Ionospheric and Atmospheric Outflow from Mars: Identification of Major Plasma Energization Mechanisms

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The escape of the upper ionized atmosphere of Mars has an impact on the evolution of the planet. A number of escape processes have been suggested to explain the removal of volatiles such as H_2O and CO_2 from the surface and atmosphere of Mars. The upper Martian atmosphere is in the plasma state due to ionization by solar UV radiation (and associated secondary electrons) and the impacts of accelerated charged particles. Mars has no significant internal magnetic field that globally protects its atmosphere. In situ observations by the ESA Mars Express spacecraft together with earlier observations show an ion outflow that on geological time-scales can be very significant. Recent observations also show that the solar wind can reach down to low altitudes of a few hundred kilometers. However, very few in situ observations are available to identify the plasma energization mechanisms causing the outflow of ionospheric ions. Different processes have been suggested to explain the energization of the planetary ions, including direct solar wind momentum transfer, acceleration by an externally applied solar wind electric field and different types of wave activity at low altitude. We discuss how a small but complete plasma instrument package with instruments to observe ions, electrons and electric and magnetic fields up to reasonably high frequencies can be used to identify various energization mechanisms. Such an instrument package has been suggested for the Mars Orbiting Plasma Surveyor (MOPS) spacecraft.