Mars UV-Visible dayside airglow observations and predictions for EXOMARS-TGO

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Introduction: Airglow observations have proven to be an efficient tool to probe composition and dynamics of planetary atmospheres. Several missions to Mars such as Mariners, Mars Express and MAVEN were equipped with ultraviolet spectrometers that probed the distribution of airglow intensity features in the spectral range extending from 120 to 340 nm. They have provided a wealth of information on several emissions arising from O, C and N excited atoms or CO, CO_2^+ and N_2 molecules. These, in turn, have been analyzed to provide thermospheric temperature, O densities, etc.

In particular, limb profiles from the SPICAM instrument on board Mars Express have used the topside scale height of the CO Cameron and CO_2^+ UV doublet to determine the dependence of their brightness [1,2] and the derived temperature [3] on solar activity. The IUVS spectrograph on board MAVEN has been collecting limb profiles of UV emissions for 2.5 years and temperatures in the thermosphere have been deduced from the airglow vertical intensity distribution [4]. A detailed Monte Carlo model has been developed to calculate the photoelectron contribution to the excitation of many of the UV and visible emissions observed so far in the Mars and Venus airglow [1,5].

With the upcoming science phase of the EXOMARS-TGO mission, it is expected that the ultraviolet-visible UVIS instrument will provide additional spectral coverage into the visible domain and be able to measure emissions not observed so far.

We will briefly summarize current knowledge about the Martian airglow based on past comparisons between observations and models. We will then review some of the new features that are expected from UVIS-NOMAD airglow observations.

Ultraviolet and visible airglow: The FUV and EUV features in the Mars dayglow spectrum are excited by different processes whose efficiency may depend on several factors:

- density of the target species
- solar EUV and X-Ray activity
- chemical composition
- vertical and large-scale horizontal transport processes

The UVIS-NOMAD instrument will obtain spectra in the 200-650 nm range with a spectral resolution of 1.5 nm. This region covers the OI $^1S \rightarrow ^1D$ forbidden emission at 297.2 nm, a fraction of the Cameron bands, the CO_2^+ UV doublet and FDB bands and additional transitions (Fig. 1). The CO_2^+ FDB bands are well within the UVIS range of sensitivity and their intensity is directly linked to the CO2 density (Fig. 2).

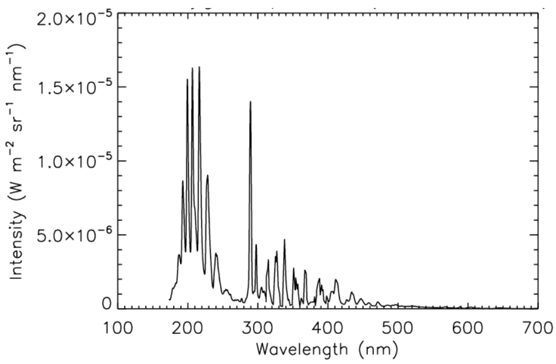

Figure 1: UV and visible limb spectrum of the Martian dayglow.

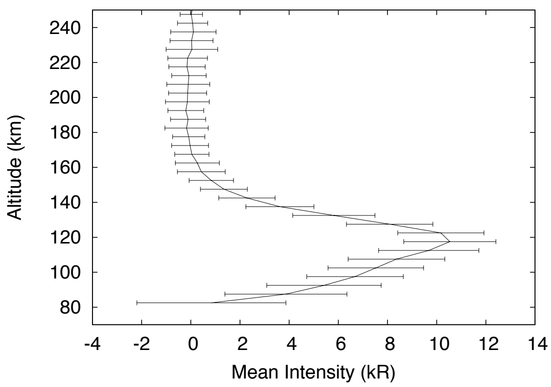

Figure 2: Limb profile of dayside CO_2^+ FDB bands observed with the IUVS-MAVEN instrument.

The OI 297.2 nm emission has the same common upper state as the auroral green line at 557.7 nm. It is approximatively 15-20 times less bright but offers the advantage of expected lower contamination from solar radiation. It was first detected with spectrometers on board the Mariner missions and is currently observed with the IUVS (MAVEN) spectrograph. O ^1S atoms are excited in the Mars dayglow by electron impact on O, photodissociation and electron impact dissociation of CO_2 and CO and dissociative recombination of O_2^+ ions.

Figure 3 presents estimates of the green line brightness and its variation based on the IUVS limb observations at 297.2 nm at different latitudes, seasons and local times.

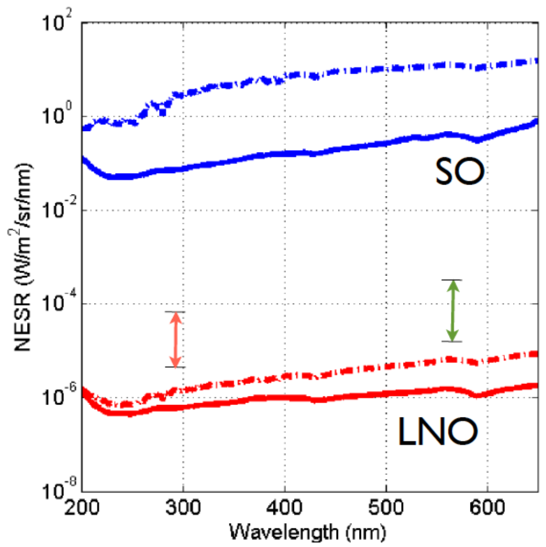

Figure 3: Observability by UVIS/NOMAD: NESR of the SO and LNO UVIS channels on board NOMAD. The arrows indicate the expected brightness level of the OI 297.2 and 557.7 nm dayglow emissions.

Model tools: A versatile airglow-aurora versatile Monte Carlo model has been developed over the years to calculate the nadir brightness and limb profiles of a series of spectral features of the terrestrial, Jupiter, Saturn, Venus and Mars atmospheres. The energy spectrum of the photoelectrons is calculated at fixed grid points and, in a second step, is folded with electron impact excitation cross sections to derive the corresponding excitation rate. The production from these collisional processes are combined with other solar-induced or photochemical sources to obtain the total volume production rates. In the case of an optically thick emission a radiative transfer code is used to calculate the emerging nadir or limb intensity.

Figure 4 shows a calculated limb profile of the CO_2^+ UV doublet emission produced by photoelectron impact and photoionization of CO_2.

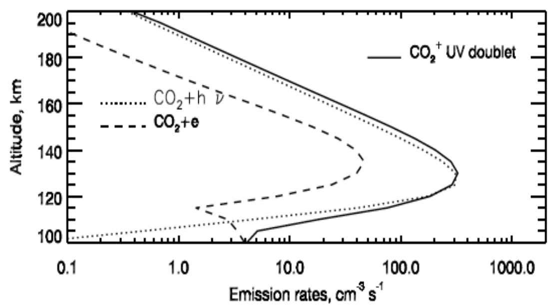

Figure 4: Calculated volume emision rate of the CO_2^+ UV doublet dayglow [1].

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