Calculation of ionization efficiency in the Martian dayside ionosphere: modelling using MAVEN observations

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Ionospheric photoelectrons play an important role in determining the structureof the planetary ionosphereand thermosphere as they contribute to various processes such as heating the thermal electrons, generating airglow emissions, and ionizing the major constituents of the atmosphere. Detailed calculations of the photoelectronflux spectrum are laborious since it involves energetic electron propagation through the background neutral atmosphere and subsequent electron impact. Hence it is a common practice to avoid calculating the photoelectron flux and simply estimate the photoelectron impact ionization rate as a fixed percentageof the photoionization rate. Ionization efficiency is defined as the ratio between electron impact ion production rates and the photon impact ion production rates.

A recent study by Cui et al [1], calculated the ionization efficiency curve for Martian dayside ionosphere by combining the Mars Atmosphere Volatile Evolution Mission (MAVEN) measurements of neutral atmospheric density, solar EUV/X-ray flux, and differential photoelectron intensity measured during 240 nominal orbits. The study calculated the ionization efficiency for the altitude range 160-250 km and obtained a constant ionization efficiency of 0.19 for CO2 and 0.27 for O. The nominal MAVEN orbits usually have periapsis at ~160 km and hence the behaviour of ionization efficiency towards the ionospheric peak is not discussed.

The current study aims at calculating the ionization efficiency for Martian dayside ionospheric peak region by using MAVEN Deep Dip (DD) campaign observations during which the periapsis gets lowered to 120–130 km so that the measurements near the ionospheric peak could be made. Our model suggests an ionization efficiency of ~0.35 for CO2 and ~0.6 for O at altitudes ~125-130 km. At 160 km, the model calculated ionization efficiency for CO2 (O) is 30% (70%) larger than the values of Cui [1] which primarily occur due to the difference between the modeled and the measured photoelectron flux. While the observations suggested a constant value for ionization efficiency for the entire altitude range, our calculations shows that ionization efficiency should have an increasing trend as we go deeper towards the ionospheric peak. This trend is consistent with the previous modelling studies for different planetary atmospheres that suggests an increase in the electron impact ionization rates towards the ionospheric peak [2][3][4].

References:[1] Cui et al (2018), *ApJL, 857:L18* . [2] Richards and Torr (1988), *JGR, 93(A5), 4060-4066* [3] Galand et al (2009), JGR, 114, A06313 [4]Nicholson et al (2009), MNRAS, 400, 369–382.