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Photochemical escape of oxygen from the Martian atmosphere: first results from MAVEN

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One of the primary goals of the MAVEN mission is to characterize rates of atmospheric escape at the present epoch and relate those escape rates to solar drivers. One of the major escape processes is known as photochemical escape, which is broadly defined as a process by which a) an exothermic reaction in the atmosphere results in an upward-traveling neutral particle whose velocity exceeds planetary escape velocity and b) the particle is not prevented from escaping through any subsequent collisions. At Mars, photochemical escape of oxygen is expected to be a significant channel for atmospheric escape, particularly in the early solar system when extreme ultraviolet (EUV) fluxes were much higher. Thus characterizing this escape process is central to understanding the role escape to space has played in Mars' climate evolution.

Because escaping hot atoms cannot easily be directly measured, models of production and transport (through the atmosphere) of such atoms must be used to constrain escape rates. These models require altitude profiles of neutral densities and electron and ion densities and temperatures, as well as compositional information.

All the relevant quantities upon which photochemical escape depends will be measured by MAVEN at the relevant altitudes (150-250 km). LPW will measure electron density and temperature, NGIMS will measure neutral and ion density and STATIC will measure ion density and temperature. 4 separate calculations must be made for every altitude profile:

1. Profiles of O_2^+ dissociative recombination (DR) rates will be calculated straightforwardly from electron temperature, electron density and O_2^+ density.
2. Profiles of rotational and vibrational distributions of O_2^+ ions will be calculated from profiles of CO_2, O, O_2, O^+, CO_2^+ and CO^+ via a lookup table from an empirical model.
3. Profiles of energy distributions of hot O atoms will be calculated from the results of step 2 and from profiles of electron and ion temperatures.
4. Profiles of all neutral densities will be input into models of hot O transport in order to calculate photochemical escape fluxes from DR of O_2^+.

We will present photochemical escape fluxes as a function of all relevant factors, in particular solar zenith angle and EUV flux. The latter will change with solar activity, solar rotation and Mars heliocentric distance, while MAVEN will sample the former from 40 to 150 degrees as the periapsis location precesses over the first 5 months of the primary mission.

This, combined with further simulations with progressively higher EUV fluxes, will eventually enable a total integrated loss estimate over the course of Martian history and hence a determination of the impact of this loss process on the evolution of the Martian climate.