Study of proton escape from Mars based on MAVEN observations

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Mars is considered to have had water on surface in ancient days, while there is no surface water at present. Escape of atmospheric gases to space is considered to play an important role in this climate change. Especially, hydrogen loss has substantially affected the water content on Mars. Its main mechanism is thought to be Jeans escape of hydrogen atoms. Hydrogen molecules, which are sourced from odd-hydrogen reactions with near-surface water vapour, diffuse to the upper atmosphere. Some of them are dissociated, diffuses to the exobase as hydrogen atoms and escape. Since this molecular hydrogen is long-lived, the seasonal variation of neutral hydrogen escape is predicted to be typically less than a factor of two (Krasnopolsky, 2006). However, Halekas (2017) provided quantitative estimates of the hydrogen exosphere for over one Mars year (MY), revealing about one order of magnitude seasonal changes in column density with a peak slightly after perihelion, approximately at the southern summer solstice. Lower atmospheric dynamics such as dust storms might be one cause of this peak. It was suggested by Heavens et al. (2018) that the transport of water vapour and ice to the middle atmosphere by deep convection in Martian dust storms can enhance hydrogen escape. Chaffin et al. (2017) suggested by using their photochemical model that hydrogen escape flux can increase by one order if there is water vapour in the middle atmosphere around 80km altitude.

If the Martian dust storms can enhance the hydrogen corona and escape by one order of magnitude, the proton escape sourced by neutral hydrogen will also increase. In order to assess the hypothesis, we will investigate proton escape from Mars based on MAVEN (Mars Atmosphere and Volatile EvolutioN) observations from November 2014 to March 2019. We will also investigate if the seasonal variation depends on size of the dust storms by comparing MY32, 33 and 34, since Martian global dust storm occurred only in MY34.

For this purpose, we implemented methods to separate planetary-origin protons from solar-origin protons. The separation methods utilize characteristics of phase space density (PSD) observed in investigated regions, i.e., solar wind, magnetosheath, and magnetotail wake, by STATIC (Supra Thermal and Thermal Ion Composition) instrument. For identification of each region, we used data from MAG (magnetometer) and SWIA (Solar Wind Ion Analyzer) onboard MAVEN. STATIC can measure ion distribution functions with energy and mass discrimination. In the magnetotail wake region, we divided the energy range in three parts: less than 20eV, between 20eV and 100eV, and greater than 100eV. The lowest energy one was assumed to be planetary protons. The result shows that planetary proton density in the wake region had a seasonal variability which was more than one order, while variations in MY32, 33 and 34 were similar. Therefore, it is thought that the size of dust storm does not affect proton escape in the magnetotail wake. The method to separate planetary protons from solar wind protons needs to be different from that in the wake region. In this study, we calculated partial moments of picked up protons originated from hydrogen corona to derive parameters of planetary protons in the solar wind and magnetosheath. The obtained variations of the planetary protons are compared with EUV flux at Mars as well as with dust storm activities in order to understand the cause of seasonal variations of protons.

References:

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