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Ion loss to the Solar Wind from Venus at Solar Minimum

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Abstract

The absence of an intrinsic magnetic field on Venus allows the solar wind to interact directly with the ionosphere and upper atmosphere of the planet. The loss of ions from the Venusian environment to the solar wind has direct implications for the evolution of the planetary atmosphere. Escape mechanisms induced by the solar wind are thought to be the dominant loss processes at solar maximum for heavy atmospheric gases such as oxygen and several escape processes are cited. These include: loss from the outer exosphere, where proximity of the bow shock to the planet means that a large portion of the exosphere is located in the shocked solar wind flow and results in planetary ionisation being directly removed in the flow; loss by sputtering, where ions gyrating around the magnetic field embedded in the tailward convecting plasma mantle, between the shocked solar wind and the ionosphere, may re-enter the atmosphere; loss due to ion acceleration by electric fields that result from the transport of photoelectrons; loss due to variation in the solar wind that results in a complex array of planetary plasma structures on both day and night sides.

Observations conducted by Venus Express around solar minimum were used to build average maps of ions of ionospheric origin within the Venusian environment. These showed the presence of oxygen ions up to altitudes of few hundreds of km on the dayside and to several planetary radii on the nightside. In all sectors within this region some observations showed ions with energies greater than that required to escape from the planet, with the largest energies observed in the shocked solar wind on both the dayside and the nightside. In view of these observations two types of ion loss mechanisms are suggested to occur at Venus at solar minimum. At the highest altitudes plasma was lost by direct interaction with the solar wind. At lower altitudes the day-to-night pressure gradient accelerated ions into the tail region and some of these ions had sufficient energy to reach the escape velocity driving ion outflow at solar minimum.