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H and O Escape from the Martian Upper Atmosphere

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Abstract

Hubble Space Telescope (HST) far-UV images and long-aperture spectra reveal the altitude profiles of the far-UV emissions of H and O, which can be modeled and used to derive estimates of the escape fluxes of H and O from the martian atmosphere. Important issues include the derivation of density and temperature, and the presence of any superthermal component in the populations. Superthermal atoms in particular can make a large difference in the derived escape fluxes, even though they may be a small fraction of the total populations. In this talk we will present experience gained from the HST data which is preparing us to analyze future profiles to be derived from MAVEN IUVS data.

1. Introduction

HST far-UV images and long-aperture spectra have been used to study the altitude dependence of the H Ly α and OI 1304 emissions from the extended martian atmosphere. Observations of the H emission show the very extended H exosphere through resonant scattering of solar emission. Fits to the emission brightness with altitude require a radiative transfer model to take into account the optically thick emissions from altitudes $z < 1000$ km. The HST data are high quality, with an altitude resolution as high as 25 km when Mars is closest to the Earth. Fits to the altitude profiles can be made by varying the exobase density and temperature, assuming a Chamberlain model exosphere for the distribution of atoms at altitudes where the atmosphere is collisionless. We have found that there is an ambiguity between temperature and exobase density, with a range of values giving good fits to the brightness and altitude profiles. In addition, it is challenging to identify any superthermal component of H due to the naturally high altitude extent of the exosphere. For the OI 130.4 nm emissions, the emission scale height is much smaller due to the higher mass of the atoms, and a superthermal component can easily be detected. Fits to these profiles place limits on both the number density and temperature of the hot O, which will be presented in the talk.

The first HST observations of O were obtained in 2003, and a more recent set of observations is scheduled for late spring 2014 in preparation for the MAVEN mission arrival at Mars in Sept. 2014. A campaign of HST and Mars Express / SPICAM observations was obtained in Fall 2007 as Mars was moving away from the Sun and shortly after a large dust storm. A strong decrease in the brightness and altitude extent of the H emission was found in both data sets, consistent with a large decrease in H density over a period of many weeks. At the time, near solar minimum, the solar Ly α flux was nearly constant, and the solar wind was quiet. It appears likely that the changing density of hydrogen in the upper atmosphere was in response to the supply from water molecules in the lower atmosphere, perhaps driven by a short-lived increase during local summer and/or the large dust storm. If this were the case, it would imply a strong dependence of the escape flux on conditions in the lower atmosphere, which has implications for the historic escape of water into space. These correlations can be tested by future HST and MAVEN IUVS observations.

2. Figures

One figure is included to show the observed extent of the hydrogen exosphere in Ly α emission with HST from the ACS/SBC observations on 9 Nov. 2007. The image is obtained through the difference of two images, one with a bandpass that includes the H Ly α emission and solar continuum, and the other blocking the Ly α emission. On the disc it is a small difference of two large count rates, and therefore has been replaced with a far-UV image. Off the disc beyond about 1.2 R_{Mars} the signal is dominated by the Ly α emission.

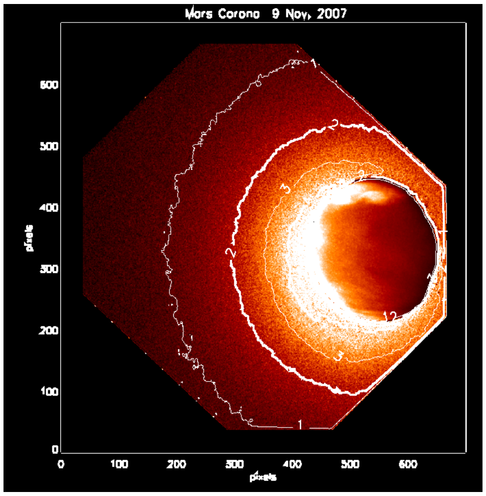

Figure 1: Derived H Ly α emission from the martian exosphere on 9 Nov. 2007. Contours are constant brightness in kilo-Rayleighs.

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