EPSC Abstracts
Vol. 10, EPSC2015-751, 2015
European Planetary Science Congress 2015

Initial Results from the MAVEN IUVS Echelle

J.T. Clarke (1), M. Matta (1), W. McClintock (2), N. Schneider (2), J. Deighan (2), I. Stewart (2), G. Holsclaw (2), and B. Jakosky (2)
(1) Center for Space Physics, Boston University, USA, (2) LASP, University of Colorado, USA (jclarke@bu.edu / Fax: +01-617-353-6463)

Abstract

This presentation will give the present status and early results of the echelle channel in the IUVS instrument on the MAVEN spacecraft at Mars. The channel studies H, D, and O in the upper atmosphere of Mars at high spectral resolution (0.008 nm). One primary goal is to study the ratio of D/H in the martian upper atmosphere, and determine the underlying principles that control the escape of H and D into space, with relevance to the historic escape of water from Mars. Initial data indicate that the echelle channel is working well, and we detected the D emission in the first observation of the sunlit disc of Mars.

1. Introduction

The IUVS instrument on MAVEN contains the first echelle spectrograph to be sent to another planet. The system has a novel optical design to enable long-aperture measurements of emission lines in the absence of continuum emission, intended primarily to measure the H and D Ly α emission lines and thereby the D/H ratio from the martian upper atmosphere [1]. The design provides for higher photon counting rates by observing through the long aperture, while maintaining the high spectral resolution in the narrow direction of the aperture. The system also detects the OI 1304 triplet emission with the three component lines well resolved. The echelle system obtains altitude profiles of these emissions every fourth MAVEN orbit, with data both outbound and inbound looking at a constant look direction that scans the atmosphere in altitude. The echelle spectrum is recorded using the same FUV microchannel plate detector as the low resolution IUVS system, and emission lines appear diffusely filling a 1.6 x 0.1 degree aperture (Figure 1) with a spectral resolution of 0.008 nm.

2. Scientific Goals

The main scientific goal of the echelle channel is to measure H and D Ly α emissions from resonantly scattered solar emission, and from these data derive the D/H ratio of the martian upper atmosphere. The ratio HDO / H_2O is roughly 5-10 times higher than in the terrestrial atmosphere. This has been interpreted as being due to the escape of a large volume of water into space, likely early in the history of Mars [2,3]. Since H atoms escape faster than D atoms, the D/H ratio increases with time as more water is lost [4]. There are a number of caveats to this interpretation, including uncertainties in the diffusion of H and D atoms to the upper atmosphere, and different condensation and photodissociation rates of H_2O compared with HDO. MAVEN measurements are intended to determine the average ratio, and any changes with location or season on Mars, to provide a detailed understanding of the physical principles of the escape of both species. This study has gained new importance with the detection of an apparently changing ratio of HDO / H_2O in the lower atmosphere with latitude and season on Mars [5], which implies that the isotopic ratios of different reservoirs of water differ from location to location, perhaps from the poles to the equator.

The derivation of the D/H ratio from brightness measurements requires the use of a radiative transfer model, since the H line is optically thick while the D line is optically thin. The D line exhibits limb brightening, and the effective altitude of the peak can also in principle be used to determine the altitude of the homopause. The OI 1304 triplet line ratio will provide information about both the optical depth of the O line of sight column, and also the contribution of photoelectron excitation to the total emission. Early results from the echelle channel will be presented.

3. Figures

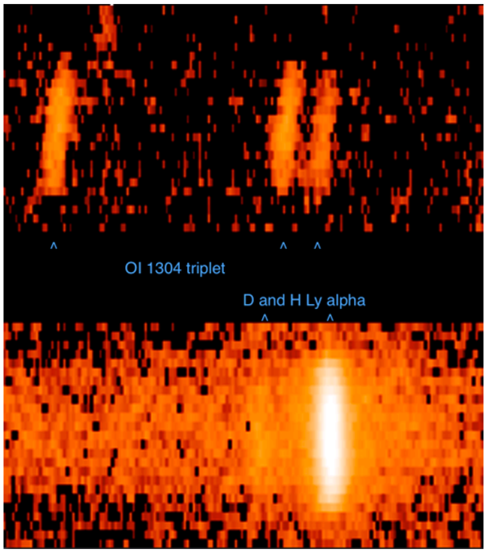

Figure 1: Detector image of the H and D lines (below) and the OI triplet (above) resolved into images of the aperture. The H and D lines (separation 0.033 nm) are well separated by the 0.008 nm resolution of the instrument, however the D line is much fainter and requires a longer integration time to detect.

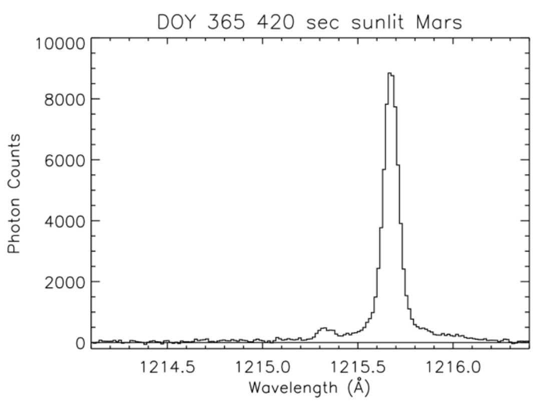

Figure 2: Reduced spectrum of the H (121.567 nm) and D (121.533 nm) lines from the observation in Figure 1, with a 420 sec exposure looking down on the sunlit martian disc. The extended wings on the H line are due to grating scatter.

Acknowledgements

We acknowledge the contributions of the whole MAVEN IUVS team, including the science team, the engineering support staff, and all the people who worked on the MAVEN mission. This research has been supported by NASA sub-contract 1543375 from LASP to Boston University.

References

[1] McClintock, W.E. et al. (2014) *Sp. Sci. Rev.* doi:10.1007/s11214-014-0098-7.

[2] Owen, T., in *Mars,* ed. H. Keiffer *et al.,* Univ. of Arizona Press, 818-833

[3] Krasnopolsky, V., M. Mumma, and R. Gladstone [1998], *Science, 280*, 1576-1580

[4] Yung, Y.L. and D. Kass, (1999) *Science, 280,* 1545-1546.

[5] Villanueva, G. *et al.* [2015], *Science*, 10.1126/science.aaa3630.