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PLANETARY ION FLUXES IN THE VENUS WAKE

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Measurements conducted with the ASPERA-4 instrument and the magnetometer of the Venus Express spacecraft show that the kinetic pressure of planetary O+ ions measured in the Venus wake can be significantly larger than the local magnetic pressure and, as a result, those ions are not being driven by magnetic forces but by the kinetic energy of the solar wind. Beams of planetary O+ ions with those properties have been detected in several orbits of the Venus Express through the wake as the spacecraft traverses by the noon-midnight plane along its near polar trajectory. Peak values of the kinetic pressure of the O+ ions are sufficient to produce superalfvenic flow conditions. It is suggested that such O+ ion beams are eroded from the magnetic polar regions of the Venus ionosphere where the solar wind carves out plasma channels that extend downstream from those regions. Issues related to the acceleration of planetary ions as the solar wind interacts with the Venus ionosphere are related to the energetics of the plasma. When the kinetic pressure of the particle populations involved in the interaction is smaller than the local magnetic pressure the latter will be dominant and hence the particles will follow trajectories dictated by the magnetic field. Such conditions should occur by the magnetic barrier that is formed over the dayside Venus ionosphere where the interplanetary magnetic fluxes pile up thus leading to enhanced values of the magnetic field intensity. Different conditions are expected when the kinetic pressure of the plasma is larger than the local magnetic pressure. In this case the latter will be convected by the particle fluxes as it occurs in the superalfvenic solar wind.

Plasma conditions applicable to the planetary ions that stream in the Venus wake and that have been removed from the Venus ionosphere can be examined using the plasma and magnetic field data obtained from the Venus Express (VEX) measurements. A suitable example is provided by the plasma and the magnetic pressure profiles that were obtained from the data in orbit 123 on August 22-2006 and that are reproduced in Figure 1. The profiles in the lower panel show that the peak kinetic pressure of the O+ ions becomes substantially larger than the local magnetic pressure (between 01:48 UT and 02:00 UT) and also that within a wide region of the wake (between ~02:00 UT and ~02:25 UT) the kinetic pressure becomes smaller than the magnetic pressure. Values of the ratio of the kinetic to the magnetic pressure that are obtained from both profiles are given in the upper panel to show that in the region where the peak kinetic pressure of the O+ ions are measured that ratio is substantially larger than one thus indicating that the local ions move under superalfvenic conditions. The opposite is true in other regions of the wake where values of that ratio are smaller than one and thus the plasma is subalfvenic.

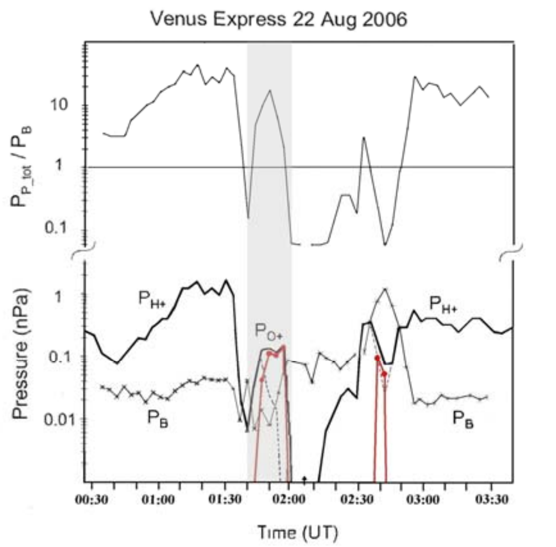

Figure 1 (lower panel) Profiles of the kinetic pressure of the O+ ions (marked in red) and the H+ ions (heavy profile), together with the profile of the magnetic field pressure P_B measured through the Venus wake in the VEX orbit 123. (upper panel) Ratio values of the total kinetic pressure of the plasma to the magnetic field pressure derived from the profiles shown in the lower panel. The outbound bow shock crossing occurs at ~ 02:53 UT and the peak value at ~01:50 UT is provided by the kinetic pressure of the O+ ions.

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Differences between both regimes should be due to the location of the region of the wake that is probed by the spacecraft with dominant kinetic forces encountered downstream from the magnetic polar regions where plasma channels extend over the nightside ionosphere[1]. Subalfvenic flow conditions will occur along the magnetic lobes by the flanks of the wake where the local density of the O+ ions is substantially small and the magnetic field fluxes extend downstream from the magnetic barrier.

The plasma conditions inferred from the data in Figure 1 are also encountered in the data of a large number of VEX orbits with the persistent result that peak pressure values of the planetary O+ ions occur under superalfvenic conditions. An important issue is the manner in which the planetary ions acquire their kinetic energy since the pressure profiles do not show comparable superalfvenic flow conditions in the immediate vicinity of the planet as the spacecraft moved toward the terminator (by 02:40 UT). It is possible that the O+ ions become gradually accelerated with the downstream distance from the planet which could in turn be produced through the local transport of the solar wind momentum.

1- Pérez-de-Tejada, H., JGR, 109, A04106, doi: 10.1029/2002JA009811, 2004.