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Constraining the Water Production Rate and Impact on Mars' Ionosphere of Comet Siding Spring

M. Mayyasi* (1), J. Clarke (1,2), D. Bhattacharyya (1), M. Mendillo (1,2), M. Combi (3), N. Fougere (3), E. Quemerais (4), O. Katushkina (5), M. Benna (6), N. Schneider (7)
(1) Center for Space Physics, Boston University, MA, USA, (*previously, M. Matta, Email: majdm@bu.edu / Tel: +1-617-358-5128) (2) Department of Astronomy, Boston University, MA, USA, (3) AOSS, University of Michigan, MI, USA (4) LATMOS/IPSL, Guyancourt, France, (5) SRI/RAS, Moscow, Russia, (6) NASA GSFC, Greenbelt, MD, USA, (7) LASP, University of Colorado, CO, USA

Abstract

The approach of comet C/2013 A1 (Siding Spring) provided Mars with a unique opportunity for investigating how an Oort cloud comet coma interacts with a planet's atmosphere. Studies predicted a water production rate of ~10^{28} molecules/s [e.g., 1]. Here we present comet Hydrogen Lyman-α spectra measured with the high-resolution echelle mode of the Imaging Ultraviolet Spectrometer (IUVS) instrument on board the Mars Atmosphere and Volatile Evolution (MAVEN) mission. The comet H Lyman-α emissions are resolved from Mars H Lyman-α and so are used to calculate a water production rate using emissions exclusively from comet coma. These observations as well as those made by the Hubble Space Telescope (HST) of the extended Mars corona are used to constrain the amount of cometary water and subsequent atomic H flux on the ionosphere of Mars. The effects of H influx on the upper atmosphere and ionosphere of Mars are assessed using a fluid ionospheric model. Model results are compared with *in situ* ion density measurements made by the MAVEN Neutral Gas and Ion Mass Spectrometer (NGIMS) instrument.

1. Introduction

The MAVEN IUVS instrument obtained hydrogen Lyman-α spectra of comet Siding Spring and Mars' extended H corona. Low-resolution images were used to determine the water production rate of the comet [2]. These data were unable to resolve the combined contribution of H Lyman-α emissions from the Mars extended coma, interplanetary hydrogen (IPH), as well as cometary hydrogen. A recent analysis of high-resolution spectra, using calibrated data [3], measured by IUVS have shown that these three contributions can be separated, as shown in Figure 1, to determine a more accurate estimate of the observed water production rate, as well as to provide constraints on the H-producing photochemical reactions near the comet nucleus [4, 5].

A refined comet water production rate is derived using a Direct Simulation Monte Carlo Model [6, 7] that will be used to derive the H influx into the upper atmosphere of Mars, together with upper limits of this flux, derived from HST observations of the extended Mars corona and a Radiative Transfer model [8]. The perturbations due to increased concentration of neutral hydrogen in the martian atmosphere affect the chemical balance of the ionosphere [9]. These effects are simulated, as shown in Figure 2, to produce ionospheric density enhancements that are compared with NGIMS *in situ* measurements taken at the time of the comet closest approach to Mars.

2. Figures

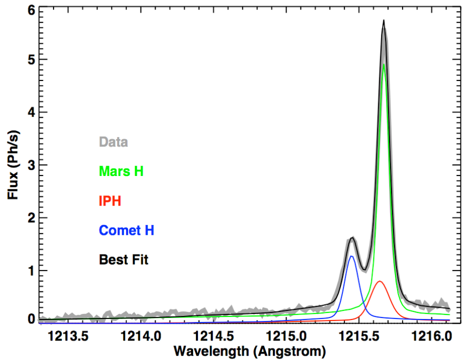

Figure 1: MAVEN IUVS echelle spectrum obtained by averaging over 70 high-resolution observations.

The spectrum (grey) shows separate contributions of Mars H (green), IPH (red), and comet H (blue) that are separated by Doppler shifts. A model based on Solar Wind Anisotropies (SWAN) instrument observations is used to optimize the fit to the IPH and remaining H contributions (black).

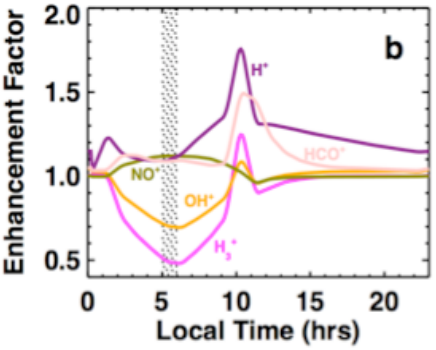

Figure 2: Preliminary estimates of the enhancement of ionospheric ions at Mars due to the influx of cometary hydrogen as a function of local time. The shaded vertical region indicates the time of closest approach of the comet to Mars. Enhancements and depletions of a few key hydrogenated ions are simulated using a fluid ionospheric model [10].

References

[1] Moores, J. E., T.H. McConnochie, D.W. Ming, P.D. Archer Jr., and A.C. Schuerger (2014), The Siding Spring cometary encounter with Mars: a natural experiment for the Martian atmosphere?, *Geophys. Res. Lett.*, 41, doi:10.1002/2014GL060610.

[2] Crismani, M. M. J., et al. (2015), Ultraviolet observations of the hydrogen coma of comet C/2013 A1 (Siding Spring) by MAVEN/IUVS, *Geophys. Res. Lett.*, *42*, 8803–8809, doi:10.1002/2015GL065290.

[3] Mayyasi, M., et al. (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. Space Physics, 122, doi:10.1002/ 2016JA023466.

[4] Combi, M., A. Reinrad, J.-L. Bertaux, E. Quemerais, T. Makinen (2000), SOHO/SWAN observations of the structure and evolution of the hydrogen Lyman-α coma o fcomet Hale-Bopp (1995 O1), *Icarus*, 144, 191-202, doi:10.1006/icar.1999.6335.

[5] Shinnaka et al (2017), Imaging Observations of the Hydrogen Coma of Comet 67P/Churyumov-Gerasimenko in 2015 September by the *PROCYON*/LAICA, *Astro. J.*, 153:76, doi:10.3847/1538-3881/153/2/76.

[6] Yelle, R., A. Mahieux, S. Morrison, V. Vuitton, and S. Hörst (2014), Perturbation of the Mars atmosphere by the near-collision with Comet C/2013 A1 (Siding Spring), *Icarus*, 237, p. 202 – 210.

[7] Tenishev, V., M. Combi, and B. Davidsson (2008), A global kinetic model for cometary comae: The evolution of the coma of the Rosetta target comet Churyumov-Gerasimenko throughout the mission, *Astrophys. J.*, *685*(1), 659.

[8] D. Bhattacharyya, J. Clarke, J.-L. Bertaux, J.-Y. Chaufray, M. Mayyasi (2017), Analysis and modeling of remote observations of the martian hydrogen exosphere, *Icarus*, 281, 264-280.

[9] Matta, M., P. Withers, M. Mendillo (2013), The composition of Mars' topside ionosphere: effects of hydrogen, *J. Geophys. Res.* 118, p. 2681 – 2693, doi: 10.1002/jgra.50104

[10] Matta, M. M., Modeling the Martian ionosphere (2013), Ph.D. Thesis, Boston University, Boston, MA