MORPHOLOGY OF EUV AND FUV MARTIAN AIRGLOW EMISSIONS OBSERVED BY THE EMUS INSTRUMENT ON BOARD THE EMIRATES MARS MISSION.

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Introduction

The spectroscopy of the Martian atmosphere in extreme and far-ultraviolet wavelengths has been extensively used to study planetary atmospheres. The FUV and EUV emissions provide information about the atmospheric composition (both neutral and ionized) and structure and can be used to study energy deposition, dynamics, and chemistry. The Emirates Mars Mission Ultraviolet Spectrometer (EMM/EMUS) is the first instrument capable of simultaneously observing the EUV and FUV emissions in the Martian upper atmosphere (*Holsclaw et al.*, 2021). Due to the large and unique orbit (55 hours elliptical orbit) of the EMM spacecraft around Mars, The EMUS disk observations cover the majority of temporal (dayside local hours) and spatial (latitudes and longitude) conditions in a relatively small-time scale (in few weeks of observations) (*Holsclaw et al.*, 2021; *Almatroushi et al.*, 2021). These disk observations of Mars in the EUV and FUV wavelength regions are enabling us to understand the global scale variations in the upper atmosphere. Figure 1 shows the average spectrum from EMUS SYS15 observations. This paper present a detailed analysis of global and local variations in the state of the upper atmosphere and airglow emissions (EUV and FUV) observed by the EMUS instrument. The FUV spectrum is dominated by CO fourth positive group band system along with the brightest atomic emissions of H Ly-α and O I 130.4 nm. The EUV wavelength region of the spectrum is mostly dominated by atomic emissions from atomic hydrogen, argon, nitrogen, and oxygen along with Hopefield-Birge band system of CO. The EMUS observations are consistent with previous observations of Mars in the EUV and FUV wavelengths (*Feldman et al.*, 2000; *Krasnopolsky and Feldman*, 2002, cf. Figure 1).

Data

In this analysis, we have used disk observations from EMUS UOS-1 and UOS-2 (*Holsclaw et al.*, 2021). Both types of observations provide coverage across latitude, longitude and local time. For the present analysis, we have taken data limited to the SZA less 60 and emission angles less than 70 degrees. We have used level2b which uses the Poisson multiple linear regression approach to reduce the spectral data into the radiance of various EUV and FUV emissions. We used data from the start of the nominal science of the EMM.

Observations and Results

In the present analysis, we have used the averaged disk brightness to understand the spatial and temporal variations in the major EUV and FUV emissions. Figure 2 shows the average daily brightness for various emissions in FUV (C I 156.1 nm, O I 135.6 nm, OI 130.4 nm, and H I 121.6 nm) and EUV (Ar 106.6 nm, CO HB: C-X; B-X bands). The figure also showed normalized Lyman alpha irradiance measured by Extreme Ultraviolet (EUV) Monitor aboard the MAVEN (*Eparvier et al.*, 2015). From the start of nominal science observations until 15 Sept 2021 (hereafter, the first time period) the average disk brightness didn't show significant variations that are in line with low solar activity during this time period (please see Figure2-bottom panel). Between Dec 2021 and Feb 2022 (hereafter, the second time period), all the major EUV and FUV emissions start to show upward trends in the daily average disk brightness. During this time we also notice ramp up in the Lyman alpha irradiance measured by the EUVM instrument. We found that both the EUV and FUV emissions are correlated with the solar forcing, however, our analysis indicates that FUV emissions such as O I 135.6 nm show a slightly lower correlation with solar forcing compared to the EUV emissions (such as CO B-X and Ar 106.6 nm). We also found that the correlation between the solar EUV and OI 135.6 is lower during the first time period when the solar forcing was not that strong. This indicates that lower atmosphere coupling could be affecting the brightness of OI 135.6 via waves.

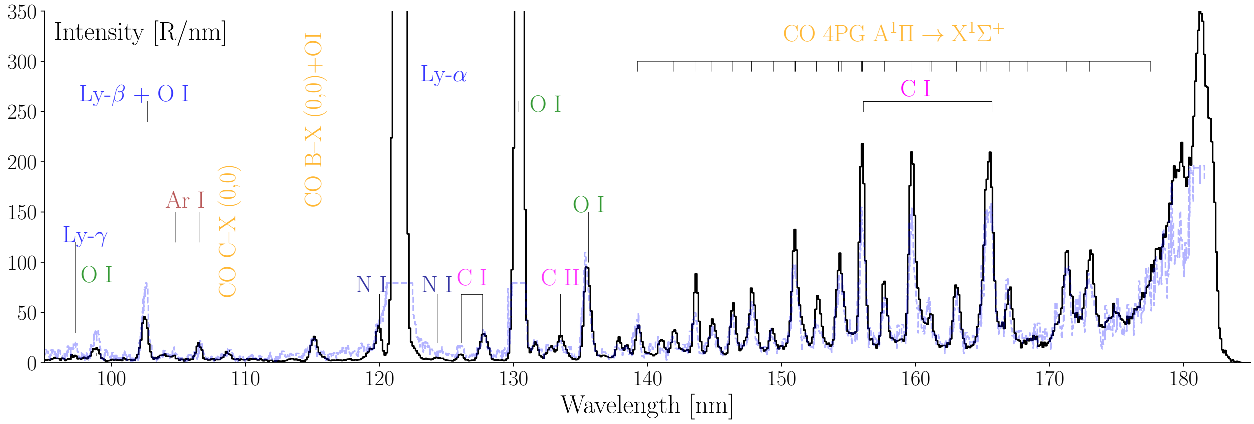

Figure 1: The figure shows the average EMUS EUV and FUV spectrum from EMUS SYS15 observations. The blue curve shows the disk observations taken from the Hopkins Ultraviolet Telescope (HUT) (*Feldman et al.*, 2000). The Lyman alpha and OI 130.4 nm were out of scale in the data provided in *Feldman et al.* (2000).

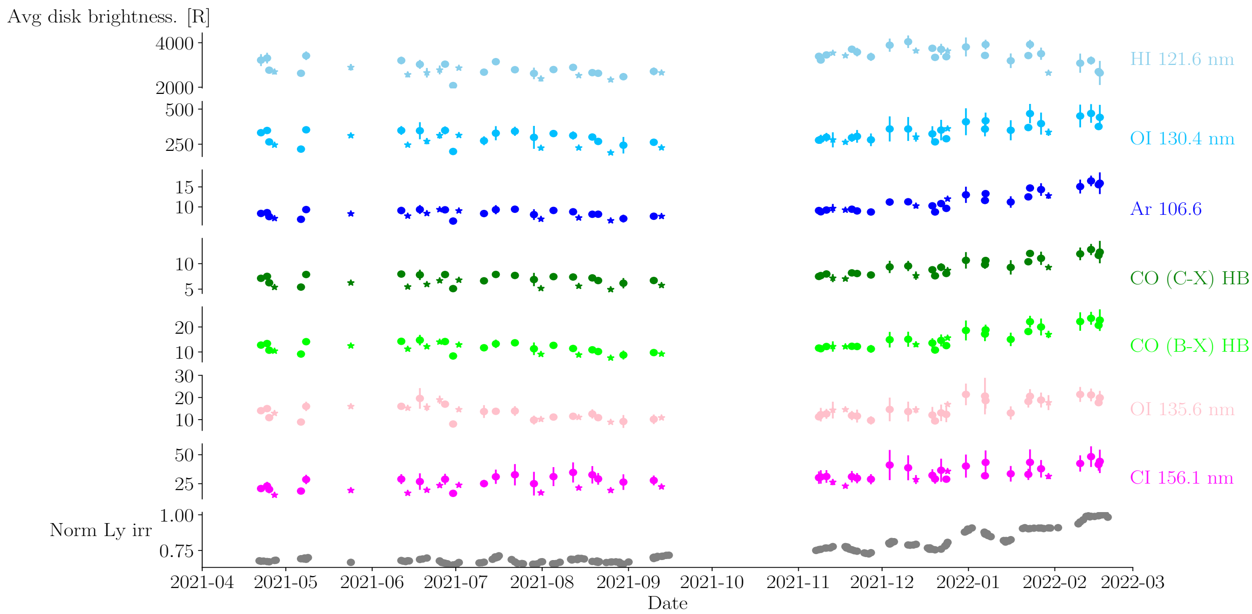

Figure 2: The daily average disk brightness for various emissions observed by EMUS instrument on board EMM. Solid star and circle symbols show average brightness from EMUS USO-1 and USO-2 observing mode. The geophysical variations are 1-σ standard deviation in the plots. Bottom panel shows normalized lyman alpha irradiance measured by EUVM monitor on board the MAVEN spacecraft.

References

Almatroushi, H., et al. (2021), Emirates Mars Mission Characterization of Mars Atmosphere Dynamics and Processes, *Space Sci. Rev.*, *217*(8), 89, doi:10.1007/s11214-021-00851-6.

Eparvier, F. G., P. C. Chamberlin, T. N. Woods, and E. M. B. Thiemann (2015), The Solar Extreme Ultraviolet Monitor for MAVEN, *Space Sci. Rev.*, *195*(1-4), 293–301, doi: 10.1007/s11214-015-0195-2.

Feldman, P. D., E. B. Burgh, S. T. Durrance, and A. F. Davidsen (2000), Far-ultraviolet spectroscopy of Venus and Mars at 4Å resolution with the Hopkins Ultraviolet Telescope on Astro-2, *Astrophys J.*, *538*, 395 – 400, doi:10.1086/309125.

Holsclaw, G. M., et al. (2021), The Emirates Mars Ultraviolet Spectrometer (EMUS) for the EMM Mission, *Space Sci. Rev.*, *217*(8), 79, doi:10.1007/s11214-021-00854-3.

Krasnopolsky, V. A., and P. D. Feldman (2002), Far Ultraviolet Spectrum of Mars, *Icarus*, *160*, 86 – 94, doi: 10.1006/icar.2002.6949.