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D and H in the Upper Atmosphere of Mars

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Abstract

The atmosphere of Mars has been remotely sounded at Ultraviolet wavelengths using the NASA Mars Atmosphere and Volatile Evolution (MAVEN) mission [1]. A high-resolution echelle channel on board MAVEN, capable of resolving Lyman-α emissions of hydrogen and deuterium at 121.567 nm and 121.535 nm, respectively, has been used to measure emission brightness from these atomic species along the disk, limb and corona of Mars with unprecedented coverage. The remotely-sensed MAVEN observations have been consistently calibrated using Solar Wind Anisotropy (SWAN) instrument observations and model estimates of diffuse interplanetary H [2]. In situ and remote sensing measurements are collectively used in order to determine properties of H and D in the martian upper atmosphere. This presentation highlights the results of these efforts to date.

1. Introduction

A key scientific goal of the MAVEN mission is to understand water escape at Mars. One way to quantify this escape is to examine the ratio of D and H abundances in the upper atmosphere in order to examine the rate of preferential loss of the lighter to heavier isotopologue. The classical (pre-MAVEN) perception of H loss originates with the atomic and molecular photo-dissociated byproducts of water diffusing slowly (timescale of years) to higher altitudes where chemistry liberates atomic H and allows a population of those atoms to leave the planet's upper atmosphere via Jeans escape [3]. D undergoes similar processes as H but escapes at a slower rate due to its larger mass. Therefore, determining the properties of D and H in the upper atmosphere would improve our understanding of water escape rates, the water cycle, and ultimately, would help to constrain the amount of primordial water at the planet.

2. Summary of Variability Studies

MAVEN measurements of D and H brightness have been mapped across nearly two Mars Years. These measurements have shown that both D and H vary on multiple timescales, all of which are much faster than the classical theory suggests. Analysis of MAVEN echelle observations has revealed several trends in the D and H brightnesses. These variations are summarized below, in order of increasing timescale:

1) Lyman-α is a solar resonant scattering emission. Therefore, to first order, the brightness of this emission exhibits trends consistent with solar flux variability, such as solar zenith angle variations as well as periodic trends with a solar-rotation timescale (~28 days) [4, 5, 6].

2) Changes in Mars' orbital distance from the Sun triggers climate dynamics and seasonal dust storms that affect the water cycle and the flux of D and H atoms into the upper atmosphere. These lower-atmospheric processes vary with a seasonal and repeatable periodicity that affects the properties of H and D in the upper atmosphere with timescales of months [5].

3) Solar activity affects the flux of solar H Lyman-α that reaches Mars. Variations on this 11-year timescale are expected and seen throughout the MAVEN mission timeline [5]. Additional space weather events have been seen to trigger significant changes in the properties of D and H in the upper atmosphere of Mars, mainly through upper atmospheric heating [6].

In this presentation, the variations in D and H properties in the upper atmosphere of Mars, observed by MAVEN to date, are presented and put in context of variability of molecular water isotopologues lower in the atmosphere. Estimates of the escape rates are made. These results will be significant for complementary lower atmospheric studies by TGO and will improve our understanding of historic water escape at Mars.

References

[1] Jakosky, B. (2015). MAVEN explores the Martian upper atmosphere. *Science*, 350(6261), 643.

[2] Mayyasi, M., Clarke, J., Quénerais, E., Katushkina, O., Bhattacharyya, D., Chaufray, J.-Y., …Jakosky, B. (2017). IUVS echelle-mode observations of interplanetary hydrogen: Standard for calibration and reference for cavity variations between Earth and Mars during MAVEN cruise, J. Geophys. Res., 122, 2089–2105.

[3] Hunten, D. M. & McElroy, M. B. *J. Geophys. Res.*, 75, 5989–6001 (1970).

[4] Clarke, J. T., et al. (2017), Variability of D and H in the Martian upper atmosphere observed with the MAVEN IUVS echelle channel, *J. Geophys. Res.*, 122.

[5] Mayyasi, M., Clarke, J., Bhattacharyya, D., Deighan, J., Jain, S., Chaffin, M., … Jakosky, B. (2017), The variability of atmospheric deuterium brightness at Mars: Evidence for seasonal dependence., *J. Geophys. Res.*, 122.

[6] Mayyasi, M., J. Clarke, D. Bhattacharyya, A. Catalano, M., Benna, P. Mahaffy, …B. Jakosky (2018), Significant space weather impact on the escape of Hydrogen from Mars, *Geophys. Res. Lett.*, in press.