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Analysing the Martian Atmosphere with the O 130.4 and 135.6 nm emissions observed by MAVEN/IUVS

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Abstract

We analyze limb observations of dayglow emissions from atomic oxygen in the Martian thermosphere and present highlights of the results. The data has been collected over two Martian years with the IUVS instrument on board the MAVEN spacecraft.

1. Introduction

Photodissociation of CO_2 produces neutral atomic oxygen, which then supersedes CO_2 as the most abundant neutral species above 200 km and up to the lower exosphere. It plays a major role in the control of the thermal structure of the Martian atmosphere and is used as an indicator of the thermospheric circulation. We focus in our study on the $O(^3S)$ and the $O(^5S)$ excited states that emit line multiplets at 130.4 nm and 135.6 nm, respectively. The 130.4 nm emission is optically thick as it is mainly produced by resonance scattering from the solar oxygen 130.4 nm line. Both emissions are furthermore produced by photoelectron impact on O and to a small fraction also by photoelectron impact on CO_2. Other processes are negligible, but absorption by CO_2 plays a major role for the observed limb peak intensities and altitudes.

Almost two Martian years of oxygen dayglow observed by the Imaging Ultraviolet Spectrograph (IUVS, [1]) onboard the Mars Atmosphere and Volatile EvolutioN mission (MAVEN, [2]) spacecraft are now available. The collected data show a strong variability of the two oxygen multiplets with respect to Martian season and solar zenith angle (SZA) [3].

In this presentation, we investigate individual time periods (e.g. dusty season on Mars) in more detail and present the most significant results. Furthermore, a direct comparison with mass spectrometer data is foreseen.

2. IUVS Observations

IUVS started collecting data in end of 2014 and continues to operate up to now. The instrument is capable of observing the Martian upper atmosphere within a total spectral range of 115-340 nm and operates in limb, coronal scan and disc mode. Figure 1(a) shows a spectrum of the Far-UV (FUV) channel taken in limb mode and panel (b) shows the corresponding limb profiles of the emissions at 130.4 and 135.6 nm. Up to now, the observations cover two full Martian years and provide an unprecedented dataset covering various latitude and local time ranges per epoch. We present analysis of periapsis limb observations with tangent point altitudes between 80 and 200 km using data provided by the NASA Planetary Data System (PDS).

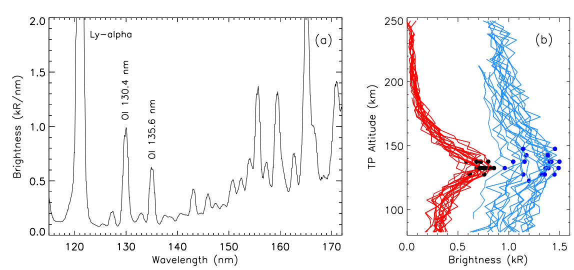

Figure 1: (a) IUVS FUV spectrum, averaged from 19 individual limb scans (shown in panel b) between 120 and 140 km tangent point (TP) altitude. (b) Limb scans at 130.4 nm are shown in blue and at 135.6 nm in red.

3. Methodology

The creation of mean profiles (Fig. 2) for narrow ranges of observational parameters (i.e. L_S, SZA/ local time, latitude) allows characterizing the emission behavior in a meaningful way. The full dataset will be binned into 'pixels' of $5°_{Ls} \times 10°_{lat}$ and peak brightness, the corresponding altitude and scale heights will be fitted.

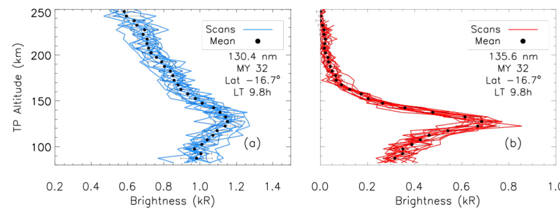

Figure 2: Mean profiles (black dots) built from several individual limb scans for a given range of observational parameters. The black horizontal bars indicate the 1-sigma variation of the dataset. Panel (a) shows 130.4 nm, panel (b) 135.6 nm.

We use in situ solar flux measurements from the Extreme UV Monitor (EUVM, [4]) on board MAVEN to remove the direct solar influence to the brightness of the two oxygen multiplets The variations in the solar flux explain the variation in the brightness only to 70 to 80%, while the remaining variation is due to changes in the atmospheric structure [3].

4. Results

The O 130.4 nm and 135.6 nm lines are strongly correlated in their peak brightness and peak brightness altitude [3]. Especially the altitude follows the Martian season (Fig. 3) as the atmosphere expands during Perihelion during Martian Southern summer around L_S = 250°. This also falls into the dust storm period, which is of particular interest as the atmospheric behavior during this time is not yet well understood and models have difficulties to reproduce it (e.g. [5]).

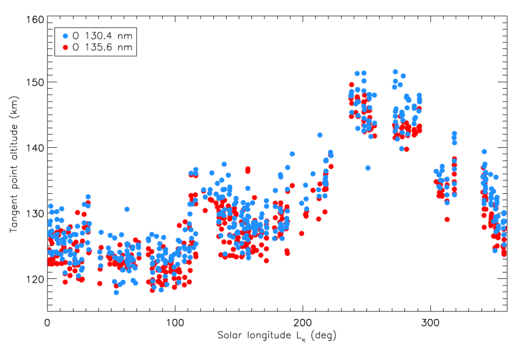

Figure 3: The behavior of the peak brightness altitude as a function of Martian season (solar longitude L_S). The altitude is the fit of the mean profiles.

MAVEN also carries the neutral gas and ion spectrometer NGIMS [6] analyzing neutrals and ions in the upper atmosphere and exosphere. During Deep Dip campaigns (e.g. [7] and references therein), the spacecraft occasionally approaches Mars down to the lower thermosphere and NGIMS provides densities of several species, among them CO_2 and atomic oxygen. We will set the available NGIMS data of the Deep Dips performed on the dayside into context with contemporaneous IUVS measurements at 130.4 and 135.6 nm.

Acknowledgements

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