Giant S-shape in the auroral region associated with accelerated flow

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Abstract

The shock arrival of an Interplanetary Coronal Mass Ejection (ICME) after 9 UT on 22 November 1997 resulted in the development of an intense (Dst < 100 nT) geomagnetic storm at Earth. During the storm the solar wind velocity was rather steady at ~500 km/s whilst the Interplanetary Magnetic Field (IMF) was more variable during the event.

In the early phase of the storm an unusual giant S-shaped structure was observed in the auroral region by the Polar UVI instrument during a period of strong dawnward (B_y > 15 nT) and northward (B_z > 20 nT) IMF. The evolution of this structure started as a polewardly displaced auroral bulge which further developed into an S-shaped structure spreading across the entire polar cap. To our knowledge such a remarkable structure has previously never been reported. During this event Geotail was at the dawnside magnetotail flank and observed accelerated magnetosheath flow exceeding the solar wind velocity by ~60 % (as compared to WIND measurements). This flow may be the result of acceleration of the magnetosheath flow by magnetic tension in the draped field configuration for northward IMF. The S-shaped auroral feature may be a result of a B_y induced twisted magnetotail configuration combined with the acceleration of the magnetosheath flow. In addition, the solar wind dynamic pressure is proposed to play an important role in the "on/off" mechanism of auroral dynamics.

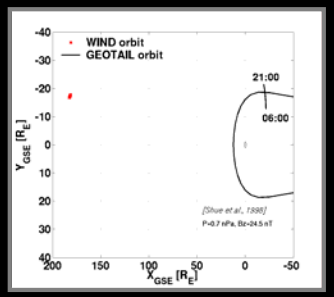


Figure 1: Spacecraft configuration between 06:00 UT and 21:00 UT on 22 November 1997. The magnetopause is predicted by the *Shue et al. (1998)* model using solar wind measurements from WIND at 19:00 UT.

Observations

The evolution of the S-formation is shown in Figure 2. An auroral bulge developed, moved poleward and forms into the S-shape (b-h) prior to 19 UT simultaneous as the observation of the accelerated flow in Geotail data (see Figure 4). After 19:11 UT the structure has suddenly faded away (i). This occurs when a slow increase in solar wind dynamic pressure is suddenly turned off at ~19:11 UT (panel 3 in Figure 4). The impact of another pressure pulse at 19:28 UT at Earth initiates a substorm onset as seen in the Polar UVI images (j-k) and AE index data (Figure 4).

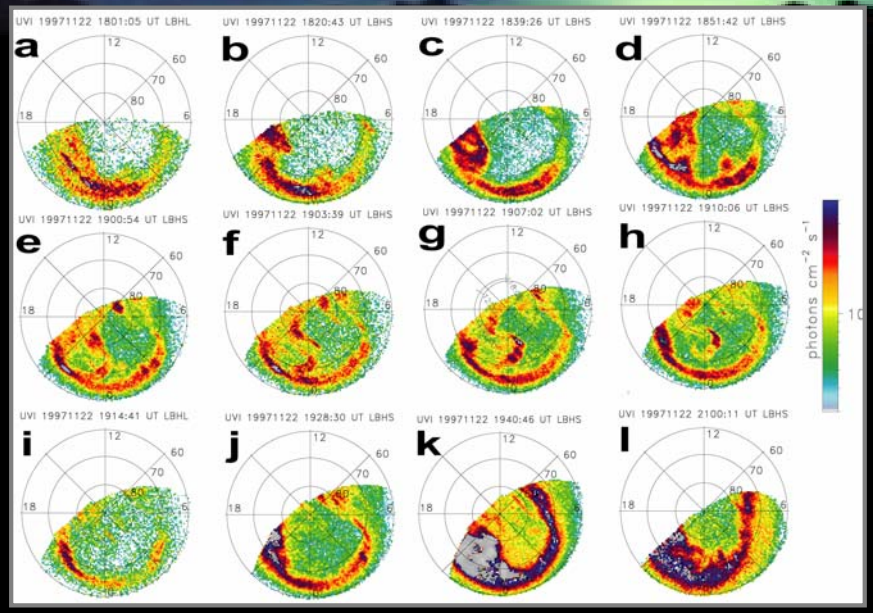


Figure 2 : Polar UVI images from 18:00 UT to 21:00 UT. The mapped projection of Geotail is overlain in image g. It was calculated using the T96 magnetic field model with the input parameters, B_y=15 nT, B_z= 25 nT, p=1 nPa, and Dst=-50 nT as depicted from the WIND data at 19 UT.

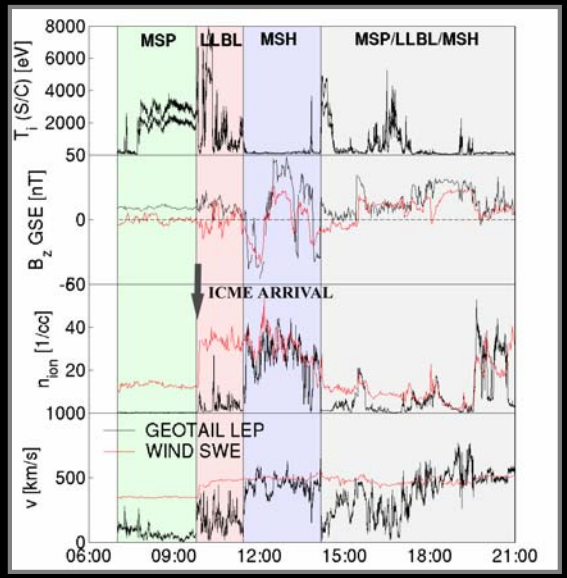


Figure 3: Overview of WIND and Geotail measurements for 22 Nov. 1997. The arrival of the shock is characterised by a clear enhancement of both solar wind velocity and density as observed by WIND. Geotail instantaneously encounters the Low-Latitude Boundary Layer (LLBL) and subsequently the magnetosheath due to the compression of the magnetosphere. A period of several encounters in and out of these regions follows. Accelerated flow is identified by Geotail close to the magnetopause.

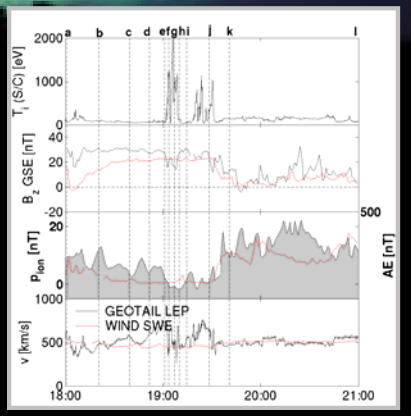


Figure 4: The times for each of the images in Figure 2 are marked by vertical dashed lines. The impact of the pressure on AE is clearly seen (panel 3). The sudden decrease in pressure at 19:11 might quench the formation of the S-shaped structure.

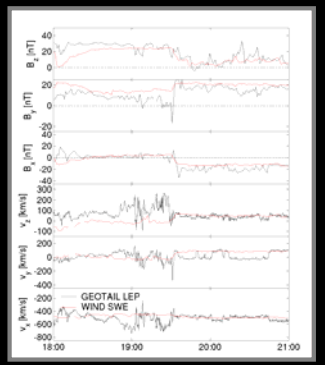
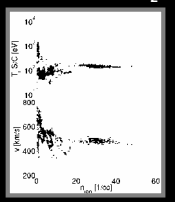


Figure 5: WIND and Geotail velocity and magnetic field GSE components. The accelerated flow is mainly upward and tailward. No clear rotations of the magnetic field are observed. Preliminary Walen test does not support reconnection as the source of flow.

Discussion

The giant S-shaped structure may be a result of the combined configuration of a B_y induced magnetotail twist and accelerated flow due to B_z draping.



High speed flow associated with low density, high temperature plasma. LLBL or magnetosheath?

Pressure variations in the solar wind may be intimately related to the initiation/quenching mechanism of auroral features.

Kelvin-Helmholtz instability due to velocity shear between the magnetosheath accelerated flow and magnetosphere flow (pc5 are observed!)?