Oxygen Outflow in the Cusp and Polar Cap Regions

Beams of singly ionized oxygen with narrow energy distributions originating in the dayside cusp region are observed frequently in the cusp and polar cap regions of the Earth. A statistical study using Cluster data shows that the source region is located near the equator-ward edge of the cusp/cleft, with a latitudinal range of ~1.5°. Cluster observations inside the source region, at ~ 4.5 - 6 R_e show high transverse heating of the O^+ population by BBELF waves.

The instrumentation onboard CLUSTER enables us to investigate the acceleration mechanism, and the location and size of the source region in great detail. Figure 1 shows an example of such an O^+ outflow event, as observed on Cluster-4. The top two panels display energy-time spectrograms of H^+ and O^+ ions, respectively. The energy-time dispersion of protons (a) is typical for the cusp, and can be attributed to different travel times of ions with different energies from a reconnection site at the dayside magnetopause to the point of observation. Oxygen (panel b) shows a narrow, beam-like, energy distribution. The third panel (c) presents parallel velocities of H^+ (green) and O^+ (black). Oxygen outflow starts at 12:46 UT. Subsequently there is a strong increase of the parallel velocity. During this time interval the S/C crossed a narrow acceleration region. The dashed line in Fig. 1 marks the equator-ward boundary of this region. After 12:49 UT the satellite leaves the acceleration region, indicated by the gradually decreasing parallel velocity of O^+ ions. The increase in energy of O^+ ions is correlated with a strong increase in the electric wave power in the frequency range 1-180 Hz, as measured with the EFW (panel d) and STAFF (panel e) experiments onboard Cluster.

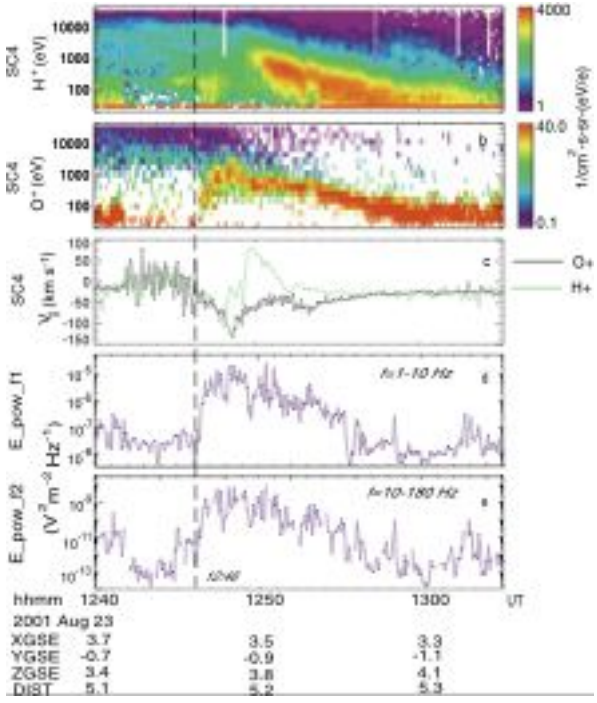

Fig. 1 *CIS, EFW and STAFF data from Cluster-4: O^+ energization event.*

This correlation suggests perpendicular energization of O^+ ions by the broad-band low-frequency wave field at altitudes of ~4-6 R_E. The velocity distribution of ions shows indeed strong perpendicular heating at the time of the maximum energy of the O^+ ions, whereas 8 minutes later, when the satellite already left the acceleration region, the velocity distribution shows a narrow, field-aligned beam.

To estimate the latitudinal and longitudinal size of the source region we used the Tsyganenko-96 magnetic field model and traced the boundaries of the acceleration region to the ionosphere level (100 km). Using data from 3 Cluster spacecraft for 10 events we find that the source is located near the equator-ward boundary of the cusp, and has an extension of ~1.5° in latitude and ~14° in longitude.

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