SCIENTIFIC PAYLOAD OF THE EMIRATES MARS MISSION: EMIRATES MARS ULTRAVIOLET SPECTROMETER (EMUS) OVERVIEW.

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Introduction: In 2014, the United Arab Emirates (UAE) announced the first outer-planetary Arab mission, Emirates Mars Mission, as a catalyst for science and technology sector development within the region. The mission focuses on developing national capabilities in both science and engineering, and on contributing with novel science to the human knowledge and civilizations. The Emirates Mars Mission's (EMM) Hope Probe will launch in 2020 to explore the dynamics in the atmosphere of Mars globally while sampling on both diurnal and seasonal timescales. EMM's primary science goals are aligned with the Mars Exploration Program Advisory Group's (MEPAG) 2015 Goal II: "Understand the processes and history of climate on Mars" [1]. Moreover, EMM's objectives and investigations will address the following MEPAG's objectives of II.A): "Characterize the state of the present climate of Mars' atmosphere and surrounding plasma environment, and the underlying processes, under the current orbital configuration" as well as II.C): "Characterize Mars' ancient climate and underlying processes" [1]. EMM is the first mission to have full diurnal coverage on sub-seasonal timescales with a global coverage which enable understanding of the transfer of energy from the lower-middle atmosphere to the upper atmosphere. On-board the Hope Probe are three scientific instruments which will provide a set of measurements fundamental to an improved understanding of the Martian climate. Two of the EMM's instruments, which are the Emirates eXploration Imager (EXI) [2] and Emirates Mars Infrared Spectrometer (EMIRS) [3] will focus on the lower atmosphere observing dust, ice clouds, water vapor and ozone. On the other hand, the third instrument Emirates Mars Ultraviolet Spectrometer (EMUS) will focus on both the thermosphere of the planet and its exosphere. This poster will cover a description and overview of the latter instrument, EMUS, and the investigations it fulfills.

EMUS Science Targets: *Thermosphere Investigation* will determine the abundance and spatial variability of key neutral species in the thermosphere on sub-seasonal timescales. To address this investigation, EMUS will provide a measure of the dynamics and energetics of the thermosphere, through which all escaping particles must travel, as it forms the lower boundary of the exosphere. This will be achieved by determining the column abundance and spatial variability of the key neutral species in the thermosphere: oxygen (O), and carbon monoxide (CO).

Exosphere Investigation EMUS will also address the EMM investigation that focuses on determining the three-dimensional structure and variability of the key species in the exosphere and their variability on sub-seasonal timescales. For this investigation EMUS will observe the neutral exospheric species hydrogen (H) and oxygen (O). Measurements of both hydrogen and oxygen in the upper atmosphere are essential for determining the loss of water from the upper atmosphere.

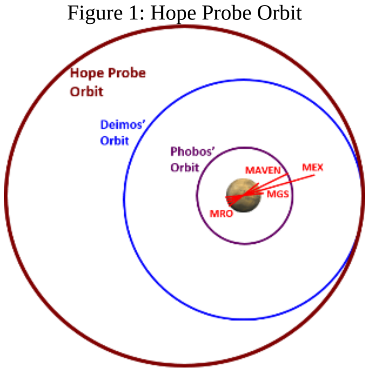
Instrument Overview: The EMUS instrument is a far ultraviolet imaging spectrograph that is jointly developed by the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado Boulder and Mohammed Bin Rashid Space Centre (MBRSC). It consists of a single telescope mirror feeding a Rowland circle imaging spectrograph with a photon-counting and locating detector (provided by the Space Sciences Laboratory at the University of California, Berkeley). The EMUS spatial resolution of 0.36° is sufficient to characterize spatial variability in the Mar-tian thermosphere (100-200 km altitude) and exosphere (>200 km altitude). EMUS measures ultraviolet emissions in the spectral range 100-170 nm with a selectable spectral resolution of 1.3 nm, 1.8 nm, or 5 nm. In order to observe and discriminate between the hydrogen and oxygen coronas, EMUS will make one-dimensional spectral measurements. To measure the hydrogen corona, the instrument will be sensitive to Lyman alpha at 121.6 nm and Lyman beta at 102.6 nm. To measure the oxygen corona, it will be sensitive to 130.4 nm and to the dimmer 135.6 nm emission. EMUS will measure the CO emissions in the Thermosphere between 140 nm and 170 nm.

Table 1: EMUS Instrument Parameters

Field of view	(0.18°, 0.25°, 0.7°) × 11.0°
Wavelength range	100 – 170 nm
Spectral resolution	1.3, 1.8, 5 nm
Spatial resolution with narrow slit	0.14° × 0.20°
Detector photocathode	CsI

Concept of Operations: EMM target science orbit, as shown in Figure 1, is of 20,000km x 43,000 with 25° inclination, resulting in 55 hour orbital period. This unique high altitude orbit, which no space-craft had ever flown into, enables comprehensive observations of the exosphere, and full sampling of latitude, longitude, and local time. The Science Phase is planned for 2 Earth years (just over 1 Mars year) to cover all the seasonal variations in the atmosphere.

Figure 1: Hope Probe Orbit



The EMUS instrument takes its observations utilizing 4 different observing strategies (U-OS) using spacecraft motion to build up two-dimensional far ultraviolet images of the Martian disk and near-space environment. U-OS1 addresses all thermospheric measurements up to 1.06 Mars Radii (RM). U-OS2 provides measurements of the hydrogen and oxygen corona up to 1.6 RM, while U-OS3 measures the extended H corona up to at least 6 RM using emission at Lyman alpha. U-OS4 addresses as well the oxygen and hydrogen corona as it will aid in observing the escaping oxygen (130.4 nm) and it will target Lyman beta at all altitudes.

Table 2: Summary of EMUS Observations

Obser-vation	Description	Slit	Frequency
U-OS1	Raster scanned images of the disk of Mars covering 0-1.06 RM	1.3 nm	2 times per orbit in one orbit per week
U-OS2	Raster scanned images of the disk of Mars covering 0-1.6 RM	1.8 nm	6 times in one orbit per week
U-OS3	Asterisk pattern scan where the spacecraft will slew out to 100 degrees in 4 swaths. It will cover 0 - at least 6 RM	5 nm	4 times in one orbit every other week
U-OS4	Provide long exposure times for the mid and outer corona when the instrument is not imaging and during charging	1.8 nm	Observe lines of sight in each 500km bin in one orbit per month

Data Completeness: There will be two types of EMUS image sets: standard and high cadence for both thermospheric and coronal measurements. To ensure adequate global coverage of the dayside thermosphere including the terminator, and continuous coverage of the equatorial (Mars-Centered Solar Orbital coordinate frame) thermosphere, the standard image set must encompass at least 6 of the 8 30°-wide intervals in MSO longitude spanning -120° to 120° (4 AM to 8 PM in MSO local time), and the high cadence image set must encompass at least 12 of the 16 15°-wide intervals. Both sets should be taken within 1/3 of a week. As for seasonal coverage, observations over 1 full Martian year shall be covered where 20 of the 24 15° intervals of solar longitude (LS) sampled for standard cadence, and at least 7 of the 8 45° intervals of LS sampled for high cadence sets.

For coronal measurements, the standard image set consists of images taken within 1/3 of a week, from at least 5 of the 8 45° intervals of MSO longitude spanning -180 to 180°, with no more than one 45° interval missed out of either the midnight centered 90°-wide quadrant of 135° to -135° (to characterize the nightside Hydrogen exosphere) or the three dayside and terminator quadrants spanning -135° to 135° (to characterize the dayside Hydrogen and Oxygen exosphere). The Hydrogen and Oxygen exospheres are not expected to be influenced by the lower atmosphere on timescales of less than one week. Therefore, at least 1 standard image set shall be collected per week. To allow the characterization of short-term, sub-week variability in all Mars seasons, high cadence data sets, consisting of 3 consecutive standard image sets in the same week, must be collected in at least seven of the eight 45° intervals of LS comprising a Martian year, to ensure that such variability does not manifest itself differently at different seasons or heliocentric distances.

References:

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