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The low frequency waves associated with energetic electrons observed by Cluster and Demeter in the polar cusp

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Abstract

The emissions with extremely high intensity around electron cyclotron frequency have been sometimes registered by satellite Magion 4 - companion of Interball 1. These waves correlate with strong fluxes of high energetic electrons often observed within the polar cusp by Interball 1 and Magion 4 as well as by Polar satellites. Multipoint measurements done by Cluster satellites give new insight of these emissions. Taking into account the plasma and magnetic field parameters in the polar cusp as well as geometry of the waves propagation, one has found that one type of these emissions can be generated by so called "fan instability" (FI) , but as a source of the emissions around electron cyclotron frequency the „horse shoe" instability has been also discussed. Beam instability and interaction of Langmuir waves with energetic electrons give the broad band emissions around plasma frequency, which can be discussed as Langmuir turbulence (LT). Kilometric radiation (KR) typical for auroral zone is observed in the vicinity of the cusp's boundary and is associated with fluxes of electrons with energy up to 100keV.Both instabilities play important role in the nonlinear wave –particle interactions leading to the isotropisation of the fluxes of the particles and heating of the plasma. The wave spectra taken by DEMETER satellite in the polar cusp at the ionospheric level are given for comparison

Observations

The observations done in the polar cusp indicate the permanent presence of plasma waves in this region [*1-6*]. These conditions indicate that cusp is an ideal region to study developing of different types of plasma instabilities and nonlinear interactions between different plasma modes. One can say that the polar cusp is an ideal laboratory to study key plasma processes interested from the point of view of geophysics as well as of astrophysics.

One of the discoveries made by the Polar, Interball 1 and Magion 4 satellites in the polar cusp is the presence of high energy particles (ions and electrons) in this region [7,8]. Strong emissions of the plasma waves are associated with these particles (Błęcki et al. 1999, Pickett et al. 1999).

The wave data used in this paper originate from the STAFF instrument onboard the CLUSTER satellites [9].

To study the wave processes in the polar cusp we use waveform of the magnetic field measurements recorded by this experiment, which can also provide spectra up to 4kHz. The maximum of the measured frequency of the waveform is 12.5Hz.

Figure 1 and 2 show the example of the wave activity registered by CLUSTER (Figure 1) and DEMETER (Figure 2) in the outer cusp and cusp at the ionospheric altitude respectively together with spectra of the energetic electrons

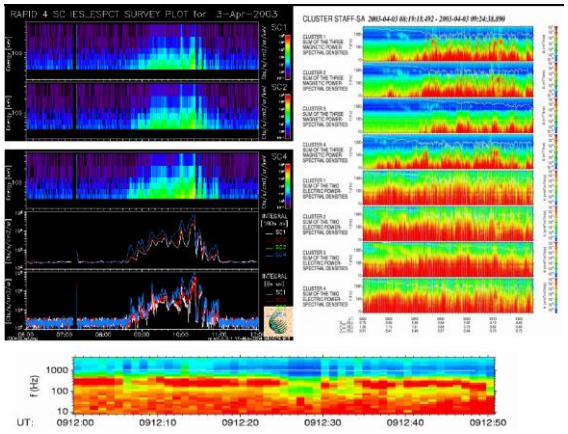

Figure 1: Energetic electrons spectra and fluxes (upper left panel) and wave spectra gathered by CLUSTER satellites in the outer polar cusp. Lower panel shows the characteristic maximum at 1/3 f_{ce} corresponding to fan instability.

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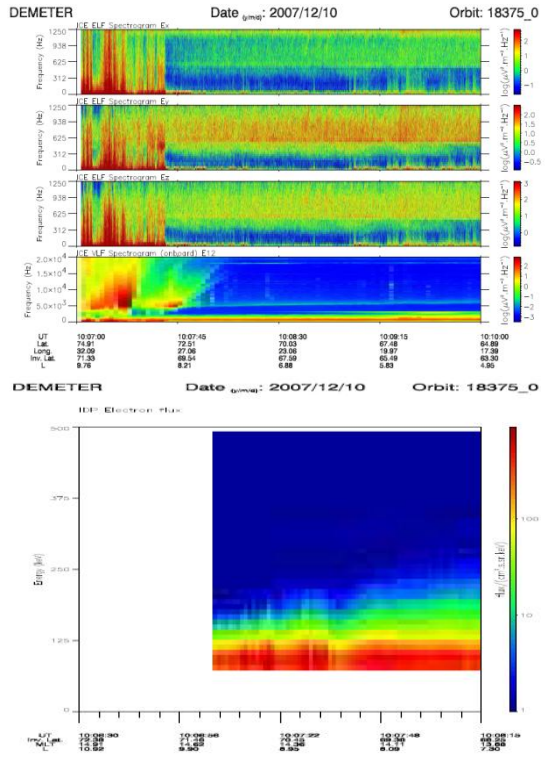

Figure 2:Wave spectra (upper panel) and energetic electrons spectra taken by DEMETER in the polar cusp at the ionospheric altitude.

Conclusions

The characteristic features of the wave spectra most frequently observed are broad band emissions, maxima at the lower hybrid, electron cyclotron frequency and sometimes its harmonics and below the ion cyclotron frequency.

Results presented here are selected from among many other cusp crossings and it was found that certainly not always such strong waves were present in the cusp. It seems that the most intensive waves in the cusp are associated with its boundaries and with the presence of high energy particles.

The waves observed in the cusp region together with energetic particles can be discussed either in the context of the plasma instabilities triggered by these particles or as a cause of the acceleration and energization of these particles.

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