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Variation of the Martian Ionosphere from Mars Express Ionospheric Sounding

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In its five years of operation, the MARSIS ionospheric sounder on board the Mars Express spacecraft has collected a large data set concerned with variations in the Martian ionosphere. In this paper, we shall review three separate topics addressed by these data.

The Martian ionopause, similar to the ionopause at Venus, has been detected and studied using two methods available to MARSIS. In addition to direct detection using the local electron density, the ionopause is occasionally clearly visible is the remote sounding data as a distinct shelf-like structure. We have shown that the ionopause at Mars definitely exists but sporadically and less frequently than at Venus.

The second topic to be presented is a multi-instrument detection of flux ropes at Mars. MARSIS is able to detect spacecraft-local magnetic fields when Mars Express is at altitudes below the magnetic pileup boundary. In two cases where the orbit of Mars Express closely coincides with that of Mars Global Surveyor (MGS), a strong magnetic field strength has been observed in the MARSIS data in regions where effects of the crustal magnetic fields are not expected. The MGS magnetometer data have been analyzed by the minimum variance technique to show that the magnetic field rotates in a manner characteristic of a magnetic flux rope. These data have been analyzed together to extract the motion of the flux rope.

The third topic is the detection of an enhanced state of fluctuation of the Martian ionosphere in the region near the planetary terminator in regions of strong crustal magnetization. These measurements are based on the ionospheric traces that are the principal product of the MARSIS ionospheric sounder. The variance of the motion of the ionosphere has been computed for approximately 40,000 times during nearly 500 orbits and mapped on the sunward face of Mars. We have found that the enhanced fluctuations show a moderate increase when the solar wind pressure is high and when the solar wind and crustal magnetic fields are oppositely directed. The latter condition suggests that magnetic reconnection may be involved in these near-terminator ionospheric fluctuations.