this is unclear.

• Magnetic Reconnection – The magnetism of this layer implies an interaction in the upper ionosphere. However, the current sheet alone does not directly imply reconnection. Plasma should be ejected at the Alfvén velocity following reconnection, but no discernable flow has been detected to date. Still, MAVEN is only able to observe flow within a limited angular field, so it could elude the instrument’s detection. It is possible that these are magnetized plasma parcels downstream from a more sub-thermal reconnection point.

• Magnetic Field Convection – The solar wind magnetic fields drape around Mars. Regions with different field orientations will form current layers between them. This layer will be transient, and most prevalent near the subsolar point. MAVEN Express, in a polar orbit, would frequently cross these draped field lines. However, this model suggests a horizontal current which is not consistent with our analysis. The solar wind field also may not rotate regularly enough, and on short enough time scales, to account for the MAVEN observations.

A CORRESPONDING CURRENT SHEET

Results from the magnetometer (MAG) aboard MAVEN revealed that the enhancement in the density was accompanied 88% of the time by a local minimum in the overall magnetic field magnitude coincides with the peak of the density enhancement in the middle panel. A rotation in the magnetic field, due to the varying components changing from a positive orientation to a negative one, or vice versa, indicates the presence of a current in this region.

KEY POINTS

1. MAVEN observed a transient peak in the density profile near 200 km altitude
2. This correlates with the upper layer discovered remotely in previous work
3. A current sheet associated with the second layer has been discovered

On October 2, 2015, the spacecraft observed nearly the same area of the ionosphere 15 minutes apart. The left panel shows remote sounding from MARSIS, which reveal the second layer to be a small change in the slope of the echo at 2 MHz. The right panel displays the density profile from in situ observations by NGIMS. This profile contains a peak in the density when MAVEN is at an altitude of about 190 km. This local density peak will call the magnetic ionospheric peak, which NGIMS approached at its perigee altitude of 145 km at 0:18:20 UTC, outside the time range of the figure.

REFERENCES and ACKNOWLEDGEMENTS


MAGSIS data are available through the Geosciences Node of NASA’s Planetary Data System (PDS) at http://pds-geosciences.wustl.edu. MAVEN data are available via the Planetary Plasma Interactions node of the PDS at http://ppl-pds.nasa.gov. We also wish to thank Majdi Mayasi and Mehdi Benna of the MAVEN team for fruitful discussions related to this research.