Photochemical escape of oxygen atoms from Mars using MAVEN in-situ measurements

Marko Gacesa[1], Rob Lillis[1], Ali Rahmati[1], Justin Deighan[2], Jane L. Fox[3], Yuni Lee[4], S. Bougher[4], J.-Y. Chaufray[5], Francois Leblanc[5], M. Combi[4], T. Cravens, and the IUVS and NGIMS teams

[1]SSL, University of California, Berkeley, CA, USA
[2]LASP, University of Colorado, CO, USA
[3]Wright State University, Dayton, OH, USA
[4]University of Michigan, Ann Arbor, MI, USA
[5]Laboratoire atmosphères, milieux et observations spatiales (LATMOS)/CNRS, Paris, France

Dissociative recombination (DR) of photoionized O_2^+ with electrons in the upper atmosphere of Mars produces translationally superthermal O atoms capable of overcoming martian gravitational potential and escaping into space. This process is known as photochemical escape and found to be one of the major escape mechanisms presently active on Mars. Photochemical escape is thought to have played an important role in climate evolution in early history of Mars.

The Mars Atmosphere and Volatile Evolution Mission (MAVEN), launched in 2014 as a part of NASA's Mars Scout program and currently in extended science phase, can constrain photochemical escape of oxygen from Mars in three is separate ways. First, MAVEN is the first mission that can measure in-situ physical quantities necessary to construct photochemical escape rates. Rates of hot oxygen production are calculated using measurements of electron temperature and density (from the Langmuir Probe and Waves (LPW) experiment) and ion temperature and density from the SupraThermal And Thermal Ion Composition (STATIC) and Neutral Gas and Ion Mass Spectrometer (NGIMS), while escape probability are calculated with neutral densities measured by NGIMS. In this way, escape fluxes of hot O from the Martian atmosphere over more than 36 months have been compiled and will be presented here. We determined average and seasonal dayside escape fluxes of hot O broadly consistent with several pre-MAVEN predictions. We also estimated non-thermal escape of light neutrals driven by collisions with superthermal O atoms and their impact on the total escape fluxes. Second, altitude profiles of 130.4 nm oxygen emission measured up to ~4,000 km by the Imaging Ultraviolet Spectrograph (IUVS) can be fit to a model of photochemical escape to constrain escape fluxes. Third, >70 keV oxygen pickup ions from the distant dayside oxygen exosphere can be detected by the Solar Energetic Particle (SEP) instrument, also allowing escape fluxes to be estimated. These three methods each give similar escape rates estimates of 6-9 x 10^{25} s^{-1} for the first ~6 months of MAVEN data when solar EUV was comparatively high, but thereafter diverge, with the in situ method giving substantially lower fluxes on the other two methods. Here we review MAVEN's results thus far on photochemical escape, speculate on how this discrepancy may be resolved and how the importance of photochemical escape varies over time with different atmospheric composition and solar EUV.