EPSC Abstracts
Vol. 5, EPSC2010-689, 2010
European Planetary Science Congress 2010

The effect of differing solar wind conditions on Venus boundary characteristics

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Abstract

The current work is an investigation of the characteristics of the bow shock, magnetic pile-up boundary, and ion composition boundary at Venus over a period of 14 months. The first aim is to provide a better resolution for the boundaries detected from ion data. The second aim is to build a picture of typical behaviours, so that on the occasions of atypical solar wind conditions, deviations from the norm can be observed. Data from the Venus Express Ion Mass Analyser (IMA), magnetometer (MAG), and Electrostatic Analyser (ELS) are used to facilitate this process.

1. Introduction

The conditions surrounding Venus are highly varied and in a constant state of change due to the variability of solar emissions. Such emissions include the cyclical variations and interactions between the slow and fast solar winds, coronal mass ejections, and one-off occurrences in the form of solar wind mass loading by commetary tails. The reaction of the Venusian magnetic and ionospheric boundary layers to these stresses is anticipated to be just as varied.

Previous work has identified some characteristics of ion behaviour at Venus during such events [1]. Three atypical events are brought as case studies. First, a co-rotating interaction region (CIR), where the compression region reached Venus on 30th May 2007. The second is a coronal mass ejection (CME), which reached Venus in two fronts; the first on 24th April 2007 and the second on the 25th April 2007. The arrival of this event has been studied by Rouillard *et al*. [2] but not its relation to the above mentioned boundaries. The final event was the mass loading of the solar wind by the tail disconnection of comet 2p/Encke, which arrived at Venus on 22nd April 2007.

2. Methodology

An algorithm is developed to automatically identify the bow shock and magnetic pile-up boundaries, both upstream and downstream of the planet. The bow shock exhibits a jump in both the electron thermal pressure and the magnetic pressure. Within the ionosheath the electron thermal pressure becomes turbulent but reduced in magnitude, whilst both magnetic pressure and turbulence increase. The magnetic pile-up boundary has been defined as where the magnetic pressure reaches its peak value.

In some cases there are multiple instances where it appears a boundary has been crossed; Figure 1 illustrates this. In the vicinity of the black vertical line (labelled BSn), multiple peaks in the electron thermal pressure are observed. A transition parameter, such as that used by Hapgood and Bryant [3], is developed to more accurately define the region in which the electrons were observed.

Figure 2 contains the time-series plot of the electron thermal pressure (b) and the magnetic pressure (c) of the orbit on 21st January 2007. The colour system is generated so that the data in panel (a) may be viewed with respect to time also. The coloured section represents the dayside solar wind and the ionosheath; the red, dot-dash line represents the bow shock location. The relationship between electron thermal pressure and magnetic pressure is shown in panel (a). The cluster of data in the bottom left corner of panel (a) was recorded whilst the spacecraft was in the solar wind. The data points which resemble a curve were recorded whilst in the ionosheath.

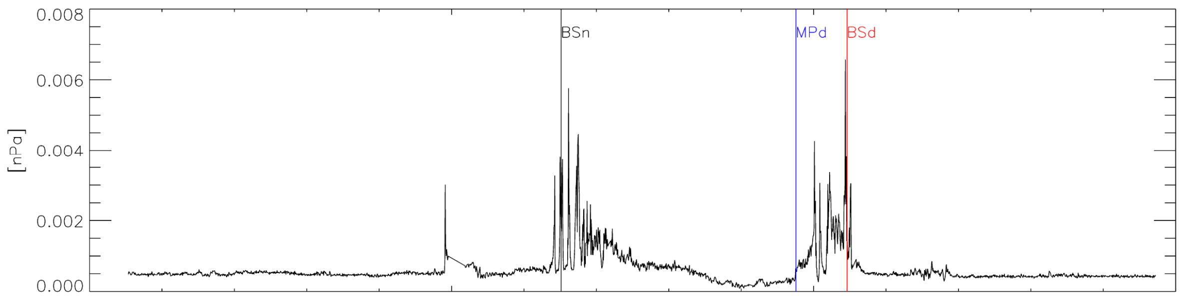

Figure 1: Time series of electron thermal pressure for 21st February 2007. The nightside bow shock (black), dayside magnetic pile-up boundary (blue) and dayside bow shock (red) are marked as vertical lines.

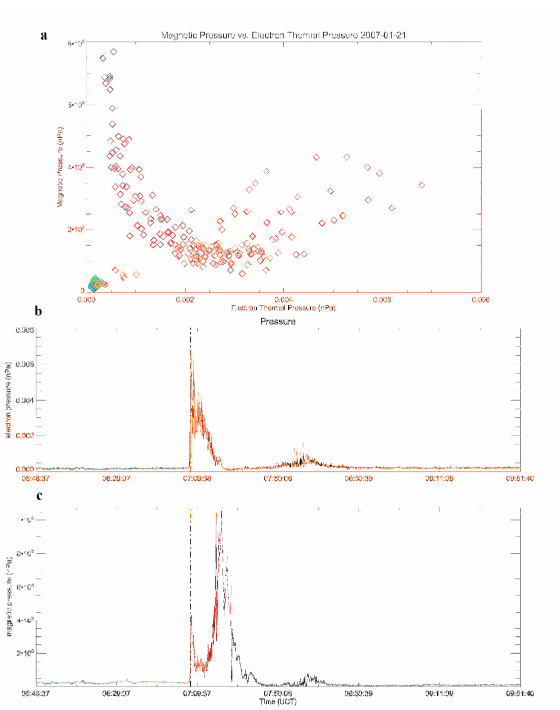

Figure 2: Dayside bow shock crossing as identified using the ion algorithm defined by Whitaker *et al*. [1]

3. Conclusions and further work

The dayside boundary crossings during the CIR arrival on 30th May 2007 exhibit much greater turbulence in the magnitude of electron thermal and magnetic pressure. The CME front arriving on 24th April 2007 causes a slight increase in turbulence of upstream solar wind electron pressure but not magnetic pressure. The effect of mass loading of the solar wind by the disconnected tail of comet 2p/Encke appears to have no large effect on the electron thermal or magnetic pressure.

Re-ordering the IMA data sets with respect to the boundaries defined from MAG and ELS will allow a more highly resolved picture to be constructed. This picture can then be compared to the existing one.

Acknowledgements

Many thanks to all members of the ASPERA-4 and magnetometer teams.

References

[1] Whittaker *et al*. (2009) submitted to Solar Physics topical issue: Remote sensing of the heliosphere.

[2] Rouillard *et al*. (2009) *JGR,* 114

[3] Hapgood and Bryant (1990) *GRL,* 17(11)