EMIRATES MARS ULTRAVIOLET SPECTROMETER'S (EMUS) PREDICTION OF MARTIAN EUV DISK EMISSIONS.

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Introduction:

The Emirates Mars Ultraviolet Spectrometer (EMUS) is one of the three instruments to be launched by 2020 on-board Hope probe of the Emirates Mars Mission (EMM). EMUS is a far ultraviolet spectrometer designed to observe the spatial and temporal variability of key constituents in the Martian thermosphere (100-200 km altitude) and exosphere (>200 km altitude) on sub-seasonal timescales. EMUS will have a selectable spectral resolution of 1.3nm, 1.8nm, 5nm and a spectral range of 100 – 170 nm to make the required observations of ultraviolet emissions of Hydrogen (H), Oxygen (O), Carbon (C) and Carbon Monoxide (CO).

The objective of this work is (1) Educate our intuition about Martian EUV disk emissions in preparations to understand and interpret the EMUS generated data. That will be carried out by relying both on literature and theoretical modeling. (2) Predict characteristics of EUV emissions that the EMUS instrument is designed to detect to input into an EMUS simulator.

Methodology:

The process begins with theoretical models of the composition and structure of the Martian upper atmosphere, initially assuming a simple hydrostatic atmosphere and using the output of an existing Global Climate Models (GCM). Leading ultimately to estimating the expected brightness of spectral features in the EMUS bandpass.

EUV Emissions Extinction in the Martian Atmosphere:

It is important to know where in the atmosphere major EUV emission features originate and often a controlling factor is the altitude where CO_2 absorbs all the photons ($\tau = 1$) and the atmosphere appears black. To move forward with this work, Major EUV emissions [1] and high resolution CO_2 cross sections aligned at those wavelengths have been identified [2]. A hydrostatic atmosphere has been assumed with a CO_2 altitude and density referenced from the Neutral Gas and Ion Mass Spectrometer (NGIMS) of the Mars Atmosphere and Volatile EvolutioN (MAVEN) mission [3]. Inputting the following through a theoretical model, the altitudes in which EUV emissions are extinct have been calculated and displayed below.

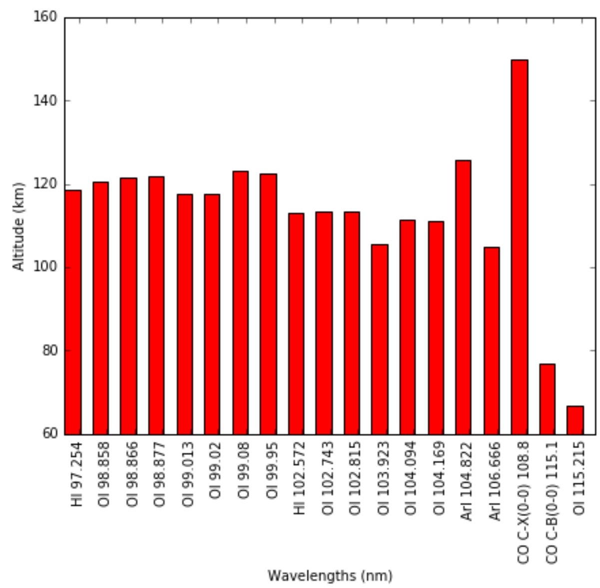

Figure 1: *Altitudes in which major EUV emissions go extinct due to CO_2 absorption for nadir viewing geometry.*

Atomic Argon Lines Analysis:

The first emission features to be examined are the two atomic Argon lines at 104.8 nm and 106.7 nm. These emission lines are optically thin providing a direct measure of Argon in the upper atmosphere. Argon, a noble gas, is photochemically inert with a close molecular weight of 40 g/mol to CO_2's 44 g/mol. Therefore, the Ar/CO_2 ratio in the upper atmosphere can offer a measure of transport from the lower atmosphere, which can be compared with Martian GCM predictions.

Firstly, based on NGIMS results at around the homopause ~130 km the Ar/CO_2 ratio is approximately 0.02 [3]. Using G-factors of 9.7e-8 and 7.0 e-8 photons/sec for Ar 104.8 nm and 106.6 nm respectively [1]; the brightness of Ar emission lines have been calculated accordingly.

λ (nm)	Pressure (Pa)	Brightness (R)
Ar 104.8	5.33E-05	3.8
Ar 106.6	2.10E-04	10.9

Table 1: *Argon Atomic Lines: Pressures at extinction and predicted brightness.*

To compare these results with the predictions of Le Laboratoire de Météorologie Dynamique's Global Climate Model (LMD GCM) [4] the pressures in Table 1, which are converted from the altitudes where the Ar lines go extinct, have been inputted into the model. In that, the conditions of Lon=0, Lat=All, Ls=0 (as this is the season where EMM is approximately planned to arrive) and Local Time=12:00 pm have been set to output Ar mixing ratios.

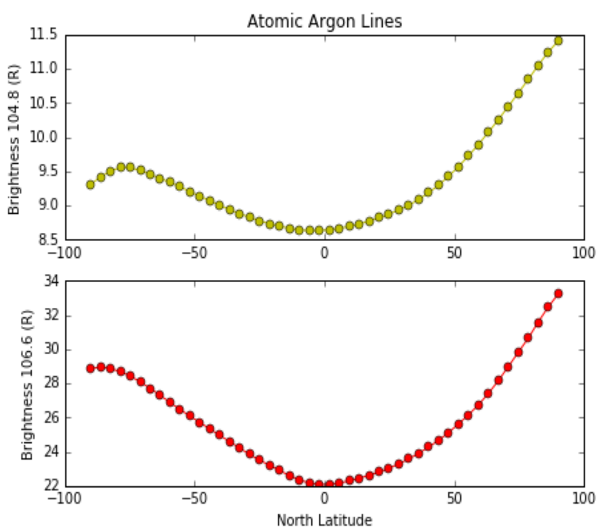

Figure 2*: Predicted Argon brightness from LMD GCM*

The Ar mixing ratios outputted from the model were ranging from 0.04 to 0.06, indicating that the LMD GCM predications are quite larger than the observations of the NGIMS [3]. The Ar mixing ratios extracted from the LMD GCM have been multiplied by their respective G-factors [1] to yield brightnesses of both the Ar atomic lines. The brightnesses are plotted against Northern Latitudes as seen in Figure 1 and seem to have a similar pattern. However, the brightnesses are also found to be larger than the brightness calculations in Table 1, and that is mainly due to the variations in the yielded mixing ratios of NGIMS observations and LMD GCM predications.

Future Work:

Based on the results found, the way forward is to look through other exisitng GCMs to conduct comparative studies, and find compatabilty with NGIMS observations. Therefore, we will be investigating the predicted Ar mixing ratios by using the Mars Thermospheric General Circulation Model to then determine the scientific value of the observations.

The next EUV emission features to be examined; which are of importance to the EMUS instrument, will be the contributions of the atomic Oxygen line 102.7 nm versus the Hydrogen Lyman-β 102.6 nm.

References:

[1] V. A. Krasnopolsky and P. D. Feldman, "Far Ultraviolet Spectrum of Mars," Icarus, no. 160, pp. 86-94, 2002.

[2] D. L. Huestis and J. Berkowitz, "Cross Sections / Carbon-oxides / CO2 / HuestisBerkowitz(2010)_300K_0.1254-201.6nm(evaluation)," Max Planck Gsellschaft, 2010. [Online]. Available: http://satellite.mpic.de/spectral_atlas/cross_sections/Carbon-oxides/CO2_HuestisBerkowitz(2010)_300K_0.1254-201.6nm(evaluation).txt.

[3] P. R. Mahaffy, M. Benna, M. Elrod, R. V. Yelle, S. W. Bougher, S. W. Stone and B. M. Jakosky, "Structure and compostion of the neutral upper atmosphere of Mars from the MAVEN NGIMS investigation," in AGU Publications, 2015.

[4] "Mars Climate Database v5.2: The Web Interface," Le Laboratoire de Météorologie Dynamique (LMD), [Online]. Available: http://www-mars.lmd.jussieu.fr/mcd_python/.