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Cold Ion Escape from the Martian Ionosphere

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Abstract

We here report on new measurements of the escape flux of oxygen ions from Mars by combining the observations of the ASPERA-3 and MARSIS experiments on board the European Mars Express spacecraft. We show that in previous estimates of the total heavy ion escape flow the contribution of the cold ionospheric outflow with energies below 10 eV has been underestimated. Both case studies and the derived flow pattern indicate that the cold plasma observed by MARSIS and the superthermal plasma observed by ASPERA-3 move with the same bulk speed in most regions of the Martian tail. We determine maps of the tailside heavy ion flux distribution derived from mean ion velocity distributions sampled over 7 years. If we assume that the superthermal bulk speed derived from these long time averages of the ion distribution function represent the total plasma bulk speed we derive the total tailside plasma flux. Assuming cylindrical symmetry we determine the mean total escape rate for the years 2007 to 2014 at $2.9 \pm 0.2 \times 10^{25}$ atoms/s which is in good agreement with model estimates. In this talk we will also try to compare these results with more recent observations by the MAVEN spacecraft. Possible mechanism to generate this flux can be the ionospheric pressure gradient between dayside and nightside or momentum transfer from the solar wind via the induced magnetic field since the flow velocity is in the Alfvénic regime.

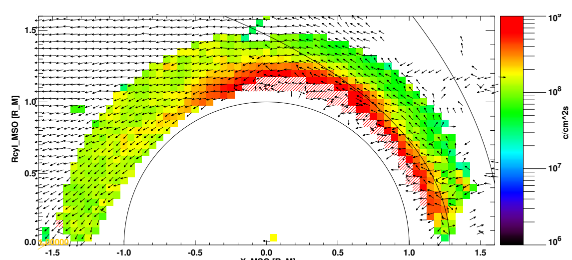

Figure 1: Total flux calculated from total velocity derived from the mean MEX Aspera IMAEXTRA VD with spacecraft velocity and potential correction observed between 1 May 2007 and 1 June 2014 multiplied by the mean MARSIS local density observed over the same period in the same spatial bins, scaled in /cm^{2}s. The vertical component of vectors shows the deviation from the cylindrical symmetry axis.

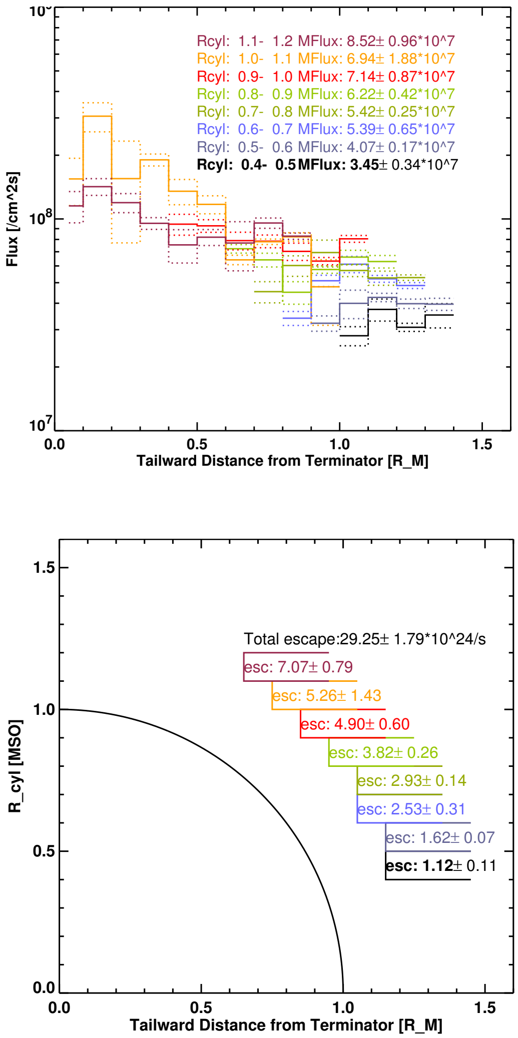

Figure 2: Top: Total mean flux as in Fig.1 in cylindrical bins with respect to the MSO_X axis as a function of tailward distance from the terminator plane. Numbers in the upper right corner give the mean flux over the last 0.3 R_M of each cylindrical shell, where combined observations of MARSIS and Aspera-3 were obtained. Bottom: Position of the cylindrical shells used for the mean flux calculation and escape (ions/s) calculated from the cross section of the cylindrical shells multiplied by the mean flux for each cylindrical shell. Standard deviations are from the flux variation over this distance.