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Martian ionosphere observed by MARSIS: identification of plasma origin

Frantisek Nemec (1), David D. Morgan (2), Donald A. Gurnett (2), Firdevs Duru (2), and David A. Brain (3)

(1) Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic, (2) Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa, USA, (3) Space Science Laboratory, University of California, Berkeley, California, USA

Radar soundings performed by the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) on board the Mars Express Spacecraft provide us with topside traces of the Martian ionosphere. By inverting these traces, we obtain profiles of electron density from the satellite altitude down to the altitude of peak ionospheric electron density. The electron densities are analyzed as a function of several key controlling parameters, namely: solar zenith angle (SZA), altitude and geographic location (or crustal magnetic field configuration, respectively). This allows us to distinguish between three different plasma source mechanisms: i) direct ionization by solar radiation, ii) plasma transport, iii) ionization by precipitating electrons. The relative importance of these mechanisms in various ionospheric regions is evaluated and discussed.

It is shown that while the low altitude region of the dayside ionosphere is controlled by direct solar radiation and can be roughly described by the Chapman profile, the high altitude region of the dayside ionosphere is controlled by plasma transport from lower altitudes. Electron densities in this region decrease exponentially with increasing altitude. Concerning the nightside ionosphere, the configuration of crustal magnetic fields is shown to be the main controlling parameter. Isolated patches of enhanced ionization are observed in regions with open field line configuration due to ionization by precipitating electrons. An overall picture of the Martian ionosphere as deduced from the up-to-date MARSIS data set is presented.