Asymmetric penetration of the shocked solar wind down to 400-km altitudes at Mars observed by Mars Global Surveyor

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Since Mars has no intrinsic global magnetic field, the solar wind can directly interact with the Martian upper atmosphere. It is thought that the solar wind encountering Mars can penetrate into the point where the solar wind dynamic pressure and the magnetic pressure due to the draped magnetic field around Mars are almost balanced and the shocked solar wind (magnetosheath) flow is deflected around the magnetic pile-up boundary (MPB). However, the actual interaction can be complicated because of the plasma processes and existence of crustal magnetic fields. It has been also pointed out that the crustal magnetic fields can locally push MPB upward and cause the asymmetric structure of MPB [e.g., Brain et al., 2003]. The Mars Global Surveyor (MGS) observations showed that MPB typically located at 800-1200 km altitudes in dayside [Crider et al., 2005]. However, this boundary location can change significantly depending on solar wind conditions. Previous studies indicate that the solar wind can penetrate into lower altitudes than usual when the solar wind pressure is high [Brain et al., 2005]. While Brain et al. [2005] also shows that the penetration of the solar wind depends on the solar wind dynamic pressure, IMF direction and season, the mechanism to cause the observed dependences is not yet well understood.

In this study, we focused on penetration of the magnetosheath, down to 400-km altitude at Mars. We used data from the MGS mapping orbits from April 1999 to November 2006, when the spacecraft was in a nearly circular orbit at ~400 km altitudes. The mapping orbit is a polar orbit fixed in the local time at 2 am/pm, and the spacecraft orbital period is roughly two hours. When MGS passed through the magnetosheath region, fluctuations of the magnetic field and the high-energy electron flux were increased [e.g., Crider et al., 2005]. Thus, we first selected the time intervals when the power spectral density of the magnetic field fluctuation above 0.1Hz was higher than $1000nT^2$/Hz, and the differential electron flux above 400eV was greater than $5*10^4$/cm*s*sr*eV. Then, we eliminated inappropriate events such as the plasma sheet crossings by inspection. We identified 244 events for the period of interest. We used both the solar wind proxy data by Brain et al. [2006] and the time-shifted ACE data to infer the solar wind sector polarity at Mars. The results of statistical analysis show that the solar wind penetration events tend to be observed during high solar wind dynamic pressure period, and it is consistent with previous study by Brain et al. [2005]. During the low solar wind dynamic pressure period, locations of the solar wind penetration tend to be distributed in the northern hemisphere where the crustal magnetic field is weak. A remarkable point is that the observation probability of the penetration is more than 2 times larger under the away IMF sector condition than that under the toward IMF sector condition. It implies that the penetrations more often occur in the upward electric field (E) hemisphere than in the downward E hemisphere. We will also discuss the possible mechanism to cause the asymmetric penetration, and the Kelvin-Helmholtz (K-H) instability is one of candidate processes to cause the penetration during low solar wind dynamic pressure period.

References:

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