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Solar cycle changes in the position of the intermediate transition in the Venus ionosheath.

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Abstract

Measurements conducted with the ASPERA plasma probe and the magnetometer of the Venus Express (VEX) spacecraft in orbits that probed by the midnight plane within the Venus wake show the presence of a sharp plasma transition outside the region where enhanced fluxes of planetary ions are observed. That transition agrees with a feature reported earlier [1] from the VEX electron measurements and that is now also characterized by a sharp change in the speed and density of the solar wind H+ ions. From the analysis of the plasma data of 10 selected VEX orbits in two different time periods (August 2006 and September 2009) it was possible to derive the position of the VEX spacecraft at the time when the plasma transition is observed in those orbits. The data show a collection of different distances downstream from Venus where the plasma transition is detected and that are grouped for each time period. As a whole the X-distance on the sun-Venus line downstream from the planet for each of the 5 orbits corresponding to the August 2006 time period is larger than that corresponding to the 5 orbits of the September 2009 time period. The average distance difference between both sets of data points is nearly one half planetary radius thus leading to two different groups in their distribution. The position of the plasma transition downstream from Venus varies along the solar cycle and/or as a result of time dependent changes in the solar wind conditions.

VEX data

An example with suitable VEX data is available from the orbit of August 22-2006 reproduced in Figure 1 that shows a sharp drop in the speed profile of the H+ ions at 01:32 UT (fourth panel). This event occurred before the initial observation of enhanced O+ ion densities at 01:38 UT and is also accompanied by a noticeable decrease in the density of the H+ ion population at 01:32 UT (third panel). From the analysis of the data in Figure 1 it has been found that the dynamic pressure of the O+ ions in the Venus wake can reach values larger than the local magnetic field pressure and thus lead to superalfvenic flow conditions [2]. A similar property was obtained from the data analysis of 10 VEX orbits that have been examined and that are reproduced in Table I (all orbits are oriented near the midnight plane). The X and Z coordinates of the position of the VEX spacecraft at the time when a change in the speed profile of the H+ ions similar to that in Figure 1 are indicated in the second and third columns of Table I.

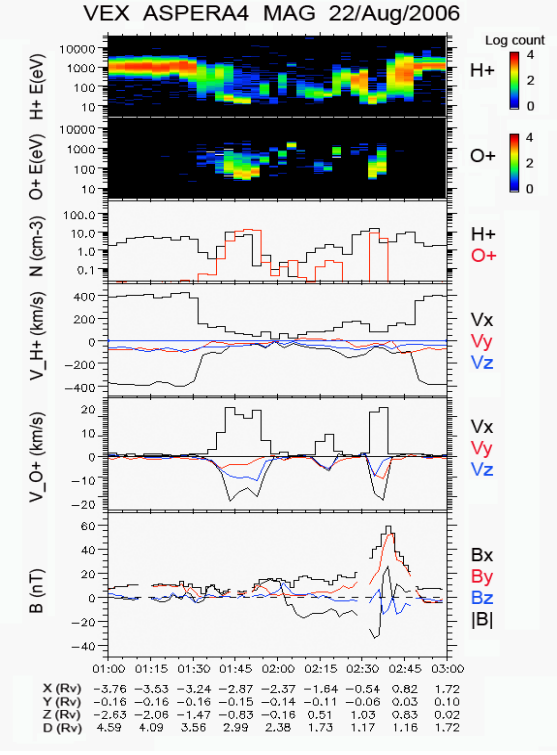

Fig. 1 – Energy spectra of H+ and O+ ion fluxes (top panels) measured in the Venus wake during the August 22-2006 orbit of the Venus Express spacecraft [2].

The data points of the position of the spacecraft on the XZ plane in the 10 orbits of Table I are presented in Figure 2 to show a collection of two different groups, each corresponding to the August 2006 and to the September 2009 time periods. The data points corresponding to the orbits of August 2006 are located at larger (negative) X distances than those corresponding to September 2009. Also notable is the lineup in the position of the data points for each of the two time periods. Their distribution does not follow the date of each orbit which is, instead, located in an alternate manner. Since the lineup follows approximately the direction of the VEX trajectory projected on the XZ plane it is possible that the position of the data points in Figure 2 is related to the shape of the polar plasma channels that are oriented according to the direction of the IMF away from the ecliptic plane, as it was indicated in Fig. 9 of a previous publication [2].

Date	$X(R_V)$	$Z(R_V)$
20/08/2006 (01:32:00 UT)	-2.90	-0.90
21/08/2006 (01:33:30 UT)	-3.01	-1.06
22/08/2006 (01:32:00 UT)	-3.20	-1.39
23/08/2006 (01:36:30 UT)	-3.23	-1.44
24/08/2006 (01:31:00 UT)	-3.06	-1.14
19/09/2009 (01:47:20 UT)	-2.56	-1.18
22/09/2009 (01:56:30 UT)	-2.51	-1.06
23/09/2009 (01:57:00 UT)	-2.53	-1.13
25/09/2009 (02:04:30 UT)	-2.44	-0.97
26/09/2009 (02:00:00 UT)	-2.58	-1.31

Table I. Position of the Venus Express in the XZ plane at the time when a plasma transition similar to that in Figure 1 was detected in 10 VEX orbits in August 2006 and September 2009.

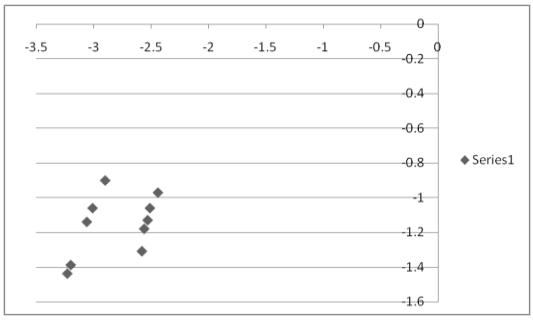

Fig. 2. Position of the VEX spacecraft on the XZ plane at the time when the plasma transition in the orbits listed in Table I was detected (X is directed to the sun (right side) and Z points to the solar north from the ecliptic plane).

Discussion

A schematic representation of the intermediate transition (IT) obtained from the Venera data [3], and that is suitable to the data points of the August 2006 and September 2009 orbits is indicated in Figure 3. It is possible that the intermediate transition, associated to the erosion of the Venus ionosphere, is different during the September 2009 orbits (inner curve) from that in the August 2006 data points (outer curve). Conditions related to the solar cycle and/or to time dependent changes in the solar wind conditions may have been responsible for the different position of the intermediate transition. As a result, its intersection with the VEX trajectory in 2006 and also in 2009 (marked by a circle in each case) could have taken place at locations closer to Venus in the September 2009 orbits as is indicated in Table I and in Figure 2.

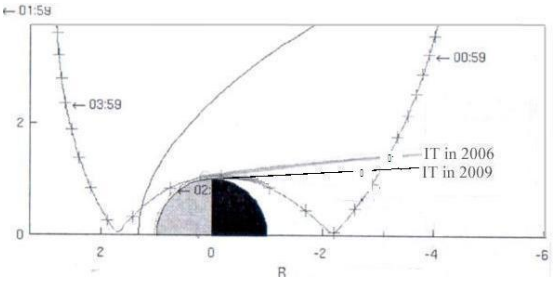

Fig. 3 - Scheme of two possible shapes for the intermediate transition, as derived from the Venera data [3], together with the VEX trajectory suitable to 2006 (a comparable trajectory is applicable to 2009).

[1] Pérez-de-Tejada, H. et al., JGR, 116, doi:JA015216, 2011.
[2] Pérez-de-Tejada, H. et al., JGR, 118, doi:JA019029, 2013.
[3] Phillips, J., and D. McComas, SSR, 55, p. 1, 1991, (Fig. 35).