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Cold Ion Escape from Mars

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Abstract

It has always been challenging to observe the flux of ions with energies of less than 10eV escaping from the planetary ionospheres. We here report on new measurements of the ionospheric ion flows at Mars by the ASPERA-3 experiment on board Mars Express in combination with the MARSIS radar experiment. We first compare calculations of the mean ion flux observed by ASPERA-3 alone with previously published results. We then combine observations of the cold ion velocity by ASPERA-3 with observations of the cold plasma density by MARSIS since ASPERA-3 misses the cold core of the ion distribution. We show that the mean density of the nightside plasma observed by MARSIS is about two orders higher than observed by ASPERA-3 (Fig.1). Combining both datasets we show that the main escape channel is along the shadow boundary on the tailside of Mars (Fig. 2). At a distance of about 0.5 R_M the flux settles at a constant value (Fig. 3) which indicates that about half of the transterminator ionospheric flow escapes from the planet. 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.

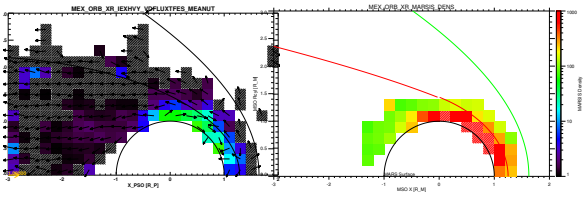

Figure 1: Mean cold ion density between May 2007 and July 2011 determined from ASPERA averaged distribution function (left) and MARSIS plasma frequency (right).

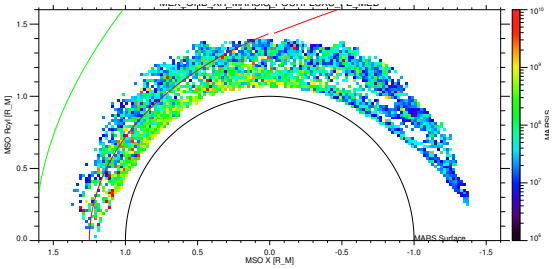

Figure 2: Median oxygen ion flux reconstructed by combining ion velocity observations of the Mars Express ASPERA-3 IMA sensor and local plasma density observations by the MARSIS radar. Each bin value is the median from observations on about 3000 orbits between May 2007 and July 2011. Horizontal axis is MSO X-axis (Sun towards the left), vertical axis is vertical distance from MSO X-axis.

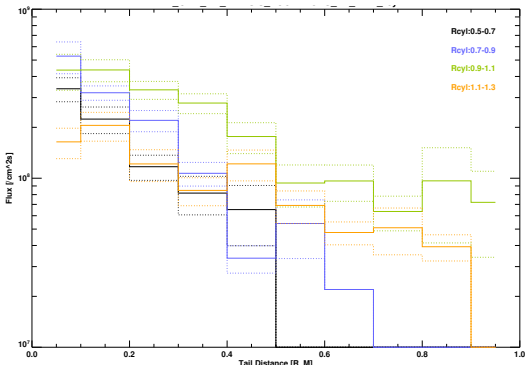

Figure 3: Ring median flux of cylindrical ring regions of all bins shown in previous figure. The different colors show median fluxes for different regions in R-cylindrical (distance from MSO-X-axis) as a function of tailward distance from the terminator (or surface for Rcyl < 1).